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SID
SOCIETY FOR INFORMATION DISPLAY

IDW '17

THE 24TH INTERNATIONAL DISPLAY WORKSHOPS

Special Topics of Interest on

- Oxide-Semiconductor TFT
- Lighting and Quantum Dot Technologies
- AR/VR and Hyper Reality
- Automotive Displays
- Wide Color Gamut and Color Reproduction

Topical Session on

- User Experience and Cognitive Engineering
- Haptics Technologies

Workshops on

- LC Science and Technologies (LCT)
- Active Matrix Displays (AMD)
- FPD Manufacturing, Materials and Components (FMC)
- Inorganic Emissive Display and Phosphors(PH)
- OLED Displays and Related Technologies (OLED)
- 3D/Hyper-Realistic Displays and Systems (3D)
- Applied Vision and Human Factors (VHF)
- Projection and Large-Area Displays and Their Components (PRJ)
- Electronic Paper (EP)
- MEMS and Emerging Technologies for Future Displays and Devices (MEET)
- Display Electronic Systems (DES)
- Flexible Electronics (FLX)
- Touch Panels and Input Technologies (INP)

Final Program

Sendai International Center
Sendai, Japan
December 6 – 8, 2017

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Innovative Demonstration

PROGRAM HIGHLIGHTS

The 24th International Display Workshops will be held as IDW ’17 for encouraging aggressive research and development of display technologies throughout the world and especially in the Asian region. IDW ’17 focuses on the following 5 special topics and 2 topical sessions, which are extremely timely, as well as 13 active workshops.

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The three-day conference will feature 462 papers, including 3 keynote addresses, 125 invited presentations, 139 oral presentations, and 195 poster presentations. Following the plenary session of keynote addresses on the Wednesday morning, presentations will begin and continue in 8 parallel oral sessions through Friday. Poster sessions, author interviews and demonstrations will enable participants to discuss topics in detail. Exhibits by universities and display industry-related businesses will also be featured from Wednesday to Friday in parallel with workshops. IDW ’17 should be of interest to not only researchers and engineers, but also managers of companies and institutions in the display community.

Special Topics of Interest on Oxide-Semiconductor TFT (OXT)

Oxide semiconductor TFTs have already occupied an important position in the industry field of flat panel displays. Constituent materials, fabrication processes, characteristic enhancement technology, life-time prolonging techniques, etc. became matured technologies. On the other hand, there is a great room to improve the characteristics. All the authors will present novel oxide semiconductor materials, new device structures, solution processes, post-deposition processes, etc. Moreover, they will also propose emerging applications beyond the conventional ones. Don't miss them!!

Special Topics of Interest on Lighting and Quantum Dot Technologies (LIT)

The Lighting and Quantum Dot Technologies (LIT) of Special Topic of Interest (STI) will cover all aspects of science and technologies of lighting including LED lighting, OLED lighting, flexible lighting, manufacturing of lighting, lighting materials, device structures for lighting

and internal or external efficiency enhancement technologies. A highlight for IDW '17 will be the development of the phosphor plate functionalized by the YAG/sapphire micro-grain structure for high brightness light sources, and the recent progress of QLED technologies (PH-WS), applications of quantum dot materials, high brightness nano/micro LED, energy-saving displays and lighting devices (MEET-WS), OLED lighting technologies with stacked white OLED and advanced LED technologies including quantum dots (OLED-WS) and Roll-to Roll fabrication processes of transparent electrodes(FLX).

Special Topics of Interest on AR/VR and Hyper Reality (AR&VR)

Augmented reality (AR) and virtual reality (VR) applications employing high-performance display devices such as sensors, cameras with tracking capabilities, and computer graphics technologies have shown significant progress in the past few years.

This year we have organized 7 oral sessions (26 papers) and 4 poster sessions (17 papers). In regard to the FMC-WS, we have organized a session on display optics. As a consequence of huge impact of the wearable devices on the market, a session has been organized by the PRJ-WS on hardware and application, and system issues while a joint session on HMD based AR applications has been organized by the LCT-WS and DES-WS. Meanwhile, the DES-WS has organized a session on various types of AR system. A session by the 3D-WS has been organized on AR 3D displays. A session on the interactive AR systems has been organized by the INP-WS. In the meantime the VHF-WS has organized a session on the latest research in NIST, ergonomic evaluations and applications.

The IDW '17 is a venue to access the versatile state-of-the-art on AR and VR.

Special Topics of Interest on Automotive Displays (AUTO)

One of applications of display systems is the one for transportation systems including automobiles. From 2016, Automotive Displays (AUTO) was initiated as the new Special Topic of Interest (STI) where a lot of presentations concerning automobile displays were given. In 2017, WSs such as VHF, DES, INP, UXC, HAP and PRJ will organize the AUTO. In this session, you can hear new technological presentations, for examples, the Head-Up Display (HUD) that can give a stable display regardless of the ambient light changes, and the gesture touch display without direct touching on the surface of the display. Furthermore, flight deck display development will be reviewed. This AUTO will surely interest audiences such as users of automobiles as well as their designers.

Special Topics of Interest on Wide Color Gamut and Color Reproduction (WCG)

Thanks to rods and three color cones in our retinas, we can enjoy high dynamic range and wide color gamut (WCG). To realize true colorful life, we need to understand our rods, cones, and nerve systems, and then to develop suitable materials, components, displays and systems with color gamut expansion technologies and color reproduction technologies based on color / color vision research and WCG-related standardization. At the first year as Special Topics of Interest (STI), papers related to color vision, color conversion materials, and color enhancement system are gathered into WCG STI. One oral session and one poster session in VHF-WS await audiences who are not only color enthusiasts but also those who wish to listen quietly. Especially, in the VHF's special session, novel color systems including CIE LMS and CIM XYZ will be introduced as a base of color vision. With novel achievements in color vision and color conversion, you will find yourself addicted to WCG STI.

"Faith your color Till You Make your color"

Topical Session on User Experience and Cognitive Engineering (UXC)

The first day has 2 joint sessions with VHF (VHF1/UXC1, UXC2/VHF2). The presentations include education and reading. The second day has 2 joint sessions with INP (UXC3/INP3, INP4/UXC5). The presentations include touch, haptic feedback, and pen input. UXC4 includes the analyzation of eye movement. The third day has a joint session with EP (UXC5/EP5). The presentations include the environmental impact of an e-book and studies to compare reading on paper and reading on e-book devices.

Topical Session on Haptics Technologies (HAP)

Haptic technologies have been attracting attention in various fields as a next-generation technology to provide new user experiences. As a forum for discussing the integration of display technologies and haptic technologies, we have planned the first technical sessions on haptics at IDW. The invited talks given by the leading Japanese researchers will cover the wide range of haptic technologies that include human haptic perception and measurement, presentation, and modulation of haptic information. In the demonstration session, participants can actually "experience" the technologies related to the talks.

Workshop on LC Science and Technologies (LCT)

The LCT workshop covers topics from fundamental studies to recent developments in LCD technologies and LC materials. Of special note this year are the eight invited presentations related to novel materials such as liquid crystalline organic-semiconductors, highly polar LC materials, photo-alignment materials, polyimide-less LCDs, high contrast IPS-LCDs, highly transparent LCDs and AR/VR related technology. Moreover, several emerging applications which lead to Flexible LCDs, LC lenses and wearable LCDs polarized light-emitting film and LCDs for smart windows are presented.

Workshop on Active Matrix Displays (AMD)

The AMD workshop covers oxide TFTs, Si-TFTs, organic/carbon TFTs, OLEDs, sensors, memories, and the other devices. Recent paper presentations continue to focus on oxide TFT, which is highly expected to play a role in applications for higher resolution LC and OLED displays. We highlight the oxide TFT as a special topic of interest (OXT-STI) with four dedicated sessions covering a wide area from materials, physics, devices, and processes to applications. Furthermore, we have prepared two sessions for organic/carbon devices and for next generation displays. We look forward to your participation!

Workshop on FPD Manufacturing, Materials and Components (FMC)

The FMC workshop (WS) covers recent developments and achievements in the field of flat panel display technologies, including display optics, materials, components, display panel manufacturing and measurements technologies. The oral sessions are made up of 22 papers of which 8 are invited papers, and the poster session contains 14 papers. In the FMC sessions, the papers related to high transmissive glass, chemically strengthened cover glass are highlighted. In addition, flexible electrodes for electronics and wide color gamut color filters with optical polarizer films are also highlighted. Papers on equipment for roll-to-roll manufacturing such as exposure equipment, imprinting and film, and transparent polyimide and film will be presented in electrode materials and photoresist technologies session. Presentations on manufacturing of μ LED and LTPS and related technologies will be held in manufacturing and measurement technologies session. Recent trends in the fields of augmented reality and virtual reality will be presented at display optics for AR/VR session.

Workshop on Inorganic Emissive Display and Phosphors (PH)
This workshop presents the latest achievements in devices and phosphors for emissive displays, lighting, and imaging. Invited talks will include emerging technologies such as laser-phosphor light source, and up-conversion nanophosphors for multimodal imaging and display application.

Workshop on OLED Displays and Related Technologies (OLED)
The OLED workshop covers all aspects of the science and technologies of OLED, QLED and other organic devices, ranging from material science, basic device physics for OLED device and display technologies, and other applications. The oral and poster sessions will cover OLED display and device technologies including OLED/QLED lighting technologies (LIT), and advanced technologies relating OLED and materials. Recent progress such as micro-OLED display, thermally activated delayed fluorescent (TADF) materials and advanced lighting, and evaluation methods etc. will be reported on at IDW '17.

Workshop on 3D/Hyper-Realistic Displays and Systems (3D)
3D/hyper-realistic displays and systems workshop consists of many papers on 3D systems and devices for holography, autostereoscopic display, integral photography, and emerging applications for AR. We have some invited talks related to an ultra-fine LCD that features 1 μm pitch pixels, a novel AR display based on multiple viewpoint images, and emerging displays for VR etc. 3D poster sessions include demonstrations, which will give you brand-new experiences with 3D images.

Workshop on Applied Vision and Human Factors (VHF)
The VHF workshop covers all ergonomic factors on human interfaces, such as visual aspects, environmental related aspects, and measurements. We have eight oral sessions and four poster sessions, including special topic sessions on Color vision, Automotive applications, and Virtual reality, in addition to HDR and Motion image quality and sickness, Display measurements, and so on. We also have a joint session on User Experience and Cognitive Engineering. Seven invited talks will be given in the oral sessions, concerning Colorimetry, Automotive ergonomics, Visually induced motion sickness, AR/VR measurements, Cognitive aspects, and 8K, 120 Hz motion image quality.

Workshop on Projection and Large-Area Displays and Their Components (PRJ)
The PRJ workshop covers the latest wearable applications, vehicle display technologies, head lights, solid-state light sources, holograms, short throw optics etc., projection mapping, Augmented Reality / Virtual Reality, 3D measurement, standardization of wearable/new light sources and all the projection related technologies. This year's papers discuss state of the art topics focusing on vehicle displays, display standardization, cinema & projection mapping, wearable related technologies and holograms. We have ready for you 27 presentations including 8 invited talks. There will be 20 oral and 7 poster sessions.

Workshop on Electronic Paper (EP)
The EP workshop covers all technical fields related to electronic paper, including research presentations on material technologies, display technologies, application systems, usability, and the IoT. Interesting themes in presentations related to coloring technologies of e-paper including those on solid-state Reflective Display, Color Changing EPD, and Plasmonic Reflective Displays are scheduled. A joint session with UXC5 (User Experience and Cognitive Science) will also be held.

Workshop on MEMS and Emerging Technologies for Future Displays and Devices (MEET)
The MEET workshop is unique in covering all aspects of MEMS, nanotechnologies and emerging technologies concerning future

displays, imaging devices, and emerging electron devices. It seeks to broaden the horizon of display and imaging technologies into cutting-edge technologies. Research areas such as materials, basic physics and fabrication processes are included. Among all the MEMS and display conferences in the world, this is the only opportunity for MEMS and cutting-edge technology researchers to gather and discuss such devices. Authorities from top research institutions around the world in this field have been invited. Invited speakers are from the University of Cambridge, CEA-LETI, Brunel University, Wolfson Center for Materials Processing, Kyung Hee University, University of Central Florida, Southern University of Science and Technology, Beijing Institute of Technology, Nanosys, QD Laser, Merck, and Tohoku University. Together with contributed papers with high-quality content, this workshop is aimed at participants who wish to open up new fields in displays, imaging devices and emerging devices.

Workshop on Display Electronic Systems (DES)
The DES workshop covers all aspects of display electronic systems in relation to video data processing, interface technologies, and cooperative operations between display components such as cells and backlights and sensors. This year, we will have 18 papers including 8 invited talks and 5 poster presentations. We will organize five sessions including three normal and two joint sessions. The normal sessions' themes are various visualization technologies, novel displays for transportation, and various Augmented Reality systems. The joint sessions are two sessions, one is co-organized with 3D-WS focusing on 3D in AR/VR and Hyper Reality and the other with LCT-WS is on Head Mounted Display applications. The related STIs are AR/VR and Hyper Reality, AUTO, and HMD.

Workshop on Flexible Electronics (FLX)
The FLX workshop focuses on advanced technologies for flexible electronics including displays, wearable sensors, and IoT technologies, which are composed of a wide range of fields from material science to practical applications. The sessions cover all aspects of the hottest flexible devices and material technologies including new TFT fabrication technologies, flexible sensors, stretchable displays and innovative Roll-to-Roll machines and processes.

Workshop on Touch Panels and Input Technologies (INP)
Interface technologies such as touch panels and interactive technologies which already extend to PC screens are the stars of the session. This year, we have many important papers related to these technologies. AR/Interactive systems such as haptics and AR are special topics of INP. This year, new topics will be presented: Finger print detection and new essential technologies on AR/VR are topics to be focused. INP papers will open a new window in displays and interactive technologies, not only for devices but also for systems, making them essential viewing.

IDW Best Paper Award and IDW Outstanding Poster Paper Award
IDW will present “IDW Best Paper Award” and “IDW Outstanding Poster Paper Award”. The award committee of IDW will select the most outstanding papers from those presented at IDW ’17. The award winners will be announced on the IDW website and given a plaque after the conference.

I-DEMO (Innovative Demonstration Session)
I-DEMO will be held on December 7 at Exhibition Hall (Exhibition Bldg.). IDW provides the opportunity for an interdisciplinary technical demonstration/discussion in a larger space, more preparation and demonstration time than in the “Author Interviews”. Demonstration Award will be awarded to the demonstration that has the biggest impact on the audience. See page 227 for details.

Exhibition

The IDW ’17 Exhibition, which will be held from December 6 through December 8, covers materials, components, manufacturing and measuring equipment, software systems and other related products for display devices. Please join in and enjoy discussions at exhibitors’ booths (Exhibition Hall, Exhibition Building).

December 6 (Wed.) 12:40 – 18:00
December 7 (Thu.) 10:00 – 18:00
December 8 (Fri.) 10:00 – 14:00

SID Display Week 2018

May 20 – 25, 2018

Los Angeles Convention Center

Los Angeles, California, USA

http://www.displayweek.org/

IMID 2018

Aug. 28 – 31, 2018

BEXCO

Busan, Korea

http://www.imid.or.kr/

IDW ’18

The 25th International Display Workshops

Dec. 12 – 14, 2018

Nagoya Congress Center
Nagoya, Japan

http://www.idw.or.jp/

GENERAL INFORMATION

SPONSORSHIP
IDW ’17 is sponsored by the Institute of Image Information and Television Engineers (ITE) and the Society for Information Display (SID).

CONFERENCE SITE
Sendai International Center
Aobayama, Aoba-ku, Sendai,
Miyagi 980-0856, Japan
http://www.aobayama.jp/english/

ON-SITE SECRETARIAT
Telephone and fax machines for IDW ’17 will be temporarily set up in the secretariat room (Meeting Room 5) at Sendai International Center (December 5-8). Phone/FAX : +81-22-266-1761

RECEPTION
A buffet style reception will be held on December 6 from 18:30 - 20:30 at the Zuiun (2F) in Sendai Shozankan, 2-1-50, Uesugi, Aobaku, Sendai. As the number of tickets is limited, you are urged to make an advance reservation through the registration website.

EVENING GET-TOGETHER WITH WINE
A get-together will be held on December 5 from 18:00 to 20:00 at Café Leaf (1F) in Sendai International Center. Wine (sponsored by Merck Performance Materials Ltd.) will be served to participants in a relaxed atmosphere for networking.

REGISTRATION
Registration is available in advance and also on-site. However, advance registration is strongly recommended to speed up the arrival procedure at the conference site.

Registration Fees
The registration fee for IDW ’17 includes admission to the conference and a USB flash drive of the proceedings. Detailed information will be announced on the website.

	Until Oct. 27	On and After Oct. 28
Individual Member (ITE/SID/ASO*)	¥ 40,000	¥ 50,000
Non-Member**	¥ 50,000	¥ 60,000
Student***	¥ 13,000	¥ 15,000
Life Member of ITE/SID	¥ 13,000	¥ 15,000
Reception	¥ 8,000	¥ 10,000

*ASO: Academic Supporting Organizations
(See p.16 as well as “Supporting Organizations and Sponsors” at the end of each workshop section.)
**Non-Member: If you intend to join either ITE or SID, the one year membership fee will be subsidized by IDW ’17 committee.
***Photocopy of student ID is required.

Please note that the payment of reduced registration fee is accepted until October 27. The full fee will be charged for payments made on and after October 28. Also note that the number of reception tickets to register on site is limited.

Additional proceedings (USB flash drive)

At the conference site	¥ 8,000
Airmail after the conference	¥12,000
Domestic mail after the conference	¥10,000

Payment
Two ways are provided for registration.

(1) Advance Registration
Access the following URL.
http://www.idw.or.jp/regist.html
Advance registration will be accepted until November 24, 2017.

(2) On-site Registration
Conference registration desk will open:

December	5 (Tue.)	17:00 – 20:00
December	6 (Wed.)	8:00 – 18:00
December	7 (Thu.)	8:00 – 18:00
December	8 (Fri.)	8:00 – 13:00

On-site registration fee will be payable by:
1. Cash (JAPANESE YEN only)
2. Credit Card (visa, MasterCard, JCB, AMEX or China Union Pay)

Bank transfer, bank checks, or personal/traveler's checks are not accepted.

Cancellation Policy
Until **October 27**, cancellation is accepted by writing to IDW '17 Secretariat to obtain refunds for registration and reception. All bank services charges will be deducted from the refunds. Please note that refunds will not be made under the following conditions:
- Cancellations received on and after October 28
- No-shows
- Cancellations by presenters
- Cancellations by visa invitation letter applicants who have already received a visa invitation letter.

However, after IDW '17 closes, a USB flash drive of the proceedings will be sent to the registrants who have paid the registration fees. If it becomes difficult to hold IDW '17 due to the outbreak of infectious diseases and other unavoidable factors, we will substitute the IDW with the mail delivery of the IDW '17 proceedings at a later date to all those who have registered and completed payment.

IDW Best Paper Award

IDW Outstanding Poster Paper Award

These awards will go to the most outstanding papers selected from those presented at IDW '17.
The 2017 award winners will be announced on the IDW website: http://www.idw.or.jp/award.html

INQUIRIES

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c/o Bilingual Group Ltd.
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Academic Supporting Organizations (ASO)

- The Chemical Society of Japan
- The Electrochemical Society of Japan
- The Illuminating Engineering Institute of Japan
- The Imaging Society of Japan
- Information Processing Society of Japan
- The Institute of Electrical Engineers of Japan
- The Institute of Electronics, Information and Communication Engineers
- The Institute of Image Electronics Engineers of Japan
- International Electrotechnical Commission
- The Japan Ergonomics Society
- The Japan Society of Applied Physics
- The Japanese Liquid Crystal Society
- The Japanese Society for Artificial Intelligence
- The Optical Society of Japan
- The Society of Automotive Engineers of Japan
- The Society of Instrument and Control Engineers
- The Society of Polymer Science, Japan
- The Virtual Reality Society of Japan
- Vision Society of Japan

FUNDS

- Sendai Tourism, Convention and International Association
- JSPS KAKENHI Grant Number 17HP0303

For final updated information, please visit our website, http://www.idw.or.jp/

TRAVEL INFORMATION

ACCOMMODATIONS
JTB Touhoku will handle arrangements for your hotel reservations.

Hotel reservations can be made at the IDW official website.
http://www.idw.or.jp/accommodation.html

JTB Touhoku
E-mail: tohoku-ec2@jbn.jtb.jp

There will be an on-site travel information desk during the conference period to handle arrangements for transportations.

VISAS
Visitors from countries whose citizens must have visas should apply to Japanese consular office or diplomatic mission in their respective country. For further details, please contact your travel agency or the local consular office in your country.
Attention: For some countries' citizens, official documents prepared by the secretariat will be needed. Please ask the secretariat at least two months before the conference.

CLIMATE
The average temperature in Sendai during the period is around 9°C in the daytime and 1°C at night.

JAPAN RAIL PASS AND JR EAST PASS
Japan Railway (JR) provides the following economical passes. They should be purchased before you leave your country. Please contact your travel agency. Visit following sites for the details.

(1) The JAPAN RAIL PASS is the most economical way to travel throughout Japan by rail and JR buses.

(2) The JR EAST PASS is an economical and flexible rail pass to travel around Eastern Japan.
Japan Rail Pass: http://www.japanrailpass.net/eng/en/index.html
JR East Pass: http://www.jreast.co.jp/e/eastpass/

SENDAI

The city of Sendai is located in the northern part of Honshu Island, and is the largest city in the Tohoku region, with a population of more than one million. At the beginning of the 17th Century, the feudal lord Date Masamune built Sendai Castle and reigned over this district. There are many trees in the city, which is why it is called the “City of Trees”. Sendai is also famous for delicious food such as sushi, grilled beef tongue, and Sendai Dagashi (traditional sweets from Sendai). From Sendai Airport, JR Sendai Station is 18-25 minutes by the Sendai Airport Access Line. The Sendai International Center is located about 2 km from JR Sendai Station and only 200 m (a minute’s walk away) from the International Center Station (5 minutes by subway from JR Sendai Station).

PLACES OF INTEREST

Sendai Castle Ruins

Sendai Castle (about 20 minutes by taxi from Sendai Station) was built over 400 years ago. You can enjoy a view of the whole city from this site and gain a sense of its heritage although the castle and its building are no longer standing.

Sendai City Museum

This museum (8 minutes from the International Center station on foot) explains the history of the Sendai region and its arts, including "Information about the Delegation to Europe in the Keicho era," which is designated as a national treasure.

Jozenji-dori Avenue

The Avenue of Zelkova Trees (near Sendai Station) is a symbol of Sendai. In winter, an event called the “Sendai Pageant of Starlight,” with about 600,000 fairy lamps lighting up the avenue, is held.

Osaki Hachimangu Shrine

Osaki Hachimangu Shrine (about 20 minutes by bus from Sendai Station) was built by Lord Date Masamune and is the oldest structure ever built in the “Toshogu style”. The shrine pavilion is a designated national treasure and the oil press device in front of the shrine pavilion has also been designated as an important cultural property.

Akiu & Sakunami area

Akiu & Sakunami, about a 30-minute drive away from downtown Sendai, is famous for hot spring resorts with over 1,000 years of history. The beautiful nature settling of this area makes for a very soothing experience.

Matsushima

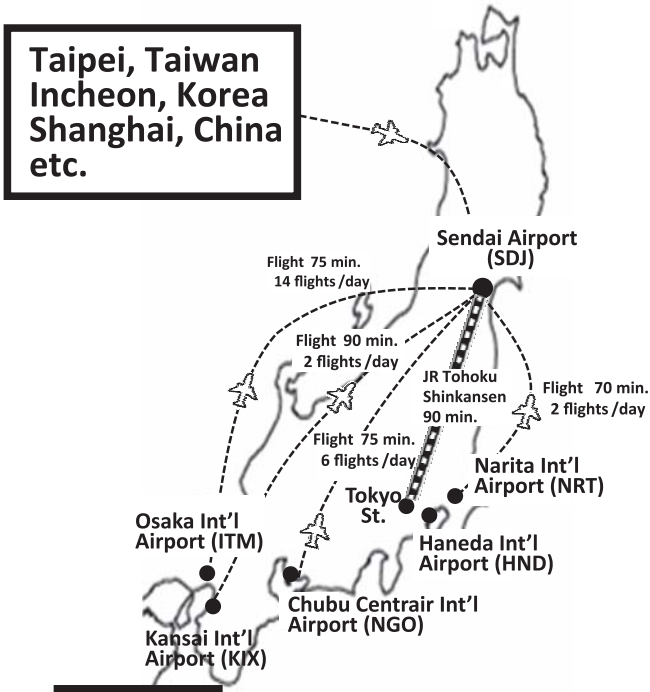
Matsushima bay, with some 230 islands, has been ranked one of Japan's three most scenic views for centuries.
In 2013, Matsushima joined the Most Beautiful Bays in the World Club.

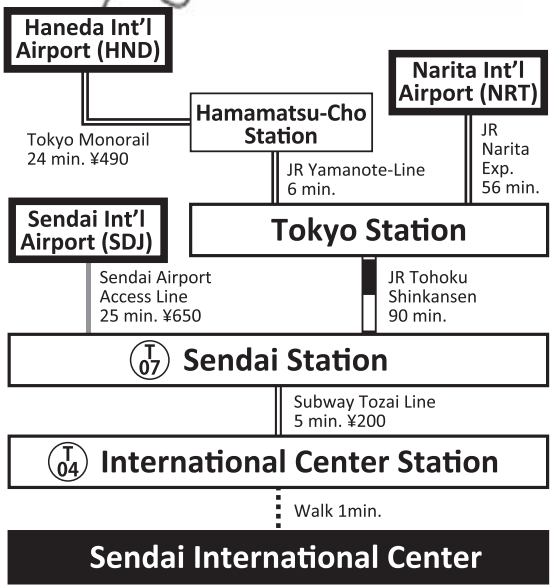
More information is available at the following websites:

http://sendai-travel.jp/

http://www.pref.miyagi.jp/site/kankou-en/en-sightseeing1.html

Access to Conference Site





Transportation information on this page may be changed. Please confirm the details with each airline company. (as of November 8, 2017)

HOTEL MAP

① Hotel Metropolitan Sendai

② Hotel Monterey Sendai

③ SENDAI WASHINGTON HOTEL

④ Sendai Kokusai Hotel

⑤ Dormy inn Sendai ANNEX

⑥ Hotel Monte Hermana SENDAI

⑦ HOTEL Premium Green PLUS

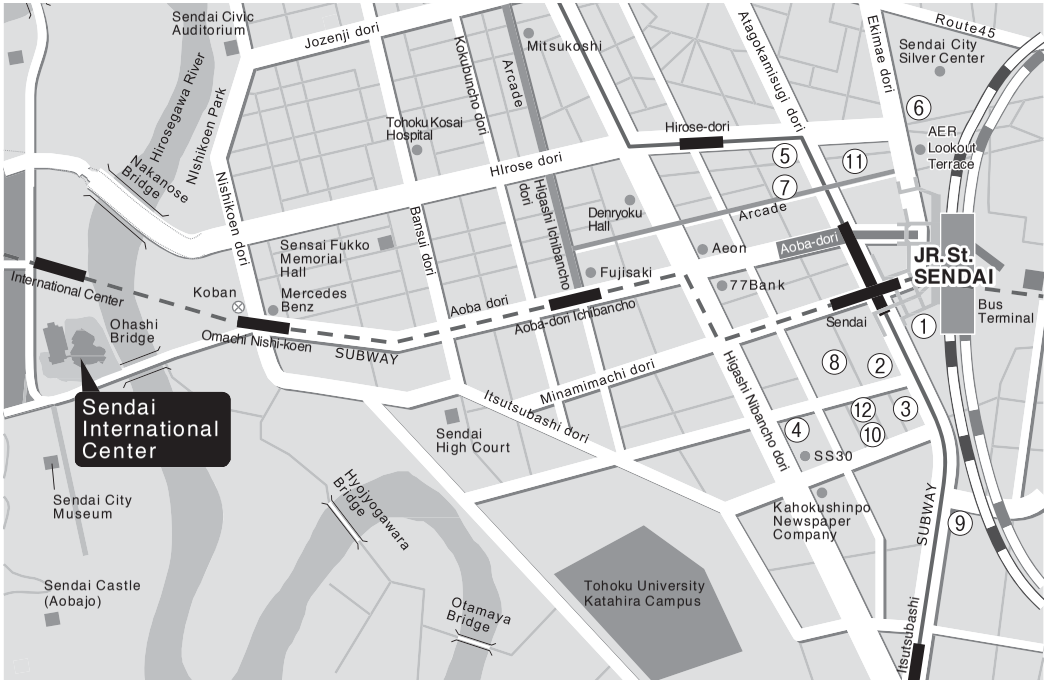
⑧ HOTEL UNISITE SENDAI

⑨ APA VILLA HOTEL <SENDAIEKI-ITSUTSUBASHI>

⑩ HOTEL Green Mark

⑪ HOTEL Green Pacific

⑫ UNIZO INN Sendai



IDW ’17 Tutorial in Japanese

Organized by SID Japan Chapter
Tuesday, Dec. 5, 2017
13:00 – 18:00
Shirakashi Conference Room
(3F, Conference Bldg.)

Sendai International Center
Detailed information will be announced at
http://www.sid-japan.org/

I-DEMO
(Innovative Demonstration Session)

Live demonstrations
of emerging information display technologies
by oral and poster presenters
Thursday, Dec. 7, 2017
15:00 – 18:00
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
See page 227 for details

Plenary Sessions

Wednesday, December 6

9:30 - 9:50 **Main Hall**

Opening

Master of Ceremony: Y. Kijima, Executive Chair, IDW '17

Opening Remarks
9:30

M. Omodani, General Chair, IDW '17
Y. -S. Kim, President, SID
K. Mitani, Vice President, ITE
H. Fujikake, Program Chair, IDW '17

9:50 - 11:50 **Main Hall**

Keynote Addresses

Chair: H. Fujikake, Program Chair, IDW '17
Co-Chair: M. Omodani, General Chair, IDW '17

Keynote Address - 1 **Next Generation Technologies for Mobile Use Display**
9:50

A. Takimoto

Japan Display, Japan

The evolution of the display for mobile devices has been ongoing. In this paper, I will introduce the recent and next-generation display technologies, such as the evolving LTPS technology, and their implementation in flexible devices.

Keynote Address - 2 **China AMOLED Status and Opportunity**
10:30

V. Tseng

Tianma Micro-elect., China

Recently several smartphone makers adopt flexible AMOLED display in flagship model. However, the supply of flexible AMOLED display is limited because that only one supplier can ship product to the market. China display makers try to catch this opportunity and announce several investment plans in flexible AMOLED factories. Here the developing status of flexible AMOLED display in China and the challenge of China AMOLED makers are updated in this presentation.

Keynote Address - 3 **Augmented Reality in Medicine**
11:10 **— Design and Applications —**

T. Nakaguchi

Chiba Univ., Japan

Augmented reality technology in medicine is being recognized as a powerful means. By integrating various data with actual patients, it is expected that physician's sensory ability will be expanded and medical safety and accuracy will be improved. This presentation describes design and application examples of medical augmented reality technology.

Evening Get-Together with Wine

Tuesday, Dec. 5, 2017
18:00 – 20:00
Café Leaf
(1F, Conference Bldg.)
Sendai International Center
(Sponsored by Merck Performance Materials Ltd.)

Reception

Wednesday evening
Dec. 6, 2017
18:30 – 20:30
Zuiun (2F)
Sendai Shozankan
See page 15 for details

Special Topics of Interest on Oxide-Semiconductor TFT

Wednesday, December 6

13:10 - 14:15 **Tachibana Conference Hall**

AMD1: Oxide TFT: Advanced Devices

Chair: H. Kumomi, Tokyo Tech, Japan
Co-Chair: K. Hayashi, Kobe Steel, Japan

AMD1 - 1: 13:10 ***Invited*** **Controllable Quantum Interference in Amorphous $InGaZnO_4$ Thin-Film Transistors**

W.-H. Wang, S.-R. Lyu, E. Heredia, S.-H. Liu, P.-H. Jiang, P.-Y. Liao[*]*, T.-C. Chang*[*]*, H.-M. Chen*[**]

Nat. Taiwan Normal Univ., Taiwan
[*]*Nat. Sun Yat-Sen Univ., Taiwan*
[**]*Nat. Chiao Tung Univ., Taiwan*

We report on the low-temperature magnetoconductivity of amorphous $InGaZnO_4$ (a-IGZO) thin-film transistors (TFTs). The magnetoconductivity exhibits coexistence of weak localization (WL) and weak antilocalization (WAL), and their competitions can be controlled by the gate voltage. Our findings demonstrate gate-controlled quantum interference in the electron systems in a-IGZO TFTs.

AMD1 - 2 13:35 **Twin-Channel Oxide TFT with High Current Drive and Its Circuit Application**

M. Nakata, M. Ochi[*]*, H. Tsuji, T. Takei, M. Miyakawa, T. Yamamoto, H. Goto*[*]*, T. Kugimiya*[*]*, Y. Fujisaki*

NHK, Japan
[*]*Kobe Steel, Japan*

A twin-channel oxide TFT having two short effective channel regions has been developed by formation of a low-resistance region in the semiconductor. This twin-channel TFT enables high current drive due to the reduction of effective channel length, and can save space by operating two channels separately on the same device.

AMD1 - 3 13:55 **Simulation Study of Novel Thin-Film Devices Using Depletion State of Amorphous Oxide Semiconductor**

K. Abe, M. Fujinaga, T. Kuwagaki
Silvaco Japan, Japan

Novel devices using amorphous oxide semiconductor (AOS) were studied through device simulation. This study confirmed that the device with a conventional first-gate and an AOS second-gate shows NAND-like function. It suggested a feature that holes and ionized traps in the depleted second-gate AOS are insufficient to compensate the negative first-gate.

----- Break -----

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:00 **Tachibana Conference Hall**

AMD2: Oxide TFT: Stability

Chair: P.-H. Jiang, Nat. Taiwan Normal Univ., Taiwan
Co-Chair: H. Kumomi, Tokyo Tech, Japan

AMD2 - 1: 9:00 ***Invited*** **Hydrogen-Induced Trap States in Amorphous In-Ga-Zn-O Thin-Film Transistors Studied by Photoinduced Transient Spectroscopy**

K. Hayashi, M. Ochi, A. Hino, H. Goto, T. Kugimiya
Kobe Steel, Japan

We have studied evolution of hydrogen-induced trap states in amorphous In-Ga-Zn-O thin-film transistors by means of photoinduced transient spectroscopy. The etch-stop layer formation conditions were successfully correlated with the threshold voltage shift originating from positive bias thermal and negative bias thermal illumination stresses.

AMD2 - 2 9:25 **AlO Sputtered Self-Aligned Source/Drain Formation Technology for Highly Reliable Oxide Thin Film Transistor Backplane**

H. Hayashi, A. Murai, M. Miura, Y. Terai, Y. Oshima, T. Saitoh, Y. Hiromasu, T. Arai
JOLED, Japan

We propose a novel self-aligned source/drain formation process by AlO sputtering for oxide TFT backplane. The method has the advantages in terms of barrier performance, large substrate production, and productivity. The AlO passivation provides a uniform and reliable oxide backplane suitable for OLED displays.

AMD2 - 3L 9:45 **Slot-Die Coating of Soluble Metal Oxide Semiconductor Towards High-Performance, High-Resolution Self-Aligned TFT Backplanes**

I. Katsouras[*], M. Marinkovic[**], J. Maas[*], D.-V. Pham[**], R. Anselmann[**], G. Gelinck[,***]*

[*]Holst Ctr., The Netherlands
[**]Evonik Resource Efficiency, Germany
[***]Eindhoven Univ. of Tech., The Netherlands

We report slot-die coating of the indium oxide-based iXsenic S precursor solution, and its first robust integration into high-performing thin-film transistors with a self-aligned architecture. We demonstrate excellent performance and uniformity of the resulting TFTs. Our results are a key ingredient towards roll-to-roll printed, high-resolution TFT arrays.

----- Break -----

10:40 - 12:05 **Tachibana Conference Hall**

AMD3: Oxide TFT: Fabrication

Chair: H. J. Shin, LG Display, Korea
Co-Chair: H. Hamada, Kinki Univ., Japan

AMD3 - 1: 10:40 ***Invited*** **Oxide TFT Fabrication Techniques for Advanced Flexible Display Backplanes**

J. W. Na, H. J. Kim, B. H. Kang, H. J. Kim
Yonsei Univ., Korea

We propose low-temperature fabricated amorphous oxide semiconductor thin film transistors (AOS TFTs) by simultaneous ultraviolet and thermal (SUT), electrically assisted thermal (EAT), and high pressure annealing (HPA) treatments. In addition, we investigated a new material, nitrocellulose, as a low-temperature processable passivation layer of oxide TFTs.

AMD3 - 2 11:05 **Direct Photoreactive Patterning Method for Fabricating Aqueous Solution-Processed IGZO TFTs**

M. Miyakawa, M. Nakata, H. Tsuji, Y. Fujisaki
NHK, Japan

A simple, direct photoreactive patterning method for fabricating aqueous solution-processed IGZO TFTs without any photoreactive additives is proposed. Uniform patterned IGZO films are obtained using a photoreactive chemical process based on a free radical reaction in conjunction with a soft etching process.

AMD3 - 3
11:25

Study on the Dry Etching Characteristics of Back Channel Etch Type IGZO TFTs

Z. R. Li, Q. Zhang, M. Lu, Y. Deng, J. Yao, S. Qin

Shenzhen China Star Optoelect. Tech., China

In this paper, we report that the selectivity ratio of Mo and a-IGZO film could be up to 300 when adopting Cl_2/O_2 as ICP dry etching process gas. Then we chose Mo as S/D electrodes and fabricated BCE structure a-IGZO TFTs exhibited excellent performance under this dry condition.

AMD3 - 4
11:45

Enhanced Scalability and Reliability of Indium-Gallium-Zinc Oxide Thin-Film Transistor Using a Combination of Plasma Fluorination and Thermal Oxidization

L. Lu[*]*, J. Li, Z. Xia, Z. Feng, S. Wang, S. Bebiche, H. S. Kwok*[*]*, M. Wong*

Hong Kong Univ. of S&T, Hong Kong
[*]*HKUST Jockey Club Inst. for Advanced Study, Hong Kong*

Attributed to the effective passivation of defects in InGaZnO, both the scalability and reliability of an InGaZnO thin-film transistor are significantly enhanced by combining plasma fluorination with thermal oxidization.

----- Lunch -----

13:10 - 14:45 **Tachibana Conference Hall**

AMD4: Oxide TFT: Application

Chair: H. J. Kim, Yonsei Univ., Korea
Co-Chair: K. Omoto, Apple, Japan

AMD4 - 1:
13:10

Invited **Novel High-Image-Quality Technologies for Premium OLED TVs**

H.-J. Shin, S. Takasugi, J.-M. Kim, C.-H. Oh

LG Display, Korea

We present an OLED display with the “Real Black” image quality and high color uniformity for premium large sized TVs. Self-aligned coplanar TFT is employed as panel backplane. Using novel high-image-quality technologies, we can enhance image quality of the OLED display. These works should play an important role in commercializing Premium OLED TVs.

AMD4 - 2 **Withdrawn**

AMD4 - 5L 13:35 **Fully Printed Oxide TFTs for Display Backplane and Logic Circuits**

L. Lan, Y. Li, J. Peng

South China Univ. of Tech., China

With the assistance of surface-energy patterns, the surface morphology of printed oxide films can be well regulated. The several issues in printing, including coffee-ring effect, ink spreading and the interaction of adjacent isolated ink islands were addressed properly. The demonstrated fully printed metal-oxide thin-film transistors exhibited good electrical performance and uniformity.

AMD4 - 3: 14:00 ***Invited*** **Novel Driving Circuit for High Resolution IGZO TFT Display**

K. Yamamoto, K. Tanaka, K. Okada, K. Yamamoto, S. Uchida, H. Katoh, A. Oda, T. Karahashi, T. Matsuo

Sharp, Japan

We have developed an ultra-high-definition liquid crystal display (2.87-in. 1008 ppi, 2K2K, 120 Hz) for HMD. The high definition and narrow bezel were realized by adopting a de-multiplexer circuit based on IGZO-TFT. We devised a novel de-multiplexer circuit of IGZO-TFT configuration, and realized high driving performance.

AMD4 - 4 14:25 **Design of Highly Reliable Depletion-Mode a-IGZO TFT Gate Driving Circuit for 85-in. 8K4K 120 Hz TFT-LCD**

L.-Q. Shi, S.-J. Chen, Y.-F. Chou, M. Zeng, T.-H. Wang, P.-J. Chiang, L.-M. Zeng, R.-L. Chen, C.-W. Liao, X.-W. Lv, W.-Y. Li, C.-Y. Chiu, C.-Y. Lee

Shenzhen China Star Optoelect. Tech., China

In this paper, high reliable a-IGZO TFT gate driving circuit was designed. The Vth integral shift margin of this proposed GOA design is from -10 V to +9 V, and the circuit exhibits good falling time 1.34 μs by using simulation. Finally, an 85-in. 8K4K 120 Hz TFT-LCD was successfully demonstrated.

Author Interviews
14:45 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* AMDp1: Oxide TFTs**

AMDp1 - 1 **Achieving High Carrier Mobility in IGZO Transistors by Catalytic Metal Assisted Crystallization**

Y. Shin, J. Lee, J. K. Jeong

Hanyang Univ., Korea

The transition metal catalytic layer has facilitated the low-temperature crystallization of amorphous indium gallium zinc oxide semiconductor. Subsequently, the significant enhancement in terms of device performance was observed for the crystallized IGZO transistor at a low annealing temperature of 300°C: the field-effect mobility increased up to 54.0 $cm^2/V{\cdot}s$.

AMDp1 - 2 **Soluble-Processed Aluminum Doped Yttrium Oxide Gate Insulator for High Performance Amorphous Oxide Transistors**

J. Lee, Y. Shin, J. K. Jeong

Hanyang Univ., Korea

The low-cost spin-cast $Al_{0.5}Y_{1.5}O_3$ films were prepared as the gate insulator for the IZO transistors. The ternary $Al_{0.5}Y_{1.5}O_3$ films provide a smooth, high permittivity with excellent insulating properties compared to binary Al_2O_3 or Y_2O_3 films. This behavior can be attributed to the structure stabilization resulting from the cation alloying mixing effect.

AMDp1 - 3 **31-in. 4K2K AMOLED Display Using High Thermal Stability and Reliability Top-Gate Self-Aligned IGZO TFTs**

X.-Y. Zhou, L. Sun, F.-M. Liu, Y.-J. Hsu, M.-J. Yu, Z.-S. Liu, X. Xiao, J.-S. Im, P.-Y. Lu

Shenzhen China Star Optoelect. Tech., China

We develop thermal stable top-gate self-aligned a-IGZO TFTs by optimizing the metallization process of n^+ IGZO regions. The PBTS reliability is significantly improved by tuning the deposition process of gate insulator and buffer film. Finally, the AMOLED display are demonstrated by employing the high-performance a-IGZO TFTs.

AMDp1 - 4 **Withdrawn**

AMDp1 - 5 **Withdrawn**

AMDp1 - 6 Development of Self-Aligned Top-Gate a-IGZO TFTs for a 31-in. 4K2K AMOLED Display

S.-M. Ge, S. Li, X.-Y. Kong, M. Jiang, Y.-H. Meng, W. Shi, W. Wu, F. Zhu, Y. Wu, G.-T. Li, X. Wang, S.-J. Chen, X. Xiao, P.-F. Liang, G. Chaw, C.-Y. Lee

Shenzhen China Star Optoelect. Tech., China

A 31-in. 4K2K AMOLED TV was developed by using self-aligned top gate a-IGZO TFTs. The electrical characteristics of the self-aligned a-IGZO TFTs were studied. Through modifying the GI layer, a-IGZO TFTs exhibited good uniformity of threshold voltage and BTS reliability. Finally, a high performance 31-in. 4K2K AMOLED TV was demonstrated.

AMDp1 - 7 Low Cost Back-Channel-Etch InGaZnO Thin Film Transistors with Cu/Mo Bus Line Fabricated by a 4-Mask Process

F. Zhu, S. Li, G. Li, Y. Wu, Y. Meng, W. Wu, S. Ge, X. Kong, S. Chen, J. Li, F. Wang

Shenzhen China Star Optoelect. Tech., China

A back-channel-etch (BCE) type IGZO thin film transistor (TFT) with Cu/Mo source/drain (S/D) fabricated by a 4-mask process is demonstrated. A novel 2wet-1dry method is introduced to pattern S/D and IGZO, resulting in process simplification and significant tact-time reduction. The back channel damage is evaluated, showing no obvious deterioration of the TFT performance.

AMDp1 - 8 Moisture Dominant Electrical Degradation of Amorphous InGaZnO Thin Film Transistors under Positive Bias Stress

Y. Zhou, J. Xu, H. Xie, L. Zhang, G. Liu, X. Tong, C. Dong

Shanghai Jiao Tong Univ., China

With the relative humidity increasing, the positive bias stress (PBS) stability of amorphous InGaZnO thin film transistors (a-IGZO TFTs) became worse first and then improved. A degradation model was proposed to explain how the moisture interacted with the back channels of a-IGZO TFTs under different humidity levels during PBS tests.

AMDp1 - 9 Development of 31-in. UD AM-OLED Display Using Self-Aligned Top Gate IGZO TFTs

Y. Meng, S. Li, S. Ge, X. Kong, C. Jiang, W. Shi, W. Wu, F. Zhu, X. Xiao, G. Chaw, P. Liang, Y. Deng, S. Chen, C. Y. Lee

Shenzhen China Star Optoelect. Tech., China

We designed structure of self-aligned top gate IGZO TFT, adjusted process flow and optimized treatment of photoresist. Then we obtained good characteristics of TFT, including an averaged mobility of 9.17 cm^2/Vs, Vth of 0.52 V, and SS of 0.25 V/dec. Finally, a 31-in. UD AM-OLED display without bright points was developed.

AMDp1 - 10 IGZO TFT Gate Driver Circuit Capable of Ripple Control without QB Node

J. Oh, J.-H. Kim, H. Lim, K. C. Park, D. Jung, Y.-S. Kim*

Sungkyunkwan Univ., Korea
**Konkuk Univ., Korea*

This paper proposes IGZO TFT gate driver circuit capable of ripple control without QB node. First, the ripple is controlled primarily through a level-shifter to prevent multi-output of V_{OUT}. Second, C2 and T6 control the ripple by preventing the CLK voltage from being applied to V_{OUT} except the bootstrapping region.

AMDp1 - 11 Withdrawn

AMDp1 - 12 Characteristics of a-IGZO TFT Stability by Dry Etching

J. Choi, S. Kim, H. Kim, S. M. Cho

Sungkyunkwan Univ., Korea

Plasma treatments were done in a process of fabricating a-IGZO thin film transistor. Cl_2, BCl_3/Cl_2 dry etching was done in a process of fabricating a-IGZO TFT. After these treatments, we observed correlation between TFT performance and plasma treatment.

AMDp1 - 13L Development of 65-in. 4K UHD OLED TV with High Reliability and Short Channel IGZO TFTs

J. S. Koo, D. H. Lee, S. J. Yun, W. C. Jeong, J. Y. Park, J. W. Kim

LG Display, Korea

We improved the PBTS instability of self-aligned IGZO TFTs by minimizing the density of non-bridging oxygen (NBO) sites within gate-insulator and defect passivation by hydrogen. In addition, we proposed the channel dependent Vth simulation model and using this model, we achieved the short channel (L=4.5 μm) device scalability (ΔV_{th}=0.4 V).

AMDp1 - 14L Fabrication of Low Temperature Process TFT Using High Density a-InGaZnO Film Deposited by Inductively Coupled Plasma Sputtering System

D. Matsuo, R. Miyanaga, S. Kishida, Y. Setoguchi, Y. Andoh, M. Fujii*, Y. Uraoka**

Nissin Elec., Japan
**NAIST, Japan*

In this study, a-IGZO TFTs were fabricated through a low-temperature process using high density two layer a-IGZO films deposited by ICP-sputtering. The field effect mobility at annealing temperature of 150°C was 8.8 cm^2/Vs, and the reliability when the annealing temperatures were 150°C and 250°C was the same.

AMDp1 - 15L Characteristic Evaluation of Ga-Sn-O Thin Films by Hall Measurement

K. Imanishi, A. Fukawa, T. Matsuda, M. Kimura

Ryukoku Univ., Japan

We investigated how the Hall effect changes when the annealing temperature of the Ga-Sn-O (GTO) changes. The highest mobility is 1.21 cm^2/Vs. Next, when we made a GTO TFT and measured the Hall effect by applying a gate voltage, the mobility was 13.4 cm^2/Vs.

15:00 - 18:00 Exhibition Hall

***Poster* MEETp3: Emerging Process Technologies**

MEETp3 - 1 Influence of Ar/O_2 Plasma on Solution Processed Ga Doped IZTO TFTs

M. N. Naik, B. R. Naik, C. Avis, J. Jang

Kyung Hee Univ., Korea

We studied the effect of plasma treatment on the surface of Ga doped IZTO TFTs with and without Ar/O_2 plasma. TFTs with treatment exhibits better characteristics than untreated one, with an increase in μ_{lin} (from 7.96 ± 5.52 to 24.64 ± 8.06 $cm^2V^{-1}s^{-1}$), decrease in SS (from 192.9 ± 39.55 to 179.28 ± 44.43 mV/dec), and decrease hysteresis from (0.21 ± 0.15 to 0.197 ± 0.24 V).

Special Topics of Interest on Lighting and Quantum Dot Technologies

Thursday, December 7

9:00 - 9:50 **Meeting Room 3**

PH2: Phosphors for Lighting Application

Chair: X. Liu, Nat. Univ. of Singapore, Singapore
Co-Chair: T. Kusunoki, Dexerials, Japan

PH2 - 1: 9:00 ***Invited*** **Micro Grain Analysis in the Ce:YAG and Sapphire Co-Crystal Phosphor**

S. Kubota, K. Nakagome, M. Matsukura, Y. Anzai, Y. Furukawa

Oxide, Japan

Based on the Monte Carlo ray trace simulation, quantitative micro grain analysis in the blue laser excited Ce:YAG and sapphire co-crystal phosphor is reported relevant to the excitation absorption enhancement, the fluorescence light spread in the grain structure, the improved thermal conductivity, and the emission extraction efficiency after facet etching.

PH2 - 2: 9:25 ***Invited*** **Towards High-Performance Solution-Processed Light Emitting Didoes Based on Quantum Dots**

Y. Jin

Zhejiang Univ., China

In the past few years, efficiency and lifetime of quantum-dot light-emitting diodes (QLEDs) achieved tremendous progresses. Here we review our activities associated with QLEDs, including material chemistry of charge-transporting layers and optimization and mechanism studies of prototype devices.

----- Break -----

10:40 - 12:00 **Main Hall**

OLED4: OLED for Lighting Applications

Chair: S. Naka, Univ. of Toyama, Japan
Co-Chair: K. Monzen, Nissan Chem. Inds., Japan

OLED4 - 1: 10:40 ***Invited*** **High-Efficiency and Stable Light-Emitting Diodes Based on Quantum Dots**

X. Yang, F. Cao

Shanghai Univ., China

This study reports highly efficient and stable quantum dot light-emitting diodes (QLEDs) based on solution processed metal-oxide films as hole injection layer (HIL). The best-performing device with Cu:NiO HIL exhibits superior performance compared to the state-of-the-art PEDOT:PSS-based QLEDs.

OLED4 - 2 11:00 **Development of High Transmittance, Low Sheet Resistance and High Thermal Stability Transparent Cathode Technology**

S. Ootsu, K. Tani, T. Suzuki

Konica Minolta, Japan

With the surge for top emission OLED, development of transparent cathode with high transmittance and low resistance is awaited. We developed our proprietary organic material that have strong interaction with Ag. Using this material, transmittance and sheet resistance were significantly improved. In addition, we could also achieve high thermal stability.

OLED4 - 3 11:20 **Enhancement of Out-Coupling Efficiency on OLED with the Improved Charge Balance Using ZnO Nanoparticle Dispersed Electron Transport Layer**

S.-J. Park, H.-J. Kim, S.-H. Jang, K.-Y. Lee, Y.-J. Kim

Yonsei Univ., Korea

We propose new method for the enhancement of electron mobility by developing a novel layer structure and the coating process of ETL dispersed with ZnO NPs. Our new ETL layer was prepared with the uniform dispersion of ZnO NPs and the OLED devices show the enhanced performance.

OLED4 - 4
11:40

High Efficiency Large Area White Organic Light-Emitting Diodes Using Phosphorescent Materials — Degradation and Stability Improvement

M. Seetharaman, A. Mohan, A. Awasthi, S. Bindu, G. Garg, J. Meenakshinathan, K. Manohara, M. Balakrishnan, M. Katiyar

Indian Inst. of Tech., India

Large area white phosphorescent OLED lighting panels of different sizes were fabricated on rigid and flexible glass with power efficiencies varying from 30 to 48 lm/W. Operational lifetime performance and degradation were investigated. Blue phosphorescent dopant was found responsible for short operational lifetime. Hybrid WOLED with improved lifetime was developed.

Also presented in Innovative Demonstration Session (see p. 227)

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster PHp2: Phosphors for Lighting Application

PHp2 - 1

Light Extraction from a Laser-Pumped Phosphor Layer with a Remote Reflector

M. Ohta, I. Fujieda

Ritsumeikan Univ., Japan

A phosphor layer emits light in both forward and backward directions when excited by a laser beam. A reflector attached to the phosphor reverses the forward emission, which then propagates the material. The self-absorption loss during this process is alleviated by a patterned phosphor layer with a remote reflector.

PHp2 - 2L

Mixed Fluoride Based Nanophosphors Synthesized Using a Hydrothermal Method for Photodynamic Therapy of Malignant Tumors

A. M. Dorokhina[,**], V. V. Bakhmetyev[*], M. M. Sychov[*], H. Kominami[**], K. Hara[**], Y. Nakanishi[**], H. Mimura[**]*

[*]St. Petersburg Inst. of Tech., Russia
[**]Shizuoka Univ., Japan

Finely dispersed $NaGdF_4$:Eu and YF_3:Yb,Er phosphors are synthesized by hydrothermal method in ethylene glycol medium and effect of hydrothermal treatment on their phase composition, dispersity and luminescent performances is studied. Phosphors synthesized by using this method allow the preparation of stable colloid solutions and can be used for photodynamic therapy.

PHp2 - 3L **Improved Photostability of Tetramethyl Orthosilicate-Modified InP/ZnS Quantum Dots**

*T. Watanabe, Y. Iso, T. Isobe, H. Sasaki**

Keio Univ., Japan
**Shoei Chem., Japan*

InP/ZnS QDs shelled by silica derived from tetramethyl orthosilicate were prepared under hydrophobic condition. Silica shelled QDs showed higher photostability than original QDs. This was because silica shell suppressed QD oxidation by oxygen in air.

15:00 - 18:00 **Exhibition Hall**

***Poster* OLEDp2: OLED/LIT Poster**

OLEDp2 - 1 **High Efficiency and Long Lifetime Electron Transporting Materials for OLED Devices and Lighting Applications**

H.-L. Huang, P.-W. Hsu, C.-C. Lai, C.-J. Lin

eRay Optoelect. Tech., Taiwan

A series of new electron transporting materials with good thermal stability were designed and developed. The devices of these ETs applied in fluorescent blue devices, exhibited high efficiency and long lifetime with efficiency of 10.8 - 11.2 cd/A and the LT95 lifetime is around 245 - 400 h under 1000 cd/m^2.

OLEDp2 - 2L **Withdrawn**

OLEDp2 - 3L **Efficiency Enhancement for Patterned Quantum Dot-Converted White OLED Display Using Photoresist Dispersed TiO_2**

H.-J. Kim, J.-H. Kim, Y.-H. Kim[*]*, M.-S. Kwak*[*]*, J.-H. Lee*[*]*, Y.-J. Kim*

Yonsei Univ., Korea
[*]*LG Display, Korea*

We applied TiO_2 nanoparticles to patterned quantum dot (QD)-converted white OLED display to enhance the optical efficiency using scattering effect. In experimental data, optical intensity of red light in white OLED was increased by 32.1% with only QD layer and 52% with both QD and TiO_2 layers.

15:00 - 18:00 **Exhibition Hall**

Poster **MEETp1: Quantum Dots and Nanotechnologies**

MEETp1 - 1 **Improved Efficiency of Light-Emitting Diodes Using InP/ZnSe/ZnS Quantum Dots and Mg-Doped Zinc Oxide**

H. Sasaki, T. Fukuda, N. Kamata, Z. Honda

Saitama Univ., Japan

In light-emitting diodes with InP-based quantum dots (QDs), one problem is that the potential difference bet-ween zinc oxide and InP-based QD layer is large. In this study, we demonstrated the improved efficiency of InP-based device with multi-shell QDs and Mg-doped zinc oxide layer.

MEETp1 - 2 **Withdrawn**

IDW Best Paper Award

IDW Outstanding Poster Paper Award

These awards will go to the most outstanding papers selected from those presented at IDW ’17.
The 2017 award winners will be announced on the IDW website: http://www.idw.or.jp/award.html

MEETp1 - 3 **Criterions and Constrains for the Fundamental Analytical Solutions of Interlaced Microstructures for Display Element and LED**

C.-J. Ou, J.-F. Qian, Z.-Y. Shih, M.-Y. Huang, K.-Y. Chen, Y.-C. Chien

Hsiuping Univ. of S&T, Taiwan

This report explores the analytical formulations and prove the feasibility and robustness of the interlaced prism structure for display application. Expressions are derived for numerical implementation, and methodology for sensitivity analysis is also presented.

MEETp1 - 4 **Simultaneous Optimization of LED Angular Apodization and Spatial Locations for Performance Metric of Lighting Display**

C.-J. Ou, M.-Y. Huang, S.-R. Yang, M.-J. Liu, F.-R. Lin, J.-F. Qian, C.-Y. Ou[*]

Hsiuping Univ. of S&T, Taiwan
[*]Taichung Municipal Taichung Second Senior High School, Taiwan

Based on the transient factor between the near field area source and the far field point source approach, a reliable illuminating spreadsheet is developed for LED lighting and various kinds of lamp device with specific apodization pattern.

MEETp1 - 5 **Prelude for Hyper-Geometric Function of Cosine n^{th} Apodization and the Application to Display LED Encapsulates**

C.-J. Ou, Z.-Y. Shih, K.-S. Hsu, K.-Y. Chen, C.-F. Chang, P.-X. Huang

Hsiuping Univ. of S&T, Taiwan

Analytical solution with Hypergeometric function for the light source is derived, and is capable to bring reasonable balance of the directional extraction energy that is given out from the LED die and the contours of the encapsulates.

MEETp1 - 6 **Alcohol-Soluble Quantum Dots for Lighting and Display**

Z. Bai, D. Han, X. Zhang, Y. Ge, S. Chang, H. Zhong

Beijing Inst. of Tech., China

Alcohol-soluble quantum dots, with unique solubility and hydroxyl-terminated ligands, exhibit “green” processability, organic solvent resistance, tunable electrical band gap and multiple reaction sites on surface. Thus, alcohol-soluble quantum dots possess notable performance and processing superiorities in on-chip and remote structure WLEDs as well as QLEDs for lighting and display devices.

MEETp1 - 7L Core-Shell Structure Ratio of the Quantum Dots $CuGaS_2$ / ZnS and the Light-Emitting Properties

R. Itoh, J. Nagakubo[*], T. Ban, S. Yamamoto

Ryukoku Univ., Japan
[*]ULVAC, Japan

In this study, Cu-Ga-S_2/ZnS quantum dots (QDs) with a core-shell structure using Ga instead of In were attempted. QDs were evaluated as a function of core-shell structure ratio photoluminescence. Also used to characterize the QDs was energy dispersive X-ray spectroscopy.

Friday, December 8

9:00 - 10:00 Meeting Room 3

FLX6: Advanced Process and Evaluation Technologies

Chair: T. Shiro, Teijin, Japan
Co-Chair: T. Eguchi, Sumitomo Bakelite, Japan

FLX6 - 1 9:00 Roll-to-Roll Processing of Functional Films for Flexible Electronics

J. Fahlteich, M. Fahland, P. Kudlacek[*], W. Manders[*], M. Junghähnel, S. Mogck, C. Keibler

Fraunhofer Inst. for Organic Elect., Germany
[*]Holst Ctr., The Netherlands

This paper discusses roll-to-roll processing of flexible substrates for OLED lighting application addressing transparent electrode deposition on both permeation barrier films and ultrathin glass. Functional polymer substrates with water vapor transmission rates of 10^{-6} g/m²d at 20°C / 50% r.h. and a surface sheet resistance below 25 Ohm are reported.
Also presented in Innovative Demonstration Session (see p. 227)

FLX6 - 2 9:20 Novel Roll-to-Roll Fabrication Processes of Transparent Electrodes on Ultra-Thin Glass

T. Furukawa, N. Kawamura, T. Noda[*], Y. Hasegawa[*], D. Kobayashi[**], M. Koden

Yamagata Univ., Japan
[*]Nippon Elec. Glass, Japan
[**]Seria, Japan

We developed novel fabrication technologies of transparent electrodes on ultra-thin glass by roll-to-roll process. The transparent electrode consists of IZO and assistant electrodes with insulating patterns. The assisting electrodes and the insulating patterns were printed on the IZO by screen printing. OLED lightings were fabricated after cutting the roll substrate.

FLX6 - 3 9:40 **Novel Evaluation Method for Flexible OLED Lighting Device**

K. Hyodo, S. Maeda[*], A. Horiguchi[*]

Konica Minolta, Japan
[*]CEREBA, Japan

Recently developed novel organic light emitting diodes (OLEDs) for lighting applications are flexible and deformable. Unlike the conventional lighting devices, such as fluorescent light tube and light bulb, the novel flexible and deformable devices require new evaluation methods. We have evaluated flexible and deformable OLEDs using new methods.

----- Break -----

Author Interviews
12:00 – 12:40

13:50 - 15:30 **Main Hall**

MEET4: EL Quantum Dots Technologies

LIT

Chair: W. Milne, Univ. of Cambridge, UK
Co-Chair: S. Chen, Southern Univ. of S&T, China

MEET4 - 1: *Invited* 13:50 **All Inorganic QLED with Metal-Oxide Electron and Hole Injection Layers**

J. Jang, H.-M. Kim

Kyung Hee Univ., Korea

This paper reviews the all-inorganic processed quantum-dot light emitting diodes (QLEDs). All inorganic QLEDs with the interface treatment to reduce the exciton quenching exhibits the current efficiency of 7.3 cd/A and power efficiency of 2.3 lm/W. These performances are much improved compared to those of QLED without the interface treatment.

MEET4 - 2: *Invited* 14:10 **Displays Using Quantum Dot Color Conversion by Inkjet Printing of Quantum Dot Inks**

R. Tangirala, A. Smith, S. Kan, C. Hotz, H. Kim, R. Kempt, T. Miki[*], S. Yoshihara[*], T. Kizaki[*], A. Ishizuka[*], I. Kiyoto[*]

Nanosys, USA
[*]DIC, Japan

Quantum dot color conversion layers have potential to revolutionize displays by improving efficiency and color gamut. To achieve these changes, QDs have to be deposited at sub-pixel pitch. Here we report on the fabrication and characterization of QD inks, as well as films made from inkjet deposition of these materials.

MEET4 - 3: ***Invited*** **Efficient QLEDs with Novel Structures**
14:30

S. Chen

Southern Univ. of S&T, China

Various device structures including top-emitting, microcavity, inverted, tandem, transparent, full-solution vacuum-free processed QLEDs will be talked. Charge balance is carefully optimized in these structures. In addition, we show that by substituting the problematic ZnO with $Zn_xMg_{1-x}O$, our recently developed tandem QLEDs exhibit efficiency over 100 cd/A (23.5%).

MEET4 - 4: ***Invited*** **Quantum-Dot Electroluminescence to**
14:50 **Achieve Saturated Colors for Rec.2020 Compatibility**

P. Kathirgamanathan, M. Kumaraverl, N. Bramananthan, S. Ravichandran

Brunel Univ. London, UK

We report here red quantum dot based electroluminescent devices (QLEDs) that meet the colour co-ordinates requirement set by REC2020. We also report the world first dark red CFQD (heavy metal free) ((x,y), (0.690, 0.309)) devices. The electroluminescent characteristics of devices of both CdSe/ZnS and cadmium free quantum dots are compared.

MEET4 - 5: ***Invited*** **Stability of Quantum Dot Color Pixel**
15:10 **Converter Printed by Ink Jetting**

M. Hasegawa, Y. Hirayama

Merck PM, Japan

We evaluated a stability of ink jetting printed Cd-free quantum dots(QDs) color pixel converter by using quantum yield (QY) measurement system and also using optical in situ measurement setup. We examined effects of coating materials to a stability of printed QDs, and found effects of solvent to QY of QDs.

15:30 - 17:10 **Main Hall**

MEET5: Emerging Quantum Dots and Nanotechnologies

Chair: J. Jang, Kyung Hee Univ., Korea
Co-Chair: M. DeMiguel-Ramos, Univ. of Cambridge, UK

MEET5 - 1: ***Invited*** **Luminescent Perovskite-Polymer Composite**
15:30 **Films for Display**

J. He, H. Chen, Y. Wang[*]*, C. Zhang, H. Chan, S.-T. Wu, Y. Dong*

Univ. of Central Florida, USA
[*]*Chinese Ac. of Sci., China*

Ultrastable, highly luminescent green perovskites – polymer composite films have been achieved with a swelling-deswelling microencapsulation approach. A hybrid downconverter system comprising such films and state-of-the art red emitters are proposed for low cost, yet high efficiency wide color gamut liquid crystal displays (LCD).

Also presented in Innovative Demonstration Session (see p. 227)

MEET5 - 2: *Invited* Halide Perovskite Quantum Dots: New Generation Materials for Display Applications
15:50

H. Zhong

Beijing Inst. of Tech., China

Halide perovskite quantum dots exhibit high photoluminescence quantum yields (60 - 90%), wide wavelength tenability (400 - 800 nm), ultra-narrow band emissions (20 - 50 nm) as well as additional polarization. The combination of these superior optical properties and low cost fabrication makes them to be potential candidates for display technology.

MEET5 - 3: *Invited* Innovative Display Technology for Low Vision Aid and Medical Application
16:10

M. Sugawara, M. Suzuki, N. Miyauchi, M. Ishimoto

QD Laser, Japan

Retinal Imaging Laser Eyewear has a miniature laser projector inside the frame which provides the wearer with digital image information through the pupil using the retina as a screen. This paper describes its principle of focus-free imaging, prototype, laser safety, and application as low vision aid and ophthalmic testing equipment.

MEET5 - 4 Withdrawn

MEET5 - 5 Interfacial Improvement Using Solution Processed Interlayer on Inverted Perovskite Quantum-Dot Light Emitting Diodes
16:50

H. Jun, E. Moyen, H.-M. Kim, J. Jang

Kyung Hee Univ., Korea

We report a solution processed interlayer for the inverted perovskite quantum-dot (QD) light emitting diodes (PeQLEDs). The insertion of interlayer under the QDs increases the photoluminescence (PL) intensity of QDs by 10 times. Moreover, device performances of PeQLED with the interlayer were improved compared with those without it.

Author Interviews
17:10 – 17:40

Special Topics of Interest on AR/VR and Hyper Reality

Wednesday, December 6

13:15 - 14:35 **Sakura Hall 2**

INP1: AR and Interactive Systems

Chair: H.Ando, Osaka Univ., Japan
Co-Chair: J.Akita, Kanazawa Univ., Japan

INP1 - 1: 13:15 ***Invited*** **Lensless Light-Field Imaging with LC Fresnel Zone Aperture**

K. Tajima, Y. Nakamura, M. Sao, T. Shimano, K. Matsumoto, A. Tanabe*, N. Hashimoto**

Hitachi, Japan
**Citizen Watch, Japan*

A lensless light-field imaging technology with a Fresnel zone aperture (FZA) has previously been developed. To obtain clear images, it is necessary to cancel several kinds of noise components. Accordingly, in the present study, a technique for noise cancellation using a liquid crystal FZA is proposed and experimentally evaluated.

INP1 - 2: 13:35 ***Invited*** **Yet Another Approach for Enhancing Image Quality: Pixel Placement**

J. Akita

Kanazawa Univ., Japan

Conventional approaches for enhancing image quality, such as increasing pixel count, reducing pixel size, would result in increased quantity of image information. In this paper, we propose and discuss the method of randomizing (effective) pixel placement as another approach for enhancing image quality.

INP1 - 3: 13:55 ***Invited*** **Low Resource Visual Display Method Based on Illusion of Eyeball Movement**

H. Ando

Osaka Univ., Japan

We are studying the display system using illusion. By using illusion and utilizing human resources, it is possible to minimize device resources. Here, we will explain the display using human eye movements (Smooth Pursuit: Slit-based light field 3D display, Saccade: Saccade based display).

INP1 - 4: 14:15 ***Invited*** **Media Technologies for Education Workshops**

J. Watanabe

NTT, Japan

This paper describes previous exhibition, workshop, and escape room game performed to attract attention to self-awareness and deeper understanding of science. They used media technologies to provide self-related experiences.

----- Break -----

14:50 - 16:10 **Tachibana Conference Hall**

3D1/DES2: 3D Display in AR/VR and Hyper Reality

Chair: T. Koike, Hosei Univ., Japan
Co-Chair: H. Okumura, Toshiba, Japan

3D1/ DES2 - 1: 14:50 ***Invited*** **Development of 55-in. 8K-3D IPS LCD with 3D Polarization Filter**

J. Maruyama, R. Oke, T. Murakoso, I. Hiyama, Y. Kato, Y. Umezawa[*], T. Sato[*], T. Takahashi[*], H. Yamashita[**], K. Tanioka[**], T. Chiba[**]

Panasonic Liquid Crystal Display, Japan
[*]Arisawa Manufacturing, Japan
[**]Kairos, Japan

We have developed the world's first (*) 8K-3D IPS -LCDs with a 3D polarization filter. In addition to super-high resolution of 8K, it provides a sense of depth by stereo-vision. It enables 8K-3D surgical systems for endoscopic and microscopic surgeries. (* As of March 2017, our study)
Also presented in Innovative Demonstration Session (see p. 227)

3D1/ DES2 - 2: 15:10 ***Invited*** **A Virtual Reality Display Based on Cluster-Eye Image Stitching**

H. Yen, C. Lin, G.-D. J. Su

Nat. Taiwan Univ., Taiwan

In this paper, we present a virtual-reality display which combines the principles of optical cluster eyes and insects' compound eyes. The system consists of two curved lens arrays to focus the image on the retina. The thickness of our optical system is less than 30 mm and it provides a field of view of up to 150° per eye. Using a 3D printer, the design is demonstrated experimentally.

3D1/ DES2 - 3 15:30 **Holographic Augmented Reality Head-Mounted Display with RGB Full HD Microdisplay**

Y.-T. Kim, J. Seo, W. Seo, G. Sung, J.-S. Chung, B. Shin, C.-K. Lee, J. An, S. Kim, H. Song, Y. Kim, H. Kim, C.-S. Choi, Y. Kim, K. Won, S.-H. Lee, C. Yoo, H.-S. Lee, S. Hwang

Samsung Elect., Korea

We realized a holographic AR head-mounted display with RGB full HD microdisplay. We confirmed the real augmented reality which perfectly matches virtual images to the real world. Further, the pixel mapping algorithm based on multi-layer in computer generated holography processing is proposed for the holographic image enhancement.

3D1/ DES2 - 4 15:50 **An Augmented Reality Display System**

X. Ma, N. Wu, X. Liu, Q. Zeng, X. Zhang

BOE Tech. Group, China

Augmented Reality (AR) is a technique that add additional information to real world. We are concerned with the implementation of the drive scheme and the signal processing section. In the paper we will describe optical design, drive scheme, pixel distortion correction and compensation in three aspects.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:20 **Sakura Hall 1**

FMC3: Display Optics for AR/VR

Chair: K. Käläntär, Global Optical Solutions, Japan
Co-Chair: H. Yamamoto, Utsunomiya Univ., Japan

FMC3 - 1: 9:00 ***Invited*** **3D Display for Augmented Reality**

B. Lee, S. Lee, J.-Y. Hong, C. Jang

Seoul Nat. Univ., Korea

In immersive and realistic augmented world, users may interact with virtual objects that are integrated to the real world. 3D information of the virtual objects should be fully reconstructed so that users could not recognize artifacts of the virtual objects. Here, several 3D display technologies for augmented reality are introduced.

FMC3 - 2: 9:20 ***Invited*** **Hologram Synthesis for Near to Eye Displays**

J.-H. Park

Inha Univ., Korea

Holographic near to eye displays provide users with true focal cue, removing vergence accommodation conflict which is one of the major causes of the fatigue. In this talk, our recent computer generated hologram technique to synthesize hologram contents for the near to eye display is presented.

FMC3 - 3 **Withdrawn**

FMC3 - 4 10:00 **Optical Design of Directional Projection Screen Using Diverted Corner Cube Array**

K. Käläntär[,**], K. Wako[*], R. Ohtera[*], Y. Ishitaka[***], M. Kano[***], T. Uchida[*]*

[*]Nat. Inst. of Tech., Sendai College, Japan
[**]Global Optical Solutions, Japan
[***]Tohoku Univ., Japan

A novel directive reflector was studied for projection screen. The directivity characteristic was accomplished by applying an alternate hollow corner cube retroreflector that controls the screen reflection direction and the diffusion pattern. The novel screen possesses high luminance reflection characteristic that can preserve the power consumption of the projector.

----- Break -----

10:40 -12:20 **Shirakashi Conference Room**

LCT3/DES3: HMD Applications

Chair: H. Okada, Univ. of Toyama, Japan
Co-Chair: R. Oke, Panasonic Liquid Crystal Display, Japan

LCT3/ DES3 - 1: 10:40 ***Invited*** **The Optimal Fast Response LCD for VR-HMD**

T. Matsushima, K. Seki, S. Kimura, Y. Iwakabe, T. Yata, Y. Watanabe, S. Komura

Japan Display, Japan

We explain the moving picture characteristics of the display device required for virtual reality head-mounted displays (VR-HMD) and describe the optimum liquid crystal display mode. A short pitch lurch control (SLC)-IPS with a high-speed response and a simple structure is suitable for this purpose.

Also presented in Innovative Demonstration Session (see p. 227)

LCT3/ DES3 - 2: 11:05 ***Invited*** **Evaluation of Moving Picture Quality on LCD Device for Head-Mounted Display**

M. Kobayashi, T. Miura, N. Yamaguchi, M. Yashiki, T. Masuda, T. Katayama, S. Higashida, K. Hanaoka, H. Yoshida, S. Shimada

Sharp, Japan

We developed a LCD having EBET values of less than 1 ms with flashing backlight, and less than about 4 ms with scan backlight for our proposed measurement positions. This paper provides simple evaluation method using EBET measurements and simulations for moving picture quality of the HMD.

LCT3/ DES3 - 3: 11:30 ***Invited*** **Near Eye Application Based on Digital Electro-Optics Platform (X-on-Silicon)**

C.-W. Tsai, F. Lin, C. Wang

Jasper Display, Taiwan

Digital Electro-optics Platform is the main concept of Jasper Display Corp. (JDC) to develop various applications. These applications are based on our X-on-Silicon technologies, for example, Liquid Crystal on Silicon (LCoS), µLEDoS, OLEDoS, and CELLoS. LCoS technology is applied to Microdisplay, Spatial Light Modulator (SLM), Dynamic Optics, and Holographic Display.

Also presented in Innovative Demonstration Session (see p. 227)

LCT3/ DES3 - 4: 11:55 ***Invited*** **Head Mounted Display Implementations for Use in Industrial Augmented and Virtual Reality Applications**

T. Fukuda[*], J. Orlosky[,**], T. Kinoshita[*]*

[*]Westunitis, Japan
[**]Osaka Univ., Japan

This paper gives an overview of hardware designed for augmented and virtual reality systems designed, tested, and customized for industrial use. We will review existing technologies and their use cases and discuss a number of software implementations currently being deployed in research and industry.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* FMCp2: Aerial Imaging Optics**

FMCp2 - 1 **Omnidirectional Aerial Display with AIRR by Using Multifaceted Beam Splitters**

S. Onose[*], H. Yamamoto[,**]*

[*]Utsunomiya Univ., Japan
[**]JST ACCEL, Japan

This paper proposes an optical design to form an aerial image all around a central viewing region. Our method makes it easy to seamless omnidirectional aerial display and large-size scalability by use of multifaceted beam splitters.

FMCp2 - 2 **Constructing a Sound System As If Sound is Coming from Aerial Image**

K. Fujii, N. Kurokawa, K. Kawai, S. Morita, K. Shimose, R. Kujime, H. Yamamoto

Utsunomiya Univ., Japan

This paper proposes that constructing a sound system that gives a feeling as if sound is coming from an aerial image formed with AIRR. A vibration speaker is attached to a beam splitters or a retro-reflector and use them as speakers to realize the sound coming from the aerial image.

FMCp2 - 3L **Comparisons of Aerial Image Sharpness Formed with AIRR by Use of Retro-Reflectors Made of Glass Beads with Different Refractive Indices**

K. Onuki, H. Yamamoto

Utsunomiya Univ., Japan

This paper reports comparisons in sharpness of aerial images formed with aerial imaging by retro-reflection (AIRR) by use of glass-beads retro-reflectors of which refractive index is 1.9, 2.0, and 2.2. We have measured and compared contrast-transfer functions of aerial image.

15:00 - 18:00 **Exhibition Hall**

***Poster* 3Dp2: Aerial Imaging Systems**

3Dp2 - 1 **Aerial Hollow-Face Illusion with AIRR**

N. Kurokawa, K. Fujii, S. Ito, H. Yamamoto

Utsunomiya Univ., Japan

We have realized an aerial 3D display that evokes hollow face illusion, in which the perception of a concave mask of a face appears as a normal convex face. The depth-inverted 3D image of a projection-mapped 3D object is formed with AIRR (aerial imaging by retro-reflection).

3Dp2 - 2 **3D Lighting for Hyperspectral Imaging of Leaf Group by Use of Aerial Imaging Optics**

K, Kawai, R. Kujime, T. Okamoto, H. Yamamoto

Utsunomiya Univ., Japan

This paper proposes a lighting method aimed for hyperspectral imaging of plant leaves. In order to eliminate shadows, a 3D-controlled light illuminates the region of interest by use of aerial imaging optics, including double-layered arrays of rectangular mirror (WARM), a parabolic mirror, and aerial imaging by retro-reflection (AIRR).

3Dp2 - 3 **Omnidirectional Aerial Display for Medaka**

E. Abe, S. Onose, H. Takeuchi[*], E. Watanabe[**], Y. Kamei[**], H. Yamamoto

Utsunomiya Univ., Japan
[*]Okayama Univ., Japan
[**]Nat. Inst. for Basic Biology, Japan

This paper reports application of an omnidirectional aerial display for biology. The omnidirectional aerial screen surrounded a cylindrical water tank. A medaka in the water tank reacts to the surrounding aerial images. Because the surrounding image is shown on a flat panel, the biologist can easily change stimulus.

3Dp2 - 4 **Aerial DFD Display with AIRR**

Y. Terashima, S. Suyama[*], H. Yamamoto

Utsunomiya Univ., Japan
[*]Tokushima Univ., Japan

This paper reports a method to give aerial image depth. Our proposed design combine two Aerial imaging by retro-reflection(AIRR). We used Depth-Fused 3D(DFD) to give aerial image depth. First of all, observers are surprised to observe aerial image. Furthermore, they are surprised to observe aerial 3D image.

3Dp2 - 5 **Influence of Decreasing Motion Parallax Widths in Arc 3D Display on Perceived Depth Degradation by Decreasing Visual Acuity of One Eye**

Y. Awata, H. Mizushina, S. Suyama

Tokushima Univ., Japan

Effectiveness of small but smooth motion parallax even at fixed head has been clarified for improving perceived depth degradation by increasing visual acuity difference of both eyes. We can successfully estimate quantitatively how small smooth motion parallax is needed for improving the perceived depth degradation.

3Dp2 - 6 **Large Viewing Zone of Multi-View Fresnel Arc DFD Display**

W. Kinoshita, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We have proposed a new Multi-View Fresnel Arc DFD display. Arc DFD display has a longer viewing zone. By fusing Multi-View display, wide horizontal viewing zone can be obtained. Fresnel Arc 3D display can successfully suppress the problem of vertical disparity in conventional Arc 3D display.

3Dp2 - 7 **Compact Layered Multi-View Display Using Arc 3D Display as Directional Backlight**

S. Koyama, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We propose compact layered multi-view display using Arc 3D displays as directional backlights and confirm the principal conditions. Our proposed directional backlights do not interfere each other and has small degradation to rear image quality even when the backlights are layered. This indicates the possibility of compact layered multi-view display.

3Dp2 - 8 **Development of 35-in. Tabletop Display with Wide Viewing Angle Using Projection-Based Light Field Display Technology**

W. Jang, H. Shim, D. Lee, J. Park

Korea Photonics Tech. Inst., Korea

Several micro projectors are used to project their own images onto the local screen regions, generating entire images by stitching several individual images. Multiple CG (computer-generated) images for 3D display are pixel re-aligned by light field authoring tools and played by computer server through the 8 projectors.

3Dp2 - 9 **Haptic Feedback by Electromagnetic Array on See-Through Light Field Display with Beam Splitter**

T. Ohashi, T. Koike

Hosei Univ., Japan

We describe a light field display which presents tactile feedback when operating with a fingertip by using magnetic force. The display can present pulled feeling which was difficult to express by conventional methods.

3Dp2 - 10 **Single-Pixel Imaging on Aerial Display with AIRR**

S. Morita, S. Onose, M. Sasaki, H. Yamamoto

Utsunomiya Univ., Japan

Single pixel imaging is a technique to obtain an image without a camera. This paper proposes a method to detect finger position on an aerial display without using a camera. A retro-reflector in the AIRR (aerial-imaging by retro-reflection) system works for aerial image forming and single pixel imaging.

3Dp2 - 11L **Comparison of Image Quality of Aerial Image Formed with Aerial Image Techniques by Viewing Angle**

N. Kawagishi[,**], H. Yamamoto[*,***]*

[*]Utsunomiya Univ., Japan
[**]Yazaki, Japan
[***]JST, Japan

This paper reports on experimental results on aerial image quality for a variety of viewing angle. We have measured the contrast transfer function curves in three types of aerial image techniques, which are AIRR, AIP, and DCRA. Furthermore, sharpness change by viewing angle is investigated each aerial image techniques.

3Dp2 - 12L **Enlarging Viewing Distance and 3D Image Depth at Large Edge-Based DFD Display by Blurring Edge Parts**

Y. Nagao, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We have developed long-viewing-distance Edge-based DFD display with deep 3D image by blurring edge-part image. Enlarging viewing distance makes it easier to fuse front and rear images to one depth image in DFD display. We successfully solve these problems by blurring edge-part images in long viewing distance.

15:00 - 18:00 **Exhibition Hall**

Poster **VHFp2: Applied Vision and Human Factors — Virtual Reality**

VHFp2 - 1 **Legibility of Color Text in Outdoor Environment for Optical See-Through HMD**

Y.-J. Lin, P.-L. Sun

Nat. Taiwan Univ. of S&T, Taiwan

High legibility of text information is vital to an optical see-through HMD for AR related applications. However, in an outdoor environment, bright and complex scene would greatly reduce their legibility. Hence, a series visual experiments were conducted to summaries the rules of text placement and text rendering for the type of applications.

15:00 -18:00 **Exhibition Hall**

Poster **DESp3: Display Electronic Systems for AR/VR**

DESp3 - 1 **A Hardware Solution of High Resolution and High Frame for Module in VR**

J. B. He, C. Deng, J. B. Zhou, L. L. Zhang, L. Wang, J. E. Liu, D. W. Shen

Tianma Micro-elect., China

This paper firstly analyzes the situation of VR and the technical key points of hardware. The method in this paper is designed for LCM/OLED manufacture or solution provider, it was verified in many modules, and also is suitable for VR test and exhibition.

EXHIBITION

12:40 – 18:00 Wednesday, Dec. 6
10:00 – 18:00 Thursday, Dec. 7
10:00 – 14:00 Friday, Dec. 8
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
Free admission with your registration name tag

Friday, December 8

10:40 - 11:55 **Meeting Room 4**

DES4: Various Augmented Reality Systems

Chair: H. Okumura, Toshiba., Japan
Co-Chair: T. Kishigami, Mitsubishi Elec., Japan

DES4 - 1: 10:40 ***Invited*** **Novel MRI Hyper-Realistic Head-Up Display System for Patient Comfort**

T. Sasaki, A. Hotta, T. Murata, Y. Ueda[*]*, H. Okumura*
Toshiba, Japan
[*]*Toshiba Medical Sys., Japan*

VR technologies are significant for medical applications. New MRI system “Vantage Galan™ 3T” focused on patient comfort. MRI-HUD was also provided. Images of wide field of view created with dome screen and reflection mirror eliminate feeling of limited space of MRI gantry from the beginning to end of the examination.

DES4 - 2: 11:05 ***Invited*** **Virtual Experiments of Augmentation of a Transparent Cockpit**

Y. Ueno, T. Hoshi, A. Hiyama, M. Inami
Univ. of Tokyo, Japan

The disadvantage of the conventional transparent cockpit is that drivers cannot know the positional relationship between the transparent vehicle body and objects near the body. First, we create a transparent cockpit simulator. Next, we implement a method to solve the problem on the simulator and evaluate its usefulness by experiments.

DES4 - 3: 11:30 ***Invited*** **Augmented and Diminished Reality: Computational Imaging of Existence and Non-Existence**

S. Mori
Keio Univ., Japan

This article presents a technical summary of a research area called diminished reality (DR). DR is described from its principle to open problems, with a comparison with its opposite concept known as augmented reality to highlight their differences.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Sakura Hall 1**

PRJ4: Wearable Technology

Chair: K. Ohara, Texas Instrs., Japan
Co-Chair: T. Hashizume, Seiko Epson, Japan

PRJ4 - 1: 13:50 ***Invited*** **Display Unit Using Laser Scanning Device**

T. Matsuda, S. Onoe, Y. Seo, S. Ouchi
Hitachi, Japan

We are developing projector system with scanning fiber device and its control system. Our novel scanning systems of scanning fiber device provide high resolution, uniform brightness, rectangular display area, which are difficult matters of conventional scanning fiber device.

PRJ4 - 2: 14:10 ***Invited*** **Enhancing Both Logical and Emotional Abilities with Information and VR/AR Technologies Suitable for Infant Development**

S. Ohtsuka
Kagoshima Univ., Japan

The academic abilities of students in Japan and US have declined dramatically with the overwhelming consumption of graphic, and thus fragmented, information. We describe the importance of providing children electronic materials appropriate for their age from the perspective of development; logical information and reality of visual stimuli.

PRJ4 - 3: 14:30 ***Invited*** **Every Aspect of Advanced Retinal Imaging Laser Eyewear: Principle, Free Focus, Resolution, Safety, and Medical Welfare Applications**

M. Sugawara, M. Suzuki, M. Ishimoto, K. Hasegawa, N. Miyauchi
QD Laser, Japan

Retinal Imaging Laser Eyewear has a miniature laser projector inside the frame which provides the wearer with digital image information through the pupil using the retina as a screen. This paper describes every aspect of this compact universal-design eyewear from its principle, focus-free imaging, resolution, safety to medical welfare applications.

PRJ4 - 4 14:50 **Optical Design of Non-Telecentric Projection Lens for an LED Illumination System**

C.-K. Lo, W.-S. Sun[*]*, J.-W. Pan, P.-S. Hu*
Nat. Chiao Tung Univ., Taiwan
[*]*Nat. Central Univ., Taiwan*

A newly designed non-telecentric projection lens is proposed for a mini-projector with LED light sources. It consists of six spherical lenses. The zoom ratio is 1.1, and the throw ratio could operate at 1.23. Using this non-telecentric projection zoom lens, a very sharp image could be achieved with low cost.

----- Break -----

15:30 - 16:55 **Sakura Hall 2**

VHF8: Virtual Reality

Chair: H. Ujike, AIST, Japan
Co-Chair: S. Uehara, Asahi Glass, Japan

VHF8 - 1: 15:30 ***Invited*** **Optical Instrument Requirements for Measuring Near-Eye Displays**

J. Penczek[,**], P.A. Boynton[**]*
[*]Univ. of Colorado, USA
[**]NIST, USA

The necessary optical system design features for proper near-eye display measurements are reviewed, as well as the appropriate methods to evaluate characteristics like field of view and eye box.

VHF8 - 2 15:55 **VR Experience Player for Subjective Evaluations of Visual VR Content**

T. Järvenpää, P. Eskolin, M. Salmimaa
Nokia Techs., Finland

The requirements and details of an example VR player implementation designed for subjective evaluations of different visual VR experiences are described. The player application is built using a game engine and has a wide cross-platform VR system support. The player has successfully been used in various VR experience evaluations.

VHF8 - 3 16:15 **Methods for Subjective Evaluations of Visual VR Experience**

M. Salmimaa, T. Järvenpää, H. Toukomaa
Nokia Techs., Finland

Standardized image quality evaluation methods form good basis for the virtual reality (VR) experience evaluations. However, some VR content playback specific features may require modifications to the established methods. We have examined different methods for subjective evaluations of VR experience. Some modifications are proposed and discussed alongside three experiment designs.

VHF8 - 4 16:35 **Effect of Projection Mapping on Haptic Perception of Texture**

K. Hirai, T. Katsunuma, T. Horiuchi
Chiba Univ., Japan

This paper investigated effects of projection mapping on haptic perception of texture. We developed a frequency-modulated projection mapping technique for controlling visual appearance of real texture surfaces. Then we conducted subjective experiments using our projection mapping technique. The experimental results showed haptic perception was significantly affected by visual modulation.

Author Interviews
17:00 – 17:40

Special Topics of Interest on Automotive Displays

Thursday, December 7

9:00 - 10:05 **Meeting Room 4**

UXC3/INP3: Interaction for Automotive

Chair: H. Shibata, Fuji Xerox, Japan
Co-Chair: F. Gotoh, Japan Display, Japan

UXC3/INP3 - 1: 9:00 ***Invited*** **Lateral Force Produces Geometry and Texture Information on Touchscreen**

S. Saga

Univ. of Tsukuba, Japan

In this paper, we introduce a method that allows the user to simultaneously feel both large geometry and small textures on a touchscreen. Lateral force based haptic illusion enables geometry display, and direction-controlled mechanical vibration enables texture display. The method allows many kinds of geometry and texture information easily.
Also presented in Innovative Demonstration Session (see p. 227)

UXC3/INP3 - 2 9:25 **Position Tracking Based on Reallocation Resampling Particle Filter Algorithm on Capacitive Touch Panels**

T.-C. Chu, C.-Y. Chuang, W.-C. Chiu, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This paper presents a method by using the reallocation resampling method to enhance the ability of tracking position and solve the problem of particle degradation in the Particle filter. Experimental results show that the proposed method has lower RMSE and trajectory delay than Kalman filter for capacitive touch panels system.

UXC3/INP3 - 3 9:45 **Automotive Tablet Display with In-Cell Touch Panel for Auto after Market**

Y.-C. Li, D.-W. Ku, C.-Y. Hsu, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

We have developed a 8-in. HD FFS in-cell touch display for auto after market. The TIC panel have good quality display with high touch sensitivity. Our proposed prototype achieved high sensitivity to use a glove with 2 mm PMMA coverlens and finger with 3 mm PMMA coverlens.

----- Break -----

10:45 - 12:00 **Sakura Hall 1**

PRJ1: Automotive / Display Application

Chair: S. Shikama, Setsunan Univ., Japan
Co-Chair: S. Yamaya, Nippon Seiki, Japan

PRJ1 - 1: 10:45 ***Invited*** **Projection-Type Three-Dimensional Displays with Holographic Screen Fabricated by Wavefront Printer**

K. Wakunami

NICT., Japan

Several kinds of projection-type three-dimensional displays are introduced. All display systems were developed by using holographic optical elements as the specially designed optical screens fabricated by wavefront printing technique. In this presentation, stereoscopic 3D display, lightfield display and holographic display are demonstrated with the optical reconstructions.

PRJ1 - 2 11:05 **Performance Characterization of Delay Response Time with Wearable Displays**

T. Fujiwara, T. Kosaka, H. Nagasaka, S. Ouchi

Hitachi, Japan

Recently, more and more demands are increasing to adapt AR/VR/MR technologies to industrial domains. In this paper, we report measurement method for AR latency time of popular HMD. With the result of measurement, time range is 50-70 millisecond. We should improve the latency time over 50% for comfortable AR experiences.

PRJ1 - 3 11:25 **Bi-Functional Automotive Headlamps for Adaptive Driving Beam and Low Beam Realizing Achromatic Illumination by Using a Light Guide**

M. Nagayoshi, T. Himi, S. Fujita, M. Ohta, K. Shimada, T. Shimano

Hitachi, Japan

New optical system using a light guide for an adaptive driving beam (ADB) headlamp with integrated high beam and low beam units and without moving parts is presented that drastically reduces chromatic aberration at the low beam cutoff line.

PRJ1 - 4L 11:45 **2-Plane Head-Up Display by Single DLP-PGU**

S. Sekiya, K. Morohashi, T. Kawai, T. Tsuchida

Nippon Seiki, Japan

In this paper, future evolution of the image plane in automotive HUD is discussed. We disclose 2-Plane HUD that is HMI (Human Machine Interface) in a vehicle with high cognition and practical package volume, and its design result with single DLP-PGU.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* FMCp3: Components for Automotive**

FMCp3 - 1 **12.3-in. Free-Form Automobile Display with 2BG+R System for Wide Color Gamut**

H. Wu, I.-H. Hsieh, Y. Fu, D. Hsiao

AU Optronics, Taiwan

We have developed a 12.3" free-form display concept enables various in-vehicle designs. By using 2BG+R (It was called 2 blue chip, one green chip and red phosphor). From simulation, the 2BG+R solution in NTSC color gamut is ~6% wider than BG+R. The final module is about 110% NTSC color gamut.

15:00 - 18:00 **Exhibition Hall**

***Poster* VHFp1: Applied Vision and Human Factors — Automotive Application**

VHFp1 - 1 **Development of a Device to Improve the Attention Level while Driving Using Vibrators**

H. Maruyama, M. Yamada

Tokai Univ., Japan

In order to support safe driving, it is important for the driver to maintain a high level of attention. For that purpose, we developed a vibration presentation device to refocus the driver's attention during driving, and carried out an experiment to evaluate the device.

Friday, December 8

10:40 - 12:00 **Meeting Room 3**

HAP3/INP6: Automotive and Mobile HMI

Chair: M. Sato, Tokyo Tech, Japan
Co-Chair: Y. Tanaka, Nagoya Inst. of Tech., Japan

HAP3/INP6 - 1: 10:40 ***Invited* Use of Shape Memory Alloy as a Haptic Technology for Displays Panels**

M. Gondo, A. Hirano

Seidensha, Japan

Tactile technology using shape memory alloys has been developed. In this paper, we explain the principle of the actuator. In particular, how we overcame a fast response that is the basis of this tactile technology. We will describe actual prototypes for personal computers and tablets.
Also presented in Innovative Demonstration Session (see p. 227)

HAP3/ INP6 - 2 11:00 **An In-Vehicle Infotainment System with Automotive Grade Hover Gesture Touch Display**

W.-F. Chang, C.-L. Li, F.-H. Tsao, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

In this paper, we applied the different hover gestures to operate different functions. Through the 3D hover gestures, the user can easily operate the functions of in-vehicle infotainment system (IVI system) by simple hover gestures intuitively. Therefore, our system is not only operating easier but greatly improve the driving safety.

HAP3/ INP6 - 3: 11:20 ***Invited*** **Present and Future of Midair Haptics**

H. Shinoda

Univ. of Tokyo, Japan

Midair haptics based on non-contact tactile simulation using ultrasound radiation pressure has a great potential to renew user interfaces and VR, and broaden the use of human haptic sense. In this talk, I will summarize the present of midair haptics and discuss the future of the technology and application.

HAP3/ INP6 - 4: 11:40 ***Invited*** **Vibration Feedback for Representing Haptic Interaction**

M. Konyo

Tohoku Univ., Japan

This paper presents vibrotactile feedback methods to represent natural feelings and reactions in response to user movement. Pseudo-haptic representing methods for friction, inertia, and viscosity are briefly described. Several applications such as pointing-stick type and gesture interfaces and vibrotactile rendering method generated from first-person view videos are also reported.

Also presented in Innovative Demonstration Session (see p. 227)

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Sakura Hall 2**

VHF7: Ergonomics for Automotive Applications

Chair: Y. Endo, Asahi Glass, Japan
Co-Chair: Y. Imai, Mitsubishi Elec., Japan

VHF7 - 1: 13:50 ***Invited*** **Human Centered HMI for the Future Automobile**

M. Akamatsu

AIST, Japan

ICT have been introduced in automobiles for these twenty years and automated driving system is a hot topic now. Role of in-vehicle HMI is changing and human centered design becomes important because in-vehicle information becomes complex. History of in-vehicle HMI is reviewed and HMI for driving automation system is discussed.

VHF7 - 2: 14:20 ***Invited*** **Automotive Displays: Visual Ergonomics and Measurements**

K. Blankenbach, T. Fink[*], U. Krueger[**], M. Zobl[***]

Pforzheim Univ., Germany
[*]Porsche, Germany
[**]TechnoTeam, Germany
[***]BMW Group, Germany

Automotive displays have unique requirements in terms of optical performance, longevity in harsh environment and mass production of 100,000's per year. CE displays set the pace and premium automotive displays have to follow in short time despite long development cycles. We present challenges & solutions for optical measurements.

VHF7 - 3 14:50 **Response Time and Viewing Angle Behavior of Liquid Crystal Displays versus Temperature**

P. Boher, T. Leroux, T. Bignon

ELDIM, France

Two LCD displays, one TN and one IPS are measured at different temperatures using Fourier optics viewing angle and response time measurement systems. Liquid crystal optical index, birefringence and rotational viscosity variations due to temperature affect the LC cell rotation and consequently the viewing angle and response time behaviors.

----- Break -----

15:30 - 16:35 **Meeting Room 4**

DES5: Novel Displays for Transportation

Chair: K. Morita, Chuo Univ., Japan
Co-Chair: H. Okumura, Toshiba, Japan

DES5 - 1: 15:30 ***Invited*** **Review of Flight Deck Display Development**

K. Funabiki, H. Tsuda

Japan Aerospace Exploration Agency, Japan

Since 1980's, mechanical flight instruments have been replaced by electronic displays. Despite of the nature of the display, safety requirement for the flight display would not allow flexible design of contents. Electronic Flight Bag is now considered to be a promising solution to provide various data to the pilot.

DES5 - 2 15:55 **Efficient Modeling of LED Crosstalk of a Matrix Backlight Unit**

M. Schmidt, M. Grüning, D. Schäfer, C. Xu

Saarland Univ., Germany

An approach for calculating the image dependent backlight for Direct-Lit LCDs with a high number of LEDs is presented. It shall lift up the trade-off between local dimming results and the complexity of the algorithm. Moreover, an optimal ratio between the LED-pitch and the light spread function is proposed.

DES5 - 3
16:15

Design and Fabrication of a High-Bright Sunlight Readable Transparent Head-Up Display for Automotive Application

C.-C. Liao[,**], J.-T. Lian[*], C.-W. Su[***]*

[*]Chunghwa Picture Tubes, Taiwan
[**]Nat. Tsing Hua Univ., Taiwan
[***]Nat. Taiwan Normal Univ., Taiwan

This paper proposes a high-bright sunlight readable transparent head-up-display (HUD) using the polymer dispersed liquid crystal technology. Unlike traditional methods, the proposed HUD provides good display legibility even under bright sunlight. Experimental results indicate that the proposed transparent-HUD with good visibility, high-transparency (transmittance close to 50%), and high clarity.

Author Interviews
17:00 – 17:40

JOINT EXHIBITION

"Amazing Art Holograms and Digital-Processed Holograms"
co-sponsored by Holographic Display Artists and Engineers Club (HODIC)

Wednesday, Dec. 6 – Friday, Dec. 8, 2017
Exhibition Hall (Exhibition Bldg.)
Sendai International Center

TOHOKU ZONE

Special Exhibition
Outgoing Unique Technologies from Tohoku-Region

Wednesday, Dec. 6 – Friday, Dec. 8, 2017
Exhibition Hall (Exhibition Bldg.)
Sendai International Center

Special Topics of Interest on Wide Color Gamut and Color Reproduction

Thursday, December 7

9:00 - 10:20 **Sakura Hall 2**

VHF3: Special Session on Color Vision

Chair: Y. Imai, Mitsubishi Elec., Japan
Co-Chair: K. Hirai, Chiba Univ., Japan

VHF3 - 1: 9:00 ***Invited*** **An Introduction of New CIE Colorimetric Systems, CIE2006LMS and CIE2015XYZ**

H. Yaguchi

Chiba Univ., Japan

Recently CIE has developed two physiological based colorimetric systems. One is based on spectral sensitivities of the cone so called cone fundamentals, another is XYZ type colorimetric system based on cone fundamentals. Outlines of two colorimetric systems and their applications to industrial fields are introduced.

VHF3 - 2 9:40 **Investigation of the Helmholtz-Kohlrausch Effect in Using Laser Projectors**

C. Jin, J. Wang, J. Yang[*]*, Y. Tian*[*]*, F. Wang, X. Huang, H. Wang, X. Li, W. Liu*[*]

Southeast Univ., China
[*]*Hisense Elec., China*

Two perception experiments were conducted to investigate the Helmholtz-Kohlrausch (H-K) effect in laser projectors. The result quantified the H-K effect degree and suggested that luminance requirement for laser projectors with larger gamut can be lower compared to projectors with smaller gamut. The accuracy of three prediction models was verified.

VHF3 - 3
10:00

Individual Differences in Chromatic Perception: Continuous Variation from Dichromacy to Trichromacy

S. Hira, M. Nakamichi, K. Kanari, Y. Karakama, H. Fukuda*, M. Ayama*, S. Ohtsuka*

Kagoshima Univ., Japan
**Utsunomiya Univ., Japan*

Individual differences in chromatic perception of both color-normal and color-deficient observers are investigated by MDS (Multidimensional-Scaling). The results show that (1) the constellations of colors (word based) slightly depend on color sense, however, (2) those by color charts move from concave-shaped in dichromacy to oval-shaped in trichromacy.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster **VHFp4: Applied Vision and Human Factors — Color Vision**

VHFp4 - 1L

Performance Measurement of RGB Displays with Degenerate Colors

J. L. Bergquist

Consult., Japan

The combined color and lightness performance of RGB displays with and without degenerate colors are measured and compared in terms of color volume. It is shown that the volume of degenerate systems is significantly smaller and that color volume is a useful metric.

VHFp4 - 2L

Measured Values of the Helmholtz-Kohlrausch Effect for Natural Images and Scrambled Pixel Images

D. Takasu, S. Hashimoto, H. Aoyanagi, H. Takamatsu*, Y. Shimodaira, G. Ohashi*

Shizuoka Univ., Japan
**NEC Display Solutions, Japan*

In this study, subjective-evaluation experiments for measuring the Helmholtz-Kohlrausch effect using natural images and scrambled pixel images are conducted, and the results are compared with values calculated using the estimation equation proposed by Nayatani et al. for natural images.

VHFp4 - 3L **Evaluation of Color Perception Using Narrow Band Color Projection Display**

M. Takaya, K. Shoji[*]*, J. Shimizu*

Nat. Inst. of Tech., Numazu College, Japan
[*]*Hamamatsu Photonics, Japan*

Here, we evaluate color perception for narrow band color stimulus. As demonstrated by the results from psychophysical experiments, for the color blue, the characteristics of younger subjects tend to be different from those of older subjects.

15:00 -18:00 **Exhibition Hall**

Poster **DESp2: Display Electronic Systems for Wide Color Gamut**

DESp2 - 1 **Withdrawn**

Topical Session on User Experience and Cognitive Engineering

Wednesday, December 6

13:10 - 13:20 **Shirakashi Conference Room**

Opening

Opening Remarks
13:10

S. Uehara, Asahi Glass, Japan (VHF Chair)
H. Shibata, Fuji Xerox, Japan (UXC Chair)

13:20 - 14:45 **Shirakashi Conference Room**

VHF1/UXC1: Human Factors

Chair: Y. Hisatake, Japan Display, Japan
Co-Chair: Y. Andoh, Fuji Xerox, Japan

VHF1/ UXC1 - 1: 13:20 ***Invited*** **Displays for Reading and Writing: Learning from Cognition on Paper**

H. Shibata

Fuji Xerox, Japan

This paper provides several remarks for new directions of future displays for reading and writing which are learned from cognitive experiments on paper and displays.

VHF1/ UXC1 - 2 13:45 **Visual Resolution Quantization for Sub-Pixel Rendering Design**

Y. L. Chen, Y. R. Zhang, Y. B. Yang

Wuhan China Star Optoelect. Tech., China

Sub-pixel rendering (SPR) is a pixel design technique. The transformation of pixel arrangement and shape causes the spec problems of pixel quantity definition and perceived image quality. A psychophysical method was adapted along with plenty of images as stimulus. The resolution spec can be inferred through the visual resolution results.

VHF1/ UXC1 - 3 14:05 **Subtle Flickering Polychromatic SSVEP Visual Stimuli for Human-Computer Interaction**

Y.-Y. Chien, F.-C. Lin, H. O.-Yang, Y.-C. Chang, J. K. Zao, Y.-P. Huang, H.-P. D. Shieh

Nat. Chiao Tung Univ., Taiwan

Steady-state visual evoked potential (SSVEP) is one of the most effective brain electrical signals in human-computer interaction (HCI). This study reduced the discomfort from the flickers of visual stimuli by means of high-frequency polychromatic LED-/LCD-based stimuli, and showed that both of them could induce distinct SSVEP responses with subtle flickers.

VHF1/ UXC1 - 4 14:25 **Full-HD Autostereoscopic Display for Myopia Rehabilitation**

H. Zhang, K. Li, X. Chen, A. Zhang, Y. Zhou, H. Fan[*]*, J. Wang, J. Zhou*

Sun Yat-Sen Univ., China
[*]Guangzhou Midstereo Tech., China

With a high-quality autostereoscopic display, special 3D video was supplied to 10 myopias each day in ten days. Most of them acquired a remarkable progress at the eyesight test. The finding suggests 3D may not damage the health of user, and can be a therapeutic approach of myopia.

----- Break -----

14:50 - 16:20 **Shirakashi Conference Room**

UXC2/VHF2: Education and Reading

Chair: E. Amasawa, Univ. of Tokyo, Japan
Co-Chair: Y. Hisatake, Japan Display, Japan

UXC2/ VHF2 - 1: 14:50 ***Invited*** **Tablet Use in Elementary Schools from Ergonomic Aspect**

T. Shibata, K. Sato[*,**]*, T. Horita*[**]

Tokyo Univ. of Social Welfare, Japan
[*]Tokoha Univ., Japan
[**]Tohoku Univ., Japan

Elementary school students have difficulty in viewing tablet screens primarily because of the screen glare. Almost, one in three students complains of physical fatigue after using tablets. The experiment reveals that anti-glare films could make writing and drawing on tablets a comfortable experience in addition to preventing the screen glare.

UXC2/ VHF2 - 2: 15:15 ***Invited*** **A Development of Universal Design Font and Evaluation of Legibility on Display**

H. Yaguchi

Tokyo Denki Univ., Japan

In recent years, Japanese society ages rapidly, product development based on the concept of Universal Design (UD) has been gaining momentum. In this paper, we will show that UD fonts are effective to increase legibility on electric display and review the design conditions with UD philosophy.

UXC2/ VHF2 - 3 15:40 **Relationships Between Reading Speed and Eye Movement Parameters**

J. Kobayashi[,**], T. Kawashima[**]*
[*]Dai Nippon Printing, Japan
[**]Future Univ. Hakodate, Japan

We analyzed the relationship between reading rate and eye movement parameters in normal reading without skimming. We found that reading rates of approximately 1200 characters/minute are possible even in normal reading and the main eye movement parameter involved in the difference in reading rates is forward saccade length.
Also presented in Innovative Demonstration Session (see p. 227)

UXC2/ VHF2 - 4 16:00 **Preferred LDR to HDR Image Conversion for HDR Displays**

Y.-Z. Lai, P.-L. Sun
Nat. Taiwan Univ. of S&T, Taiwan

Visual preference of different LDR to HDR image conversion methods are tested psycho-visually with a HDR display using different types of image. The results show that simple tone scaling performed well.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:05 **Meeting Room 4**

UXC3/INP3: Interaction for Automotive

Special Topics of Interest on Automotive Displays

Chair: H. Shibata, Fuji Xerox, Japan
Co-Chair: F. Gotoh, Japan Display, Japan

UXC3/ INP3 - 1: 9:00 ***Invited*** **Lateral Force Produces Geometry and Texture Information on Touchscreen**

S. Saga
Univ. of Tsukuba, Japan

In this paper, we introduce a method that allows the user to simultaneously feel both large geometry and small textures on a touchscreen. Lateral force based haptic illusion enables geometry display, and direction-controlled mechanical vibration enables texture display. The method allows many kinds of geometry and texture information easily.
Also presented in Innovative Demonstration Session (see p. 227)

UXC3/ INP3 - 2 9:25 **Position Tracking Based on Reallocation Resampling Particle Filter Algorithm on Capacitive Touch Panels**

T.-C. Chu, C.-Y. Chuang, W.-C. Chiu, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This paper presents a method by using the reallocation resampling method to enhance the ability of tracking position and solve the problem of particle degradation in the Particle filter. Experimental results show that the proposed method has lower RMSE and trajectory delay than Kalman filter for capacitive touch panels system.

UXC3/ INP3 - 3 9:45 **Automotive Tablet Display with In-Cell Touch Panel for Auto after Market**

Y.-C. Li, D.-W. Ku, C.-Y. Hsu, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

We have developed a 8-in. HD FFS in-cell touch display for auto after market. The TIC panel have good quality display with high touch sensitivity. Our proposed prototype achieved high sensitivity to use a glove with 2 mm PMMA coverlens and finger with 3 mm PMMA coverlens.

----- Break -----

10:40 - 11:45 **Meeting Room 4**

UXC4: Eye Movement and Advertisement

Chair: H. Shibata, Fuji Xerox, Japan
Co-Chair: M. Mori, Hosei Univ., Japan

UXC4 - 1: 10:40 ***Invited*** **Decoding the Implicit Mind from Fixational Eye Movements**

M. Yoneya[*,**]*, H.-I. Liao*[*]*, M. Kashino*[*,**]*, S. Furukawa*[*]

[*]*NTT, Japan*
[**]*Tokyo Tech, Japan*

We propose a novel technique to decode the implicit mind from involuntary eye movements, instead of using brain signals. In this article, we introduce our feature extraction methods of eye movement and acoustic signals, which can be used to decode the perceptual preference of music.

UXC4 - 2 11:05 **The Influence of Text and Images on Fixation in Flyers**

Y. Andoh[*,**]*, T. Fujinami*[*]*, A. Tera*[*]

[*]*JAIST, Japan*
[**]*Fuji Xerox, Japan*

This study demonstrates the influence of text on fixation in flyers. There is a considerable degree of freedom in the design of flyers in terms of the arrangement of text and images. This study offers an original finding that text affects the viewer's gaze on the typical layout of leaflets.

UXC4 - 3 **An Analysis of the Eye-Tracking-Data During Seeing**
11:25 **Favorite Paintings**

A. Tera, T. Fujinami, Y. Andoh
JAIST, Japan

We measured and analyzed eye movements when viewing images at 1000 Hz for designers and non-designers. As a result, the convergence value in the Y-axis direction of the designer is significantly higher, and both of them found that the convergence value of the disliked image is high.

11:45 - 11:48 **Meeting Room 4**

Short Presentation UXCp1:
User Experience and Cognitive Engineering

All authors of poster papers for the UXCp1 session will give 1-minute oral presentations with no discussion time.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* UXCp1:**
User Experience and Cognitive Engineering

UXCp1 - 1 **A Framework to Support Knowledge Work in a Virtual Space**

H. Sasaki, H. Shibata, N. Hiji
Fuji Xerox, Japan

This paper proposes a novel framework to support knowledge work including intensive document work using virtual reality technologies. This framework characteristically provides several controllers specially- designed to support document work. We implemented an initial mockup to test the feasibility of our approach.

UXCp1 - 2 **High Quality Sleep by VR Goggle in an Air Pillow and a Smart Trip Line-Bot**

T. Miyachi, Y. Gonda, W. Sinki
Tokai Univ., Japan

Smart phone users and travelers often cause sleep debt. We propose “Resly Trip” with a VR display in an air pillow in order to take high quality sleep with healing music and VR video after easy trip planning and virtual visit to next destination with VR videos by Line-Bot.

UXCp1 - 3 **Detail Retina Cells Model and Array Receiver Algorithms for Sensing Qualities**

C.-J. Ou, C.-R. Ho[*], R.-Y. Lan[*], M.-Y. Huang, F.-R. Lin, C. H. Ou[**], H.-Y. Sun[***]

Hsiuping Univ. of S&T, Taiwan
[*]Feng Chia Univ., Taiwan
[**]Dong-Shan High School, Taiwan
[***]Chung Shan Medical Univ., Taiwan

To improve the imaging metric evaluation, the detail retina model is being constructed to model the sensing of the images. Comparing between the present retina based model and the traditional receiver model indicates that the detail retina model provides better visual perception capabilities.

Friday, December 8

9:00 - 10:05 **Meeting Room 4**

UXC5/EP5: E-book and Education

Chair: M. Mori, Hosei Univ., Japan
Co-Chair: K. Hashimoto, E Ink Japan, Japan

UXC5/EP5 - 1: 9:00 ***Invited*** **Visual Awareness Performance in Reading Texts on Paper versus Tablet among Indonesian Elementary School Children**

S. D. Mardiyani, N. Higuchi, T. Enomae

Univ. of Tsukuba, Japan

The use of digital or Information and Communication Technology (ICT) devices as educational aids is expanding. This study focuses on the comparison between paper and digital media by conducting a proofreading test. The test results revealed no significant performance differences. However, after separating misspelled words under error patterns, paper helped children find such errors efficiently.

UXC5/EP5 - 2: 9:25 ***Invited*** **Are E-Books Actually Green? The Role of E-Reader in Changing Reading Patterns and Environmental Impact in Book Reading Activities**

E. Amasawa[*], T. Ihara[*], K. Hanaki[,**]*

[*]Univ. of Tokyo, Japan
[**]Toyo Univ., Japan

We comparatively assessed environmental impact of paper book reading and e-book reading with an e-reader. We first investigated interchangeability of the reading experience of paper books and e-books through a web survey and an experiment, and computed environmental impact of book reading activities of consumer segments.

UXC5/ EP5 - 3L: 9:50 ***Invited*** **Cognitive Load of Handwriting and Typing: The Impact for Memorization in a Dual Task Method**

H. Shibata, K. Omura

Fuji Xerox, Japan

This paper describes experiments to compare the cognitive load of handwriting and typing using a dual task method. We found that the cognitive load of handwriting was lower than that of typing and typing interfered memorization more than handwriting. This tendency did not differ among persons with different typing skill.

----- Break -----

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Meeting Room 4**

INP7/UXC6: Pen and Touch Input Technologies

Chair: N. Hashimoto, Citizen Watch, Japan
Co-Chair: H. Shibata, Fuji Xerox, Japan

INP7/ UXC6 - 1: 13:50 ***Invited*** **New In-Cell Capacitive Touch Panel with Fine Pitch Sensor for Narrow Passive Stylus and New User Interface**

F. Gotoh, H. Mizuhashi, H. Kurasawa, Y. Kida, Y. Nakajima

Japan Display, Japan

An 8-in. 4K UHD in-cell touch IPS-LCD with 1.2 mm fine pitch sensor has been developed. By applying Code Division Multiplex (CDM) technology, the SNR is improved dramatically, resulting in the successful use of 1 mm tip stylus. Also high resolution touch image has been obtained, leading to new applications.

INP7/ UXC6 - 2 14:10 **Drawing in Talking: Using Pen and Voice for Drawing System Configuration Figures in Talking**

X. Xu, J. Liao, H. Shibata

Fuji Xerox, Japan

This paper proposes a multimodal user interface system using pen and voice to draw system configuration figures. We aim to support real time drawing in talking and explore effective mode switching technique that does not interfere speaker's natural talk. We experimentally confirmed that our proposed technique was the most efficient. We also discuss how to improve the mode switching technique.

INP7/ UXC6 - 3: 14:30 ***Invited*** **The Effect of Edge Targets on Crossing-Based Selection with Direct Touch Input**

K. Go, Y. Kagawa, Y. Kinoshita

Univ. of Yamanashi, Japan

This paper presents experimental results on evaluating the effect of edge targets on crossing-based selection in the touch screen environment. The results indicated that the edge targets had a negative effect on selection time while they had a positive effect on accuracy when compared with the center targets on screen.

INP7/ UXC6 - 4 14:50 **Multi-Mouse Puzzle, an SDG-Based Puzzle Application for Collaborative Learning**

L. Luo, S. Orio[*], M. Mori[**], H. Kita

Kyoto Univ., Japan
[*]Infourt, Japan
[**]Hosei Univ., Japan

Single Display Groupware (SDG) is an environment where multiple users collaborate by sharing information on a display and each having some control. This paper discusses design and preliminary review an SDG application 'Multi-Mouse Puzzle' for elementary education based on the authors' experience of using SDG in schools.

----- Break -----

Author Interviews
17:00 – 17:40

Topical Session on Haptics Technologies

Wednesday, December 6

14:50 - 16:10 **Sakura Hall 2**

HAP1/INP2: Haptic Technologies

Chair: M. Takasaki, Saitama Univ., Japan
Co-Chair: A. Yamamoto, Univ. of Tokyo, Japan

HAP1/INP2 - 1: 14:50 ***Invited*** **Whole-Body Haptic Interface for Virtual Reality**

H. Kajimoto

Univ. of Electro-Commun., Japan

Virtual Reality becomes popular and the importance of tactile sense is widely acknowledged. I discuss important points in designing tactile device for VR. Three factors are discussed. One is whole-body that enables the sense of presence. Another is real-time response that enables cross-modal effects. The last one is low cost.

HAP1/INP2 - 2: 15:10 ***Invited*** **Body Motion Estimation by Machine Learning**

Y. Makino, Y. Horiuchi, H. Shinoda

Univ. of Tokyo, Japan

In this paper, we propose a new system that predict human body motion 0.5 seconds before the actual motion. We utilized machine learning for forecasting human actions. This forecasting system can estimate human gestures in advance to the actual action. This is useful to reduce delays in interactive system.

Also presented in Innovative Demonstration Session (see p. 227)

HAP1/INP2 - 3: 15:30 ***Invited*** **Tactility for Communication and Well-Being**

J. Watanabe

NTT, Japan

This paper describes previous researches and workshops performed to enhance communication and self-awareness using tactile science and technologies. In addition, I will describe current project about wellbeing and its relationship with tactile technologies.

HAP1/ INP2 - 4 15:50 **Research on a Haptic Device's Capability to Enhance the Degree of Kinesthetic Illusion Through Vibro-and-Visual Stimulation**

H. Komura, S. Yoshida, Y. Kato, T. Shimura, M. Honda[*]*, M. Ohka*

Nagoya Univ., Japan
[*]*Ind. Res. Inst. of Shizuoka Pref., Japan*

To develop new rehabilitation equipment, we combine the Kinesthetic Illusion (KI) and the Rubber Hand Illusion. Using a paired comparison method, since we observe a significant difference in the KI degree between the stationary and extended wrist cases, we conclude that visual stimulus can reinforce the kinematic illusion.

Author Interviews
16:20 – 17:00

Thursday, December 7

10:40 - 12:00 **Sakura Hall 2**

HAP2/INP4: Haptic Devices

Chair: H. Shinoda, Univ. of Tokyo, Japan
Co-Chair: M. Konyo, Tohoku Univ., Japan

HAP2/ INP4 - 1 10:40 **Electrostatic Tactile Display Integrated with a Projected Capacitive Touch Screen**

H. Haga, D. Sugimoto, Y. Yang, K. Shigemura

Tianma Japan, Japan

An electrostatic tactile display with a projected capacitive touch screen integrated into a single panel was demonstrated. Every electrode is driven for both tactile presentation and the touch sensor in a time-division manner. Electrodes for tactile presentation and for the touch sensor are driven concurrently for a localized tactile sensation.

HAP2/ INP4 - 2: 11:00 ***Invited*** **Physical Interactions on Flat Panel Displays Using Electrostatic Actuation Technologies**

A. Yamamoto

Univ. of Tokyo, Japan

This paper reviews physical interaction systems for flat panel displays, which have been realized using electrostatic actuation technologies. The systems include multi-touch surface haptic displays, on which users interact with computer graphics through contact pads, and active tabletop systems where physical objects move around on the display for interactions.

Also presented in Innovative Demonstration Session (see p. 227)

HAP2/ INP4 - 3: 11:20 ***Invited*** **Tactile Display with Friction Reduced by Ultrasonic Vibration**

M. Takasaki

Saitama Univ., Japan

This presentation deals with a tactile display with friction control. Display surface friction can be reduced by surface acoustic wave (SAW), which is a kind of ultrasonic vibration mode. Basic principle to indicate human tactile sensation is described. Prototypes of the display and their control are reported.

Also presented in Innovative Demonstration Session (see p. 227)

HAP2/ INP4 - 4: 11:40 ***Invited*** **Subjective Haptic Technology and Its Applications**

Y. Tanaka[,**]*

[*]Nagoya Inst. of Tech., Japan
[**]JST PRESTO, Japan

Tactile sense is subjective because it depends on our body and movements as well as contact objects. Focused on such inner characteristics, we have developed a wearable sensor for analyzing and/or communicating individual tactile sensations and a palpation system for laparoscopic surgery for augmenting surgeons' tactile sense.

Also presented in Innovative Demonstration Session (see p. 227)

12:00 - 12:05 **Sakura Hall 2**

Short Presentation
HAPp1: Applications of Haptic Technologies

All authors of poster papers for the HAPp1 session will give 1-minute oral presentations with no discussion time.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster HAPp1: Applications of Haptic Technologies

HAPp1 - 1 **Stable Haptic Feedback Generation during Mid Air Interactions Using Hidden Markov Model Based Motion Synthesis: Increasing and Stabilizing Motion Frame Rate**

D. Babu, H. Nagano, M. Konyo, R. Hamada, S. Tadokoro

Tohoku Univ., Japan

The depth camera based motion tracking systems has low, non-uniform frame rates which adversely affects high fidelity haptic feedback in mid-air interactions. In this paper, we propose and implement an HMM based motion element synthesis for stable, higher frame rate motion artifact synthesis and subsequently improve haptic feedback rendering.

HAPp1 - 2 **Vibrotactile Representation of Camera Motion with Two Vibrators**

D. Gongora, H. Nagano, M. Konyo, S. Tadokoro
Tohoku Univ., Japan

Haptic effects enrich audio-visual media but their creation can be time consuming. This paper reports a method for using camera motion estimates to generate vibrotactile feedback for two vibrators. The method generates two haptics effects that emphasize the feeling of curves and bumps on the road.
Also presented in Innovative Demonstration Session (see p. 227)

HAPp1 - 3 **Concept of Bilateral Softness Presentation toward Haptic Tele-Communication**

K. Nitta, A. Yamamoto
Univ. of Tokyo, Japan

The concept of bilateral softness presentation is discussed using a pair of bulging type softness displays, in which the device surface bulges to simulate pressure distribution on soft surfaces. With this system, two users can share or communicate cutaneous softness sensation.

HAPp1 - 4 **Use of Ultrasonic Waves for Navigation to the Viewing Position of Aerial Secure Display**

S. Ito, K. Uchida, H. Yamamoto
Utsunomiya Univ., Japan

This paper proposes a novel application of a haptics device for free-space navigation. Ultrasonic waves are used to navigate a viewer to the limited viewing position of an aerial secure display, which is composed of polarization-processing display and aerial imaging by retro-reflection (AIRR).

HAPp1 - 5L **Development of Vibration Cube to Convey Information by Haptic Stimuli**

M. Azuma, T. Handa, T. Shimizu, S. Kondo
NHK, Japan

We aim to intuitively convey changes and movements in videos such as ball direction and player techniques in sports programs via tactile sense. This paper describes a vibration cube whose faces can be independently vibrated that we have developed for this purpose.
Also presented in Innovative Demonstration Session (see p. 227)

Friday, December 8

10:40 - 12:00 **Meeting Room 3**

HAP3/INP6: Automotive and Mobile HMI

Special Topics of Interest on Automotive Displays

Chair: M. Sato, Tokyo Tech, Japan
Co-Chair: Y. Tanaka, Nagoya Inst. of Tech., Japan

HAP3/INP6 - 1: 10:40 ***Invited*** **Use of Shape Memory Alloy as a Haptic Technology for Displays Panels**

M. Gondo, A. Hirano

Seidensha, Japan

Tactile technology using shape memory alloys has been developed. In this paper, we explain the principle of the actuator. In particular, how we overcame a fast response that is the basis of this tactile technology. We will describe actual prototypes for personal computers and tablets.
Also presented in Innovative Demonstration Session (see p. 227)

HAP3/INP6 - 2 11:00 **An In-Vehicle Infotainment System with Automotive Grade Hover Gesture Touch Display**

W.-F. Chang, C.-L. Li, F.-H. Tsao, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

In this paper, we applied the different hover gestures to operate different functions. Through the 3D hover gestures, the user can easily operate the functions of in-vehicle infotainment system (IVI system) by simple hover gestures intuitively. Therefore, our system is not only operating easier but greatly improve the driving safety.

HAP3/INP6 - 3: 11:20 ***Invited*** **Present and Future of Midair Haptics**

H. Shinoda

Univ. of Tokyo, Japan

Midair haptics based on non-contact tactile simulation using ultrasound radiation pressure has a great potential to renew user interfaces and VR, and broaden the use of human haptic sense. In this talk, I will summarize the present of midair haptics and discuss the future of the technology and application.

HAP3/ INP6 - 4: 11:40 ***Invited*** **Vibration Feedback for Representing Haptic Interaction**

M. Konyo

Tohoku Univ., Japan

This paper presents vibrotactile feedback methods to represent natural feelings and reactions in response to user movement. Pseudo-haptic representing methods for friction, inertia, and viscosity are briefly described. Several applications such as pointing-stick type and gesture interfaces and vibrotactile rendering method generated from first-person view videos are also reported.

Also presented in Innovative Demonstration Session (see p. 227)

Author Interviews
12:00 – 12:40

Supporting Organization:
Technical Committee on Haptics, System Integration Division, The Society of Instrument and Control Engineers

I-DEMO
(Innovative Demonstration Session)

Live demonstrations
of emerging information display technologies
by oral and poster presenters
Thursday, Dec. 7, 2017
15:00 – 18:00
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
See page 227 for details

Workshop on LC Science and Technologies

Wednesday, December 6

14:50 - 16:25 **Hagi Conference Hall**

FLX2/LCT1: Advanced LC Technologies for Flexible Devices

Chair: K. Akamatsu, Fujifilm, Japan
Co-Chair: H. Okada, Univ. of Toyama, Japan

FLX2/LCT1 - 1: 14:50 ***Invited*** **Curved LCD and Future Application**

W. M. Huang, C.-T. Chen
AU Optronics, Taiwan

Curved LCDs and their applications are introduced. The substrates of curved LCDs and new process for PI base LCDs are discussed. We also focus on the high curvature display for CID. The 13.2-in. curved LCDs with R50 mm curvature and 181 ppi was developed.

FLX2/LCT1 - 2: 15:15 ***Invited*** **Organic LCD: Large Area, Low Cost, High Performance LCDs on Plastic**

P. A. Cain, J. Harding, M. Banach
FlexEnable, UK

Organic LCDs (OLCDs) bring a unique set of attributes not possible with other flexible display technologies, including large area scalability, low cost, and high brightness with long lifetime. We report on the breakthrough performance of OTFT that today takes it beyond a:Si and can be manufactured on existing lines.

FLX2/LCT1 - 3: 15:40 ***Invited*** **High Quality Organic Thin Film Transistors Fabricated with LC Organic-Semiconductors**

H. Iino, J. Hanna
Tokyo Tech, Japan

We researched the potentials of liquid crystalline organic-semiconductor materials for organic thin film transistor applications. Liquid crystalline materials have good solution processability and high thermal durability for uniform polycrystalline films regardless of small crystalline materials. Furthermore, liquid crystalline organic-semiconductor, Ph-BTBT-10 shows high mobility over 10 cm^2/Vs even though polycrystalline films.

FLX2/ LCT1 - 4 16:05 **Anisotropic Electrical Conductivity of Nanosegregated LC Thin Films of Polymerizable Perylene Bisimide Bearing a Triethylene Oxide Chain and Cyclotetrasiloxane Rings**

M. Funahashi, A. Seki

Kagawa Univ., Japan

A polymerizable liquid-crystalline perylene tetracarboxylic bisimide derivative bearing a triethylene oxide chain and cyclotetrasiloxane rings was synthesized. The compound exhibited a lamella-columnar phase in which the electron transport channels and ion-conductive sublayers were nanosegregated. The spin-coated films were polymerized via exposure to the vapors of trifluoromethanesulfonic acid.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:25 **Shirakashi Conference Room**

LCT2: High Image Quality LCDs

Chair: M. Inoue, Toyo, Japan
Co-Chair: S. Oka, Japan Display, Japan

LCT2 - 1: 9:00 ***Invited*** **Reinvention of an IPS-LCD Technology Enabling Extremely High Contrast Ratio of 1 Million to 1**

Y. Yasui, T. Imaoku, D. Fuse, T. Fukami, T. Hasebe, I. Mori, T. Kodo, K. Tsuda, K. Kikuchi, M. Ishii

Panasonic Liquid Crystal Display, Japan

We have successfully developed a new IPS-LCD panel, which achieved extremely high contrast ratio of 1,000,000:1. Such a high contrast ratio is achieved by reinventing an IPS-LCD technology, which is named as "IPSα Mega". This IPSα Mega technology is targeted for medical and broadcasting industries.

LCT2 - 2 **Withdrawn**

LCT2 - 5L 9:25 **Flexible Colorful Reflective Display by Using Proprietary Surface Anchoring LC Technology**

C.-H. Chen, S.-H. Wu, J.-T. Lien

Chunghwa Picture Tubes, Taiwan

Based on CPT's Surface Anchoring liquid crystal technology, we have recently developed 6.9-in. flexible reflective display shows outstanding performance which can play video and full-color image. In addition, we show a Reflective SA-LCD on flexible substrates made possible which not requiring alignment process, polarizer free and backlight free.

LCT2 - 3
9:45

High Contrast Ratio 2000:1 Solution for Fringe Field Switching LCD without Content Adaptive Backlight Control and Backlight Local Dimming

J. Chen, Y. Ma, L. Fang, B. Zheng, L. Wu, A. Ling, P. Shen, J. Li, C. Tseng

Xiamen Tianma Microelect., China

We achieve a competitive contrast ratio (CR) more than 2000:1 with suitable design. For fringe field switching (FFS) LCD of same PPI, decreasing cell gap and increasing ITO2 pitch appropriately can enhance the CR by 6%. And high K value of the liquid crystal can improve the CR about 10%.

LCT2 - 4
10:05

Study on Minimizing Flicker Shift Phenomenon in Positive LC FFS Mode LCD Panel by Optimized Pixel Design

K.-T. Huang, Y.-W. Hung, R.-X. Fang, Y.-T. Chao, C. Lee, S.-C. Lin, C.-H. Yu, C. Kao, T.-S. Jen

HannStar Display, Taiwan

Flicker shift is a serious problem in FFS mode LCD, especially in positive FFS LC. We study the mechanism of Flicker shift phenomenon and try to minimize this issue by optimize the FFS pixel structure. In addition, LC physical properties and optimum Vcom setting of FFS LCD panel was discussed.

----- Break -----

10:40 -12:20 **Shirakashi Conference Room**

LCT3/DES3: HMD Applications

Special Topics of Interest on AR/VR and Hyper Reality

Chair: H. Okada, Univ. of Toyama, Japan
Co-Chair: R. Oke, Panasonic Liquid Crystal Display, Japan

LCT3/
DES3 - 1:
10:40

Invited **The Optimal Fast Response LCD for VR-HMD**

T. Matsushima, K. Seki, S. Kimura, Y. Iwakabe, T. Yata, Y. Watanabe, S. Komura

Japan Display, Japan

We explain the moving picture characteristics of the display device required for virtual reality head-mounted displays (VR-HMD) and describe the optimum liquid crystal display mode. A short pitch lurch control (SLC)-IPS with a high-speed response and a simple structure is suitable for this purpose.

Also presented in Innovative Demonstration Session (see p. 227)

LCT3/ DES3 - 2: 11:05 ***Invited*** **Evaluation of Moving Picture Quality on LCD Device for Head-Mounted Display**

M. Kobayashi, T. Miura, N. Yamaguchi, M. Yashiki, T. Masuda, T. Katayama, S. Higashida, K. Hanaoka, H. Yoshida, S. Shimada

Sharp, Japan

We developed a LCD having EBET values of less than 1 ms with flashing backlight, and less than about 4 ms with scan backlight for our proposed measurement positions. This paper provides simple evaluation method using EBET measurements and simulations for moving picture quality of the HMD.

LCT3/ DES3 - 3: 11:30 ***Invited*** **Near Eye Application Based on Digital Electro-Optics Platform (X-on-Silicon)**

C.-W. Tsai, F. Lin, C. Wang

Jasper Display, Taiwan

Digital Electro-optics Platform is the main concept of Jasper Display Corp. (JDC) to develop various applications. These applications are based on our X-on-Silicon technologies, for example, Liquid Crystal on Silicon (LCoS), µLEDoS, OLEDoS, and CELLoS. LCoS technology is applied to Microdisplay, Spatial Light Modulator (SLM), Dynamic Optics, and Holographic Display.

Also presented in Innovative Demonstration Session (see p. 227)

LCT3/ DES3 - 4: 11:55 ***Invited*** **Head Mounted Display Implementations for Use in Industrial Augmented and Virtual Reality Applications**

T. Fukuda[*], J. Orlosky[,**], T. Kinoshita[*]*

[*]Westunitis, Japan
[**]Osaka Univ., Japan

This paper gives an overview of hardware designed for augmented and virtual reality systems designed, tested, and customized for industrial use. We will review existing technologies and their use cases and discuss a number of software implementations currently being deployed in research and industry.

----- Lunch -----

13:10 - 14:10 **Shirakashi Conference Room**

LCT4: High Reliability

Chair: M. Suzuki, Merck PM, Japan
Co-Chair: S. Shibahara, Sony, Japan

LCT4 - 1
13:10

Analysis of FFS LCD Abnormal Images at Low Gray

Y. Q. Xu, S. N. Zhang, X. Huang, W. Quan, F. Li
InfoVision Optoelect., China

We found that the conductivity characteristics of the BM made the CF connected to the GND signal by Ag glue, then an electric field between TFT common signal electrode and CF generate, and result in abnormal black screen. Finally we proposed a method to improve this issue effectively.

LCT4 - 2
13:30

A Compensation of V_{com} Adjustment in Fringe Field Switching LCDs by Considering the Flexoelectric Effect

J.-C. Ke, T.-C. Chung, C.-T. Liao, C.-M. Yu, Y. Qiao
InfoVision Optoelect., China

A compensation of V_{com} adjustment in fringe field switching liquid crystal displays by considering the flexoelectric effect is demonstrated. We provide a method to adjust the V_{com} via gamma voltage correction to decrease the residual DC voltage, which is helpful to reducing the image sticking.

LCT4 - 3
13:50

Advance FSA (UV Curing Like) Process Technology to Improve Broken Spot for G8.6 TFT-LCDs

Y. Yao, J. Chou, J. Hsu, W. York
Chongqing HKC Optoelect. Tech., China

Advanced FSA(UV curing like) process of a-Si TFT is an excellent cell process technique. Broken spot defect is issued and caused yield loss. After optimizing the UVM process parameters that can reduce the broken spot defect and improve the yield, meanwhile keep the performance of the optical characters and Tr.

Also presented in Innovative Demonstration Session (see p. 227)

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster LCTp1: LC Lens

LCTp1 - 1 **Accumulation of Nematic Colloids at the Interfaces in Azo-Dye-Doped LCs**

A. Y.-G. Fuh, T.-W. Chang, Y.-I. Lee, S.-T. Wu

Nat. Cheng Kung Univ., Taiwan

This study demonstrates the optical manipulation of colloids dispersed in an azo-dye-doped liquid crystals where the accumulation is performed at the interfaces of the phase domains. The colloids are dragged to the interfaces of isotropic/nematic domain (IN) and air bubble/isotropic domain (AI) by the molecular interaction and Marangoni flows.

LCTp1 - 2 **Polarization Independent LC Lens with Bi-Focus Switching Mode for Wearable Display Applications**

C.-W. Chien, C.-Y. Chien, C.-H. Li, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

A hole-patterned liquid crystal (LC) lens with characteristics of switchable polarization-independence and bi-focus was realized. Furthermore, the optimized phase distributions of fabricated LC lens were achieved via operations of two independent voltages. The fabricated LC lens was also demonstrated for augmented reality.

LCTp1 - 3 **Fabrications of Polarization Independent LC Lens Arrays for Autostereoscopy Applications**

T.-H. Kao, Y.-H. Hsu, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

By means of a proposed novel lithography method, liquid crystal lens arrays (LCLAs) with polarization-independence are fabricated and demonstrated optical performance for autostereoscopic applications. The LCLAs have a double sandwich-like structures composed of two orthogonal homogeneous LC layers with periodically self-aligned hole-patterned electrode units in the middle glass substrate.

LCTp1 - 4 **Using Holographic Exposure Processes to Realize Polymer Stabilized LC Microlens Arrays with Fast Switching Focuses**

I.-L. Huang, C.-Y. Chien, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

In this study, we demonstrate an electrically tunable micro-lens array based on polymer stabilized liquid crystal cells, which were processed by a He-Ne laser holographic exposure and a photomask with hole-patterned array to generate non-uniform polymer networks to achieve the micro-lens array with fast optical response and better focusing capability.

LCTp1 - 5 **Electrically Tunable LC Lens with Characteristic of Fast-Switching Bi-Focuses for Enhancing Depth-of-Field**

C.-Y. Chien, C.-H. Li, C.-W. Chien, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

We demonstrate a LC lens with a structure of two LC layers to achieve a larger focusing power capability. Combing and switching a TN LC cell, the proposed and optimized LC lens shows functions of polarization-dependent bi-focuses to enhance the DOF range.

15:00 - 18:00 **Exhibition Hall**

Poster LCTp2: Emerging Technologies

LCTp2 - 1 **The Transflective Properties Improvement of Dual-Cell-Gap ECB LCD**

C. Wang, T. T. Wu, J. Chen, K. R. Xi, M. Xie, X. H. Li, Y. Z. Sun, J. B. Zhou, X. J. Kong, J. E. Liu, F. Qin

Tianma Micro-elect., China

Higher photo energy for organic bump promoted ECB reflection, the proper retardation of half and quarter wave plates improved transmissve bluish dark and got a neutral reflective white point color. New TFT a-Si channel design and enough storage capacity reduced the difference of Vcom between optimum transmissive and reflective flicker.

LCTp2 - 2 **Reflective-Emissive Dual Mode Display with Color PDLC Layer**

G. H. Kim, W. J. Lee, S. Kim, Y. H. Kim, C. S. Hwang

ETRI, Korea

Thermal–induced PDLC devices having a specific color were developed by doping color dyes into a prepolymer. To achieve a reflective and emissive display, we devised novel decap and lamination method to stack the fabricated T-CPDLCD with a flexible OLED, thereby making it possible to reduce thickness and weight.

LCTp2 - 3 **Video-Rate Holographic Display in ZnSe Layer-Assisted Quantum Dot Doped LC with High-Photorefractive Sensitivity**

X. Li, W. Liu, J. Cao, Z. Song, F. Li, X. Dong, X. Zhang

Hisense, China

We demonstrate a dynamic holographic display in ZnS/InP doped liquid crystal with assistance of ZnSe layer. The response time of several to tens of milliseconds is measured with very low recording intensity (1 mW/cm^2) at 460 nm. The photosensitivity S of the hybrid LC cell is measured up to 2.2 cm^3/J.

LCTp2 - 4 Withdrawn

LCTp2 - 5L Bistable Light Shutter Using Ion-Doped Cholesteric LCs

Y.-S. Jo, J.-H. Kim, J.-W. Huh, S.-W. Oh, S.-M. Ji, T.-H. Yoon

Pusan Nat. Univ., Korea

We propose a bistable light shutter using cholesteric liquid crystals doped with ionic material and dichroic-dye. It has two stable states: transparent homeotropic and opaque focal-conic states. In the opaque focal-conic state, it exhibits opaque state much better than previously reported bistable light shutters.

LCTp2 - 6L Development of Photochromic Guest-Host LC Device Driven by UV Irradiation and Electric Field

K. Goda, Y. Suematsu, K. Takatoh

Tokyo Univ. of Sci., Yamaguchi, Japan

We proposed photochromic guest-host liquid crystal device. This device can be switching between the transparent state and the colored state which polarized light is selectively absorbed by the irradiation of UV light. Additionally, the transmittance could be controlled by the electric field even when the irradiation of UV light.

LCTp2 - 7L Thermoresponsive Light Scattering Device Using Ionic Liquid-Water Mixture Exhibiting LCST-Type Phase Behavior

K. Goda, K. Takatoh, Y. Funasako

Tokyo Univ. of Sci., Yamaguchi, Japan

We proposed thermoresponsive light scattering device using ionic liquid-water mixture exhibiting LCST-type phase behavior. This device shows two states of the transparent and opaque states by the variation of temperature. In this paper, temperature transmittance property, thermal response time, and viewing angle were investigated.

LCTp2 - 8L Narrow-Bandpass LC Filter for Real-Time Multi Spectral Imaging Systems

K. Terashima, T. Ishinabe, K. Wako[*]*, Y. Fujihara, Y. Aoyagi, M. Murata, S. Nasuno, S. Wakashima, R. Kuroda, Y. Shibata, S. Sugawa, H. Fujikake*

Tohoku Univ., Japan
[*]*Nat. Inst. of Tech., Sendai College, Japan*

We have developed the high speed bandpass liquid crystal filter with narrow full width at half maximum of 5 nm for real-time multi spectral imaging systems. We have successfully achieved short wavelength-switching time of 30 ms by the optimization of phase retardation of thin liquid crystal devices.

LCTp2 - 9L **Study on PDLC Like LC Cell by Using Porous PMMA Spray Film for Millimeter-Wave Application**

Y. Watanebe, A. Kon, R. Ito, M. Honma, T. Nose

Akita Pref. Univ., Japan

We focus on PDLC type LC structure to attain extremely thick LC layer. We fabricate porous PMMA film by using spray deposition method under various conditions to utilize the porous film as polymer matrix. Furthermore, a prototype PDLC is fabricated by using the film and its operating characteristics are evaluated.

LCTp2 - 10L **Basic Performance of LC Millimeter-Wave Phase Shifter by Using Microstrip Line**

K. Iiyama, R. Ito, M. Honma, T. Nose

Akita Pref. Univ., Japan

LC MMW phase shifter was fabricated by introducing LC material to a part of dielectric substrate in microstrip line. Reflection, transmission, and phase shifting properties for MMW were investigated by using FDTD simulation including LC material loss. Then, actual LC phase shifters were fabricated and their basic performance was evaluated.

LCTp2 - 11L **LC Devices Having the V-Groove Structure by Nano-Imprint Lithography**

K. Haruna, H. Okada

Univ. of Toyama, Japan

We try to fabricate nano-sized V-groove structure using nanoimprint lithography and anisotropic etching. Periodical 200 nm line structure was well fabricated PMMA as stamping agent and anisotropic etching using SiO_2 as etching mask and KOH solution as etchant. This structure is suitable for fabrication of groove for liquid crystal alignment.

LCTp2 - 12L **Nematic LC Alignment and Anchoring Properties on Rubbed Poly (4-vinylpyridine) Surface**

K. Kudo, R. Yamaguchi

Akita Univ., Japan

An easy axis of rubbed poly(4-vinylpyridine) depends on LC materials. Fluorinated LCs which align parallel and perpendicular to the rubbing direction are mixed and alignment directions are investigated. The change of an azimuthal anchoring energy more than one order of magnitude is measured by using LC mixtures.

LCTp2 - 13L **Development of 2.9-in. 132x64 Transparent Film Displays Based on Cholesteric LC**

E.-J. Kim[*], D.-S. Yoon[,**], H.-S. Yang[*], S.-J. Lee[*], S.-B. Kwon[*,**]*

[*]Hoseo Univ., Korea
[**]NDIS, Korea

We developed 2.9-in. transparent film display composed of cholesteric LC cell accompanying TN cell. The transparency is controlled by TN cell and displayed image is provided by CLC cell. The display sample can clearly display some information even in a transparent state. The fabrication process and electro-optical properties are discussed.

LCTp2 - 14L **Electro-Optical Characteristics of Dye-Doped LC Gel Films for Stretchable Displays**

R. Saito, Y. Shibata, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

To realize stretchable liquid crystal (LC) displays, we have proposed dye-doped LC gels using dendrimer-type gelator and evaluated the electro-optical characteristics. The LC gel film has a contrast ratio of 6.7:1. Also, the LC gel film on a stretchable elastomer substrate has high elongation of 150% without tensile rupture.

LCTp2 - 15L **Electro-Optical Characteristics of In-Plane Switching LC Devices with Structural Transferred Microgroove and Wall Structure**

D. Minami, Y. Shibata, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

For fabrication of flexible displays using printing process, we proposed the in-plane switching liquid crystal devices with microgroove and wall structures by the transfer method. We clarified that our device has a high transmittance, and reduction of residual polymer film was necessary for decreasing the driving voltage.

15:00 - 18:00 **Exhibition Hall**

Poster LCTp3: New LC Applications

LCTp3 - 1 **Withdrawn**

LCTp3 - 2 **A Wide-View Angle Design for Vehicle Display Interface with Improving Performance**

B. Su, K. Wang, B. Zheng, L. Wu, L. Fang, A. Ling, J. Chen, P. Shen, J. Li, C. Tseng

Xiamen Tianma Microelect., China

In this paper, an optimized match strategy among photo alignment, transverse ITO slit and rear polarizer compensation film is studied. Such design has exhibited more promising property of vehicle display than the existing method by an improving CR at A+, A and B zone of 18%, 24.7% and 11%, respectively.

LCTp3 - 3 **Color Mixing Analysis of Large View Angle in FFS-LCD**

L. Huang, L. Jiang, Z. Su

InfoVision Optoelect., China

In this paper, we analyze the cause of the color mixing, and establish a model concluding formula as a design guide line to optimize the process and design parameters. By using the model and formula, a high picture quality LCD display without color mixing can be realized.

LCTp3 - 4 **Study of Isotropic Monomer Dopant to Improve Electro-Optical Performance of Holographic Exposed Polymer Network LC Cells**

C.-Y. Lin, C.-Y. Chien, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

Due to issues of higher voltage operations and serious electrostriction effect, the polymer network liquid crystal cells processed by the holographic exposure of He-Ne laser were doped a little of N-vinyl-2-pyrrolidinone (NVP) to investigate performance improvements and keep characteristics of fast response and low light scattering properties.

LCTp3 - 5L **A Mechanism of Short-Term Image-Sticking Phenomenon Caused by Flexoelectric Effect in IPS LCD**

D. Inoue, T. Miyake, M. Sugimoto

Tianma Japan, Japan

We propose a novel mechanism for short-term image-sticking phenomenon in in-plane switching liquid crystal displays (IPS LCDs) that is related to ionic relaxation generated by a vertical electric field due to the flexoelectric effect. We discuss the difference between electric fields due to the flexoelectric effect and DC bias voltage.

LCTp3 - 6L **Photo-Alignment Control of Lyotropic LC and its Application to Coatable Polarizers**

T. Itsukaichi, Y. Iimura

Tokyo Univ. of A&T, Japan

Photo-alignment control of a lyotropic liquid crystal (LLC) has been studied for realizing a coatable polarizer. We show LLC alignment structure is strongly influenced not only by surface anchoring, but also by coating processes. We succeed in forming uniform LLC alignment structure by selecting appropriate coating conditions.

LCTp3 - 7L Numerical Analysis in Homogeneous-Twisted Nematic Transition Mode of LC Cell Using Weak and Strong Anchoring Surfaces

Y. Sakamoto, R. Yamaguchi

Akita Univ., Japan

We have proposed a low driving homogeneous-TN Transition mode LCD using weak and strong anchoring surfaces. LC director distributions are numerically analyzed in the case which the weak anchoring strength is K_{22}/d (d; the cell thickness). Electrooptical properties are also estimated and compared to those in the conventional TN cell.

LCTp3 - 8L An ECB Mode LC Device Suitable for Low Power Consumption Smart Windows

S.-J. Lee[*], D.-S. Yoon[,**], H.-S, Yang[*], E.-J. Kim[*], S.-B. Kwon[*,**]*

[*]Hoseo Univ., Korea
[**]NDIS, Korea

We developed an ECB mode LC device suitable for low power consumption smart window, the off-state transmittance of which can be adjusted to the specified transmittance required for most use time. The design rule of it and electro-optical properties are discussed.
Also presented in Innovative Demonstration Session (see p. 227)

LCTp3 - 9L Electro-Optical Properties of a Hybrid Type PDLC with LC Emulsion and Black Dichroic Dye Doped LC Coacervates

H.-S. Yang[*], S.-J. Lee[*], E.-J. Kim[*], D.-S. Yoon[,**], S.-B. Kwon[*,**]*

[*]Hoseo Univ., Korea
[**]NDIS, Korea

Black dichroic dye doped normal PDLCs cannot show sufficiently high on-state transmittance because it is impossible to reorient the dye molecules inside polymer matrix by electric field. To solve the problem we developed a hybrid type black PDLC. It enabled to provide higher on-state transmittance as well as black background.

LCTp3 - 10L Novel Alignment Control Method Using Mortar-Shaped Structure for High-Contrast Twisted-VA mode Reflective LCDs

Y. Kuge, Y. Shibata, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

We have proposed a mortar-shaped electrode structure to improve response time and alignment uniformity of twisted vertically aligned (TVA) mode liquid crystal displays for high-contrast reflective color LCDs. As a result, we clarified that response time and alignment uniformity of TVA mode were improved by axisymmetrically-controlled alignment in each pixel.

LCTp3 - 11L **Formation of Layered Polymer Structure of PDLC by Anisotropically Diffused UV Irradiation**

Y. Horii, Y. Shibata, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

To control the diffused light distribution of polymer-dispersed liquid crystal (PDLC), we investigated a control of polymer structure distribution by anisotropically diffused UV irradiation. As a result, we obtained PDLCs having layered distribution of polymer structure, and clarified that UV irradiation under isotropic phase was needed for PDLCs.

Friday, December 8

9:00 - 10:20 **Shirakashi Conference Room**

LCT5: LC Alignment Technology (1)

Chair: S. Ishihara, Osaka Inst. of Tech., Japan
Co-Chair: K. Miyachi, JSR, Japan

LCT5 - 1: 9:00 ***Invited*** **Homogeneous Self-Alignment Technology without Using Conventional Alignment Layer Materials**

M. Mizusaki, H. Tsuchiya, K. Minoura

Sharp, Japan

A novel method for obtaining a homogeneous liquid crystal alignment without using a conventional alignment layer material was developed. The method would be useful for flexible and/or narrow-frame LCDs because it does not need high temperature process.

LCT5 - 2 9:25 **Development of Self-Alignment LC Mixture for Vertical Alignment Mode without Polyimide Alignment Layer**

H. Endo, Y. Katano, F. Kondo, K. Ogita, H. Tanaka, M. Yano

JNC Petrochem., Japan

We developed new liquid crystal mixtures that is possible to align by themselves without polyimide alignment layer in the cell. In this study, we evaluated alignment, optical properties and reliability of the LC cell prepared by new LC mixture. Also we compared the performance of PI-Less cell with conventional cell.

LCT5 - 3 9:45 **A Novel Reversed Scattering Mode Using Polymer Stabilized Ferroelectric LC**

Y. Kudoh, D. Yoshii, R. Suzuki, T. Takahashi

Kogakuin Univ., Japan

We propose a novel reversed scattering FLC mode with high-speed switching using the polymer stabilized technique under applying the dc voltage to the cell. The very fast response time between 0 V to 20 V switching voltage was obtained such rise time τ_r: 0.55 ms and decay time τ_d: 0.38 ms.

LCT5 - 4L 10:05 **Electrically-Switchable Liquid Crystal Phase Grating Device for Window Display Applications**

T.-H. Choi, J.-H. Woo, B.-G. Jeon, T.-H. Yoon
Pusan Nat. Univ., Korea

We report an electrically-switchable two-dimensional liquid crystal (LC) phase grating device for window display applications. The device has outstanding features, such as a low operating voltage, high transmittance, and wide viewing angle characteristics in the transparent state as well as high haze in the translucent state.

----- Break -----

10:40 - 12:00 **Shirakashi Conference Room**

LCT6: LC Alignment Technology (2)

Chair: M. Suzuki, Merck PM, Japan
Co-Chair: Y. Iwashita, DIC, Japan

LCT6 - 1: 10:40 ***Invited*** **Novel Photo-Alignment Materials for High Transmittance Ultra-High Definition VA LCDs**

*M. Koechlin, Y. Yamada, Q. Tang, Y. Yamamoto**
Rolic Techs., Switzerland
**V-Tech., Japan*

Ultra-high definition vertically photo-aligned LC-displays inherently suffer from lower backlight transmittance. We proved, by simulation and experimentally, that the transmittance is increased by lowering the pre-tilt angle. Novel materials based on Rolic's proprietary photo-alignment technology yielding low pre-tilt angles and high reliability were developed and introduced into mass production.

LCT6 - 2 11:05 **Novel E-O Properties in Nano-Phase-Separated LCs**

T. Fujisawa, K. Jang, H. Hasebe, H. Takatsu
DIC, Japan

V-T properties in NPS-LCDs to be almost compatible with PSA-LCDs and 40% faster decay time than that of PSA-LCDs have been achieved by advancement of alignment in azimuthal direction of tilted liquid crystals in addition to control pretilt angle.

LCT6 - 3 11:25 **Homogeneous-Twisted Nematic Transition Mode LCD by Out-of-Plane Field**

R. Yamaguchi, Y. Sakamoto
Akita Univ., Japan

We have proposed a low driving LCD which changes from homogeneous to TN orientation. The cell is prepared using asymmetric weak/strong anchoring surfaces and is driven by out-of-plane field. Transmittance can be increased from 0% to almost 100% by the voltage of 1 to 1.5 V between crossed polarizers.

LCT6 - 4L 11:45 **Fast Switching of a Vertical Alignment LC Cell by Two-Dimensional Confinement with Virtual Walls**

B.-G. Jeon, T.-H. Choi, J.-H. Woo, Y. Choi, T.-H. Yoon

Pusan Nat. Univ., Korea

We investigated the two-dimensional confinement effect on the switching of vertically-aligned LCs. The LC molecules are confined not only by the two substrates but also by the virtual walls so that the turn-off time of the cells can be reduced simply by decreasing the pitch of the patterned electrodes.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Shirakashi Conference Room**

LCT7: Transparent LCDs

Chair: T. Ishinabe, Tohoku Univ., Japan
Co-Chair: T. Nose, Akita Pref. Univ., Japan

LCT7 - 1: 13:50 ***Invited*** **Highly Transparent Color LCD by Using Scattering LCD Mode, Direct Edge Light and Field Sequential Color Driving Method**

K. Okuyama, T. Nakahara, Y. Numata, T. Nakamura

Japan Display, Japan

We have developed highly transparent color LCD using newly developed scattering-type liquid crystal without color filter and polarizer. Light with field sequential color (FSC) driving is directly introduced to the panel from the edge of substrates. It shows high transmittance (80%), wide color gamut and fast response time.
Also presented in Innovative Demonstration Session (see p. 227)

LCT7 - 2 14:15 **A Hybridized Scattering-Type LCD with Concurrent Use of UV Curable Silica Nanoparticles and UV Curable Monomers**

E. Fukuda, M. Akimoto, H. Morita, S. Kobayashi

Tokyo Univ. of Sci., Yamaguchi, Japan

Electro-optical properties of a hybridized scattering-type LCD implemented with a liquid crystal-UV curable silica nanoparticles-UV curable monomer composite are investigated. It is found that the threshold and working voltage of this hybridized scattering-type LCD are reduced and the contrast ratio is improved.

LCT7 - 3 14:35 **17-in. High Quality Transparent Display Using by Polymer-Dispersed LC**

S.-H. Wu, C.-H. Chen, J.-T. Lian

Chunghwa Picture Tubes, Taiwan

In this paper, we have succeeded to develop a 17-in. transparent display by using polymer-dispersed liquid crystal (PDLC) technology. The colorful transparent display can have a lot of advantages, such as polarizer free, low driving voltage, and so on. Finally, the 17-in. colorful transparent display has good visibility and transparency.

LCT7 - 4L 14:55 **Development of Transparent Emissive LCD Using Novel Polarized Light-Emitting Film**

N. Mochizuki, R. Morita

Nippon Kayaku, Japan

We succeeded in developing new light-emitting films that exhibit transmittances of over 90% and emit polarized light. The application of these new films resulted in the successful fabrication of novel self-emissive liquid crystal displays that exhibited high transparency, high contrast, and good visibility.

----- Break -----

15:30 - 16:50 **Shirakashi Conference Room**

LCT8: Emerging Technologies

Chair: Y. Iwashita, DIC, Japan
Co-Chair: T. Takahashi, Kogakuin Univ., Japan

LCT8 - 1: 15:30 ***Invited*** **A Highly Polar LC Material**

H. Nishikawa, K. Shiroshita, H. Higuchi, Y. Okumura, Y. Haseba[*]*, S. Yamamoto*[*]*, K. Sago*[*]*, H. Kikuchi*

Kyushu Univ., Japan
[*]*JNC Petrochem., Japan*

An anomalously large dielectric permittivity of about ten thousand is found for an LC compound having a 1,3-dioxane unit in the mesogen core part (DIO). Our experimental results suggest that a ferroelectric-like unidirectional parallel polar arrangement of the molecules is generated along the director in an LC phase of DIO.

LCT8 - 2 15:55 **Image Evaluation of Large Aperture LC Fresnel Lens**

G. Shibuya, H. Abe, A. Tamaki, S. Yamano, H. Yoshida, M. Ozaki

Osaka Univ., Japan

Large aperture liquid crystal Fresnel lens was manufactured and its transparent images were evaluated. Concentric interdigitated electrodes and high-resistivity layer could form the Fresnel saw-tooth distribution of retardation. Obtained maximum tunable range of the lens grade by the lens meter was ±8 Diopters that can be applied for tunable eyeglasses.

LCT8 - 3 16:15 **The Optical Properties of Viewing Angle Controllable LCD**

M. Q. Zhu, S. N. Zhang, X. Huang, P. Liao, S. Chung, B. C. Jia

InfoVision Optoelect., China

This paper researched the optical characteristics of viewing angle controllable LCD. The measurement results shows that the viewing angle can be effectively controlled from wide viewing angle (85°) to narrow viewing angle (50°).A good privacy protection on horizontal direction can be available.

LCT8 - 4L 16:35 **Optical Homogeneous Effects in Nanoprticle-Embedded Liquid Crystal Devices**

S. Kobayashi, Y. Shiraishi, H. Furue[*], K. Takeishi[**], H. Takatsu[**], K.-H. Chang[***], L.-C. Chien[***]

Tokyo Univ. of Sci., Yamaguchi, Japan
[*]Tokyo Univ. of Sci., Japan
[**]DIC, Japan
[***]Kent State Univ., USA

The doping of nanoparticles of PgCyD-ZrO_2 and Aerosil R-812 into LC-cells brings optical homogeneous effects such as reduction of laser speckle pattern and increase of output intensity. In the FSC-LCDs wide color gamut of 140% of NTSC and clearing of the Energy Star Program with an index LE were achieved.

Author Interviews
17:00 – 17:40

Workshop on Active Matrix Displays

Wednesday, December 6

13:10 - 14:15 **Tachibana Conference Hall**

AMD1: Oxide TFT: Advanced Devices

Special Topics of Interest on Oxide-Semiconductor TFT

Chair: H. Kumomi, Tokyo Tech, Japan
Co-Chair: K. Hayashi, Kobe Steel, Japan

AMD1 - 1: 13:10 ***Invited*** **Controllable Quantum Interference in Amorphous $InGaZnO_4$ Thin-Film Transistors**

W.-H. Wang, S.-R. Lyu, E. Heredia, S.-H. Liu, P.-H. Jiang, P.-Y. Liao, T.-C. Chang*, H.-M. Chen***

Nat. Taiwan Normal Univ., Taiwan
**Nat. Sun Yat-Sen Univ., Taiwan*
***Nat. Chiao Tung Univ., Taiwan*

We report on the low-temperature magnetoconductivity of amorphous $InGaZnO_4$ (a-IGZO) thin-film transistors (TFTs). The magnetoconductivity exhibits coexistence of weak localization (WL) and weak antilocalization (WAL), and their competitions can be controlled by the gate voltage. Our findings demonstrate gate-controlled quantum interference in the electron systems in a-IGZO TFTs.

AMD1 - 2 13:35 **Twin-Channel Oxide TFT with High Current Drive and Its Circuit Application**

M. Nakata, M. Ochi, H. Tsuji, T. Takei, M. Miyakawa, T. Yamamoto, H. Goto*, T. Kugimiya*, Y. Fujisaki*

NHK, Japan
**Kobe Steel, Japan*

A twin-channel oxide TFT having two short effective channel regions has been developed by formation of a low-resistance region in the semiconductor. This twin-channel TFT enables high current drive due to the reduction of effective channel length, and can save space by operating two channels separately on the same device.

AMD1 - 3 13:55 **Simulation Study of Novel Thin-Film Devices Using Depletion State of Amorphous Oxide Semiconductor**

K. Abe, M. Fujinaga, T. Kuwagaki

Silvaco Japan, Japan

Novel devices using amorphous oxide semiconductor (AOS) were studied through device simulation. This study confirmed that the device with a conventional first-gate and an AOS second-gate shows NAND-like function. It suggested a feature that holes and ionized traps in the depleted second-gate AOS are insufficient to compensate the negative first-gate.

----- Break -----

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:00 **Tachibana Conference Hall**

AMD2: Oxide TFT: Stability

Special Topics of Interest on Oxide-Semiconductor TFT

Chair: P.-H. Jiang, Nat. Taiwan Normal Univ., Taiwan
Co-Chair: H. Kumomi, Tokyo Tech, Japan

AMD2 - 1: 9:00 ***Invited*** **Hydrogen-Induced Trap States in Amorphous In-Ga-Zn-O Thin-Film Transistors Studied by Photoinduced Transient Spectroscopy**

K. Hayashi, M. Ochi, A. Hino, H. Goto, T. Kugimiya

Kobe Steel, Japan

We have studied evolution of hydrogen-induced trap states in amorphous In-Ga-Zn-O thin-film transistors by means of photoinduced transient spectroscopy. The etch-stop layer formation conditions were successfully correlated with the threshold voltage shift originating from positive bias thermal and negative bias thermal illumination stresses.

AMD2 - 2 9:25 **AlO Sputtered Self-Aligned Source/Drain Formation Technology for Highly Reliable Oxide Thin Film Transistor Backplane**

H. Hayashi, A. Murai, M. Miura, Y. Terai, Y. Oshima, T. Saitoh, Y. Hiromasu, T. Arai

JOLED, Japan

We propose a novel self-aligned source/drain formation process by AlO sputtering for oxide TFT backplane. The method has the advantages in terms of barrier performance, large substrate production, and productivity. The AlO passivation provides a uniform and reliable oxide backplane suitable for OLED displays.

AMD2 - 3L 9:45 **Slot-Die Coating of Soluble Metal Oxide Semiconductor Towards High-Performance, High-Resolution Self-Aligned TFT Backplanes**

I. Katsouras[*], M. Marinkovic[**], J. Maas[*], D.-V. Pham[**], R. Anselmann[**], G. Gelinck[,***]*

[*]Holst Ctr., The Netherlands
[**]Evonik Resource Efficiency, Germany
[***]Eindhoven Univ. of Tech., The Netherlands

We report slot-die coating of the indium oxide-based iXsenic S precursor solution, and its first robust integration into high-performing thin-film transistors with a self-aligned architecture. We demonstrate excellent performance and uniformity of the resulting TFTs. Our results are a key ingredient towards roll-to-roll printed, high-resolution TFT arrays.

----- Break -----

10:40 - 12:05 **Tachibana Conference Hall**

AMD3: Oxide TFT: Fabrication

Special Topics of Interest on Oxide-Semiconductor TFT

Chair: H. J. Shin, LG Display, Korea
Co-Chair: H. Hamada, Kinki Univ., Japan

AMD3 - 1: 10:40 ***Invited*** **Oxide TFT Fabrication Techniques for Advanced Flexible Display Backplanes**

J. W. Na, H. J. Kim, B. H. Kang, H. J. Kim
Yonsei Univ., Korea

We propose low-temperature fabricated amorphous oxide semiconductor thin film transistors (AOS TFTs) by simultaneous ultraviolet and thermal (SUT), electrically assisted thermal (EAT), and high pressure annealing (HPA) treatments. In addition, we investigated a new material, nitrocellulose, as a low-temperature processable passivation layer of oxide TFTs.

AMD3 - 2 11:05 **Direct Photoreactive Patterning Method for Fabricating Aqueous Solution-Processed IGZO TFTs**

M. Miyakawa, M. Nakata, H. Tsuji, Y. Fujisaki
NHK, Japan

A simple, direct photoreactive patterning method for fabricating aqueous solution-processed IGZO TFTs without any photoreactive additives is proposed. Uniform patterned IGZO films are obtained using a photoreactive chemical process based on a free radical reaction in conjunction with a soft etching process.

AMD3 - 3 **Study on the Dry Etching Characteristics**
11:25 **of Back Channel Etch Type IGZO TFTs**

Z. R. Li, Q. Zhang, M. Lu, Y. Deng, J. Yao, S. Qin

Shenzhen China Star Optoelect. Tech., China

In this paper, we report that the selectivity ratio of Mo and a-IGZO film could be up to 300 when adopting Cl_2/O_2 as ICP dry etching process gas. Then we chose Mo as S/D electrodes and fabricated BCE structure a-IGZO TFTs exhibited excellent performance under this dry condition.

AMD3 - 4 **Enhanced Scalability and Reliability**
11:45 **of Indium-Gallium-Zinc Oxide Thin-Film Transistor Using a Combination of Plasma Fluorination and Thermal Oxidization**

L. Lu[*]*, J. Li, Z. Xia, Z. Feng, S. Wang, S. Bebiche, H. S. Kwok*[*]*, M. Wong*

Hong Kong Univ. of S&T, Hong Kong
[*]*HKUST Jockey Club Inst. for Advanced Study, Hong Kong*

Attributed to the effective passivation of defects in InGaZnO, both the scalability and reliability of an InGaZnO thin-film transistor are significantly enhanced by combining plasma fluorination with thermal oxidization.

----- Lunch -----

13:10 - 14:45 **Tachibana Conference Hall**

AMD4: Oxide TFT: Application

Special Topics of Interest on Oxide-Semiconductor TFT

Chair: H. J. Kim, Yonsei Univ., Korea
Co-Chair: K. Omoto, Apple, Japan

AMD4 - 1: ***Invited*** **Novel High-Image-Quality Technologies**
13:10 **for Premium OLED TVs**

H.-J. Shin, S. Takasugi, J.-M. Kim, C.-H. Oh

LG Display, Korea

We present an OLED display with the “Real Black” image quality and high color uniformity for premium large sized TVs. Self-aligned coplanar TFT is employed as panel backplane. Using novel high-image-quality technologies, we can enhance image quality of the OLED display. These works should play an important role in commercializing Premium OLED TVs.

AMD4 - 2 **Withdrawn**

AMD4 - 5L 13:35 **Fully Printed Oxide TFTs for Display Backplane and Logic Circuits**

L. Lan, Y. Li, J. Peng

South China Univ. of Tech., China

With the assistance of surface-energy patterns, the surface morphology of printed oxide films can be well regulated. The several issues in printing, including coffee-ring effect, ink spreading and the interaction of adjacent isolated ink islands were addressed properly. The demonstrated fully printed metal-oxide thin-film transistors exhibited good electrical performance and uniformity.

AMD4 - 3: 14:00 ***Invited*** **Novel Driving Circuit for High Resolution IGZO TFT Display**

K. Yamamoto, K. Tanaka, K. Okada, K. Yamamoto, S. Uchida, H. Katoh, A. Oda, T. Karahashi, T. Matsuo

Sharp, Japan

We have developed an ultra-high-definition liquid crystal display (2.87-in. 1008 ppi, 2K2K, 120 Hz) for HMD. The high definition and narrow bezel were realized by adopting a de-multiplexer circuit based on IGZO-TFT. We devised a novel de-multiplexer circuit of IGZO-TFT configuration, and realized high driving performance.

AMD4 - 4 14:25 **Design of Highly Reliable Depletion-Mode a-IGZO TFT Gate Driving Circuit for 85-in. 8K4K 120 Hz TFT-LCD**

L.-Q. Shi, S.-J. Chen, Y.-F. Chou, M. Zeng, T.-H. Wang, P.-J. Chiang, L.-M. Zeng, R.-L. Chen, C.-W. Liao, X.-W. Lv, W.-Y. Li, C.-Y. Chiu, C.-Y. Lee

Shenzhen China Star Optoelect. Tech., China

In this paper, high reliable a-IGZO TFT gate driving circuit was designed. The Vth integral shift margin of this proposed GOA design is from -10 V to +9 V, and the circuit exhibits good falling time 1.34 μs by using simulation. Finally, an 85-in. 8K4K 120 Hz TFT-LCD was successfully demonstrated.

Author Interviews
14:45 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster AMDp1: Oxide TFTs

Special Topics of Interest on Oxide-Semiconductor TFT

AMDp1 - 1 **Achieving High Carrier Mobility in IGZO Transistors by Catalytic Metal Assisted Crystallization**

Y. Shin, J. Lee, J. K. Jeong

Hanyang Univ., Korea

The transition metal catalytic layer has facilitated the low-temperature crystallization of amorphous indium gallium zinc oxide semiconductor. Subsequently, the significant enhancement in terms of device performance was observed for the crystallized IGZO transistor at a low annealing temperature of 300°C: the field-effect mobility increased up to 54.0 $cm^2/V{\cdot}s$.

AMDp1 - 2 **Soluble-Processed Aluminum Doped Yttrium Oxide Gate Insulator for High Performance Amorphous Oxide Transistors**

J. Lee, Y. Shin, J. K. Jeong

Hanyang Univ., Korea

The low-cost spin-cast $Al_{0.5}Y_{1.5}O_3$ films were prepared as the gate insulator for the IZO transistors. The ternary $Al_{0.5}Y_{1.5}O_3$ films provide a smooth, high permittivity with excellent insulating properties compared to binary Al_2O_3 or Y_2O_3 films. This behavior can be attributed to the structure stabilization resulting from the cation alloying mixing effect.

AMDp1 - 3 **31-in. 4K2K AMOLED Display Using High Thermal Stability and Reliability Top-Gate Self-Aligned IGZO TFTs**

X.-Y. Zhou, L. Sun, F.-M. Liu, Y.-J. Hsu, M.-J. Yu, Z.-S. Liu, X. Xiao, J.-S. Im, P.-Y. Lu

Shenzhen China Star Optoelect. Tech., China

We develop thermal stable top-gate self-aligned a-IGZO TFTs by optimizing the metallization process of n^+ IGZO regions. The PBTS reliability is significantly improved by tuning the deposition process of gate insulator and buffer film. Finally, the AMOLED display are demonstrated by employing the high-performance a-IGZO TFTs.

AMDp1 - 4 **Withdrawn**

AMDp1 - 5 **Withdrawn**

AMDp1 - 6 Development of Self-Aligned Top-Gate a-IGZO TFTs for a 31-in. 4K2K AMOLED Display

S.-M. Ge, S. Li, X.-Y. Kong, M. Jiang, Y.-H. Meng, W. Shi, W. Wu, F. Zhu, Y. Wu, G.-T. Li, X. Wang, S.-J. Chen, X. Xiao, P.-F. Liang, G. Chaw, C.-Y. Lee

Shenzhen China Star Optoelect. Tech., China

A 31-in. 4K2K AMOLED TV was developed by using self-aligned top gate a-IGZO TFTs. The electrical characteristics of the self-aligned a-IGZO TFTs were studied. Through modifying the GI layer, a-IGZO TFTs exhibited good uniformity of threshold voltage and BTS reliability. Finally, a high performance 31-in. 4K2K AMOLED TV was demonstrated.

AMDp1 - 7 Low Cost Back-Channel-Etch InGaZnO Thin Film Transistors with Cu/Mo Bus Line Fabricated by a 4-Mask Process

F. Zhu, S. Li, G. Li, Y. Wu, Y. Meng, W. Wu, S. Ge, X. Kong, S. Chen, J. Li, F. Wang

Shenzhen China Star Optoelect. Tech., China

A back-channel-etch (BCE) type IGZO thin film transistor (TFT) with Cu/Mo source/drain (S/D) fabricated by a 4-mask process is demonstrated. A novel 2wet-1dry method is introduced to pattern S/D and IGZO, resulting in process simplification and significant tact-time reduction. The back channel damage is evaluated, showing no obvious deterioration of the TFT performance.

AMDp1 - 8 Moisture Dominant Electrical Degradation of Amorphous InGaZnO Thin Film Transistors under Positive Bias Stress

Y. Zhou, J. Xu, H. Xie, L. Zhang, G. Liu, X. Tong, C. Dong

Shanghai Jiao Tong Univ., China

With the relative humidity increasing, the positive bias stress (PBS) stability of amorphous InGaZnO thin film transistors (a-IGZO TFTs) became worse first and then improved. A degradation model was proposed to explain how the moisture interacted with the back channels of a-IGZO TFTs under different humidity levels during PBS tests.

AMDp1 - 9 Development of 31-in. UD AM-OLED Display Using Self-Aligned Top Gate IGZO TFTs

Y. Meng, S. Li, S. Ge, X. Kong, C. Jiang, W. Shi, W. Wu, F. Zhu, X. Xiao, G. Chaw, P. Liang, Y. Deng, S. Chen, C. Y. Lee

Shenzhen China Star Optoelect. Tech., China

We designed structure of self-aligned top gate IGZO TFT, adjusted process flow and optimized treatment of photoresist. Then we obtained good characteristics of TFT, including an averaged mobility of 9.17 cm^2/Vs, Vth of 0.52 V, and SS of 0.25 V/dec. Finally, a 31-in. UD AM-OLED display without bright points was developed.

AMDp1 - 10 IGZO TFT Gate Driver Circuit Capable of Ripple Control without QB Node

J. Oh, J.-H. Kim, H. Lim, K. C. Park, D. Jung, Y.-S. Kim*

Sungkyunkwan Univ., Korea
**Konkuk Univ., Korea*

This paper proposes IGZO TFT gate driver circuit capable of ripple control without QB node. First, the ripple is controlled primarily through a level-shifter to prevent multi-output of V_{OUT}. Second, C2 and T6 control the ripple by preventing the CLK voltage from being applied to V_{OUT} except the bootstrapping region.

AMDp1 - 11 Withdrawn

AMDp1 - 12 Characteristics of a-IGZO TFT Stability by Dry Etching

J. Choi, S. Kim, H. Kim, S. M. Cho

Sungkyunkwan Univ., Korea

Plasma treatments were done in a process of fabricating a-IGZO thin film transistor. Cl_2, BCl_3/Cl_2 dry etching was done in a process of fabricating a-IGZO TFT. After these treatments, we observed correlation between TFT performance and plasma treatment.

AMDp1 - 13L Development of 65-in. 4K UHD OLED TV with High Reliability and Short Channel IGZO TFTs

J. S. Koo, D. H. Lee, S. J. Yun, W. C. Jeong, J. Y. Park, J. W. Kim

LG Display, Korea

We improved the PBTS instability of self-aligned IGZO TFTs by minimizing the density of non-bridging oxygen (NBO) sites within gate-insulator and defect passivation by hydrogen. In addition, we proposed the channel dependent Vth simulation model and using this model, we achieved the short channel (L=4.5 μm) device scalability (ΔV_{th}=0.4 V).

AMDp1 - 14L Fabrication of Low Temperature Process TFT Using High Density a-InGaZnO Film Deposited by Inductively Coupled Plasma Sputtering System

D. Matsuo, R. Miyanaga, S. Kishida, Y. Setoguchi, Y. Andoh, M. Fujii*, Y. Uraoka**

Nissin Elec., Japan
**NAIST, Japan*

In this study, a-IGZO TFTs were fabricated through a low-temperature process using high density two layer a-IGZO films deposited by ICP-sputtering. The field effect mobility at annealing temperature of 150°C was 8.8 cm^2/Vs, and the reliability when the annealing temperatures were 150°C and 250°C was the same.

AMDp1 - 15L Characteristic Evaluation of Ga-Sn-O Thin Films by Hall Measurement

K. Imanishi, A. Fukawa, T. Matsuda, M. Kimura

Ryukoku Univ., Japan

We investigated how the Hall effect changes when the annealing temperature of the Ga-Sn-O (GTO) changes. The highest mobility is 1.21 cm^2/Vs. Next, when we made a GTO TFT and measured the Hall effect by applying a gate voltage, the mobility was 13.4 cm^2/Vs.

15:00 - 18:00 Exhibition Hall

***Poster* AMDp2: Active-Matrix Devices**

AMDp2 - 1 Reduction of Leakage Current for poly-Si TFTs with Metal Source/Drain by Dual Gate Structure

F. Gakiya, T. Harada, Y. Ishiki, T. Okada, T. Noguchi

Univ. of the Ryukyus, Japan

N-type top-gate TFTs with metal S/D was fabricated using laser annealing by adopting ultra-low temperature process. As a result of hydrogen annealing at 200°C after forming Al electrodes, drastic improvement of TFT has been realized while the leakage current was high. Dual-gate structure is proposed to reduce the leakage current.

AMDp2 - 2 Electrical Degradation Behavior of p-Type LTPS TFT for Flexible AMOLED Applications

F.-H. Chen, Y.-Y. Wu, S.-L. Lin, C.-H. Tsai, H.-H. Lu, Y.-H. Lin

AU Optronics, Taiwan

We investigated the electrical degradation behavior in p-type flexible LTPS TFTs. A hump behavior was occurred during positive gate voltage stress. This result may due to a current leak path at back channel. Moreover, a two-step electrical degradation behavior was also found under gate/drain voltage stress.

AMDp2 - 3 **High Mobility LTPS TFTs with 150 nm Polysilicon on the Glass Using BLA Crystallization**

S. Hong, Y. Jung, J. Jang

Kyung Hee Univ., Korea

In this study, we made a 150 nm thickness low temperature polycrystalline silicon (LTPS) TFTs with high mobility on the Corning Eagle XG glass substrate using blue laser annealing (BLA). The mobility of these TFTs are about 137.56 cm^2/Vs.

AMDp2 - 4 **Withdrawn**

AMDp2 - 5 **Factor Analysis and Evaluation Method for Crosstalk Capability of LTPS LCD**

H. Zhou, X. Zhou, B. Shen, J. Li

Xiamen Tianma Microelect., China

We found that the Crosstalk phenomenon of LCD is likely to get worse with the increase of resolution. We need to identify Crosstalk values. We establish a set of estimation methods for the Crosstalk of LCD. We can reduce our products' Crosstalk value from 1.5% to 0.8% or less.

AMDp2 - 6 **Special-Shaped Display Device with High Screen Occupation Ratio**

X. Wu, B. Liu, Z. Li, M. Bai, G. Chen, J. Li, Z. Zeng

Xiamen Tianma Microelect., China

With the development of LCD technology, high screen occupation ratio is widely used in LCD display. In this paper, the driving circuit and the sealant coating method used in special-shaped display are studied. We have successfully manufactured a 5.99-in. FHD special-shaped display based on LTPS-TFT technology.

AMDp2 - 7 **Withdrawn**

AMDp2 - 8 **Study the Characteristics of a-Si:H Thin Film Transistors by Covering with Different Materials**

W.-Y. Li, Y.-F. Chou, P.-J. Chiang, C.-W. Liao, X.-D. Liu, L.-Q. Shi, R.-L. Chen, S.-J. Chen, L.-M. Zeng, T.-H. Wang, X.-W. Lv, C.-Y. Lee

Shenzhen China Star Optoelect. Tech., China

The electrical characteristics of a-Si:H TFTs covered by different materials was investigated. It was found that TFTs performed similar Vth in initial status, but their Vth shifted differently after 60°C 90% RH High-temperature-high-humidity storage then DC Stress. The voltage of top gate ITO has little influence on the I-V performance.

Also presented in Innovative Demonstration Session (see p. 227)

AMDp2 - 9 New Integrated EM Driver Using LTPS TFTs in AMOLED Displays

J. Wu, H. Zhu, S. Hu, X. Zhu, X. Huang

Kunshan Govisionox Optoelect., China

A novel coupling circuit is proposed to reduce the risk of possible damage to the other part connected to the coupling circuit. An emission control circuit using this coupling circuit is introduced, which can withstand as twice as higher voltage difference pressure than traditional design by simulation.

AMDp2 - 10 Short-Channel Pentacene Thin-Film Transistor Circuits Patterned by Lift-Off Process Using PVA and SU-8

M. S. Kim, J. Oh, S. Y. Lee, K.-C. Park[*]*, J.-H. Jeon*[**]*, Y.-S. Kim*

Sungkyunkwan Univ., Korea
[*]Konkuk Univ., Korea
[**]Korea Aerospace Univ., Korea

We fabricated short-channel top-contact pentacene thin-film transistors (TFTs) by using lift-off process with PVA/SU-8 bilayer. SU-8 was used as photoresist for short-channel patterning and PVA prevents pentacene from the solvent of SU-8. We also simulated the p-type inverters and 5-stage ring-oscillators with the fabricated TFT model.

AMDp2 - 11 Analysis of Unusual Large Current after Reliability Test in 55-in. UD TFT-LCD TV with a-Si Integrated Gate Driver Circuit

L. Zeng, S. Chen, Y. Chou, X. Lv

Shenzhen China Star Optoelect. Tech., China

This paper analyzed unusual large current from clock signals. The current triggered over current protection system and resulted in panel shutdown. Research found that the large current will happen after aging test and pull-down method of the gate driver circuit is a key factor responsible for the unusual large current.

AMDp2 - 12 Evaluation of Thin-Film Phototransistors Arrayed for a Magnifying Viewer

I. Ogawa, S. Kitajima, M. Kimura

Ryukoku Univ., Japan

We put the thin-film phototransistors (TFPTs) array on a modulation transfer function (MTF) pattern and measured the distribution of photo-induced current (Iphoto). It was found that Iphoto increased on the bright pattern. This correct working grantees the actual working of the TFPT arrays as a magnifying viewer.

AMDp2 - 13 Application of Film Filter in Embedded Luminance Sensors

S.-B. Liu, Y. Qiao, C.-M. Yu, M.-H. Pan, C.-T. Liao, H.-C. Lai, T.-C. Chung

InfoVision Optoelect., China

We report on the application of adding a special film filter during the manufacture of embedded luminance sensor. This adscititious film filter can lessen the sensitivity of photo sensor inside the cell, and it will increase the operating range by dropping the working voltage which facilitates our using.

AMDp2 - 14L Double-Gate P-ch Cu-MIC Low-Temperature Poly-GeSn TFTs on Glass Substrates

N. Nishiguchi, R. Miyazaki, K. Ogata, R. Kuroda, Y. Takano, H. Utsumi, A. Hara

Tohoku Gakuin Univ., Japan

An amorphous GeSn film with Sn=7% was crystallized via metal-induced crystallization using copper (Cu-MIC). It was found that Cu-MIC enables us to fabricate high quality poly-$Ge_{0.93}Sn_{0.07}$ films, and double-gate Cu-MIC p-channel low-temperature poly-$Ge_{0.93}Sn_{0.07}$ thin-film transistors show a nominal mobility of 4 cm^2/Vs and an on/off ratio of 5×10^2.

AMDp2 - 15L Hybrid Compensation Method for AMOLED Pixel Circuit

C. Nie, B. Han, Y. Cai, X. Wu, G. Chaw

Shenzhen China Star Optoelect. Tech., China

We introduce a new kind of hybrid compensation method, which combines the merits of internal compensation and external compensation. By simulating a 3T1C pixel circuit using hybrid compensation method, we confirm that the method can compensate panel uniformity by external compensation, and can hold panel stability by internal compensation.

Friday, December 8

9:00 - 10:20 **Tachibana Conference Hall**

AMD5: Organic / Carbon TFT (1)

Chair: T. Minami, Univ. of Tokyo, Japan
Co-Chair: H. Minemawari, AIST, Japan

AMD5 - 1: 9:00 ***Invited*** **Stable Low Voltage Solution Processed Organic Field Effect Transistors**

X. Guo, W. Tang, J. Zhao, Q. Li, L. Feng
Shanghai Jiao Tong Univ., China

Approaches for low voltage OFETs are introduced, including using low-k/high-k bilayer gate dielectric and reducing the sub-gap DOS at the channel. Mechanisms of achieving excellent stabilities for the two type devices are discussed. The OFET is finally incorporated into a battery-powered electronic system for sensor applications.

AMD5 - 2: 9:25 ***Invited*** **Improving Charge Carrier Mobility and Operation Frequency in Polymer Transistors**

A. Perinot[*], M. Giorgio[,**], P. Colpani[*], Y.-H. Kim[***], M. Caironi[*]*
[*]Istituto Italiano di Tecnologia, Italy
[**]Politecnico di Milano, Italy
[***]Gyeongsang Nat. Univ., Korea

High operational frequency of low voltage organic transistors is necessary for widening their range of applications. Here we present direct-written and printed organic transistors on flexible plastic substrates exhibiting operational frequency in excess of 1 MHz, along with a strategy for the reduction of operating voltage down to 10 V.

AMD5 - 3 **Withdrawn**

AMD5 - 4L 9:50 **Enhanced Mobility of Top-Gate Dialkyl BTBT Transistors by Spin Coating from Non-Halogen Solvents**

*S. Sanda[*], T. Nagase[*], T. Kobayashi[*], K. Takimiya[**,***], Y. Sadamitsu[****], H. Naito[*]*
[*]Osaka Pref. Univ., Japan
[**]RIKEN, Japan
[***]Tohoku Univ., Japan
[****]Nippon Kayaku, Japan

We report the effect of organic solvents for spin coating dialkyl BTBT on the mobility of top-gate organic FETs. Top-gate C_8-BTBT and C_{12}-BTBT FETs processed using non-halogen solvents under optimized conditions exhibit high average mobilities of 5.2 and 7.8 cm^2/Vs, respectively. The maximum mobility of ~10 cm^2/Vs is achieved.

AMD5 - 5L **Inkjet-Printed Short-Channel Thin-Film Transistors**
10:05

Y. Li, L. Lan, J. Peng

South China Univ. of Tech., China

Taking advantage of the coffee effect, printed hydrophobic coffee stripes of microscale in width were utilized as the surface-energy patterns to define the channel region of Ag electrode pairs. The fabricated short-channel pentacene TFTs with channel length as short as ~2 μm exhibited a maximum mobility of 0.006 $cm^2 V^{-1} s^{-1}$.

----- Break -----

10:40 - 11:50 **Tachibana Conference Hall**

AMD6: Organic / Carbon TFT (2)

Chair: K. Nomoto, Sony, Japan
Co-Chair: Y. Fujisaki, NHK, Japan

AMD6 - 1: ***Invited*** **Vertical Organic Light Emitting Transistors**
10:40 **for Large Screen AMOLED Displays**

B. Liu[,**], M. A. McCarthy[*,**], X. Chen[*], D. J. Cheney[*,**], M. G. Lemaitre[*,**], R. Jayaraman[*], S. Vasilyeva[*,**], A. G. Rinzler[*]*

[*]Univ. of Florida, USA
[**]nVerpix, USA

The carbon nanotube enabled vertical field effect transistor technology further demonstrates its promise to allow cost effective manufacturing of large screen AMOLED displays. We discuss the important desirable benefits obtained from this novel device structure for AMOLED display applications, especially the enhanced stress stability in both PBIS and NBIS conditions.

AMD6 - 2 **Active-Matrix LED Display Using Solution-**
11:05 **Processed Single-Crystal Organic TFTs**
for Large-Area Flexible Displays

M. Sawamoto[*], S. Suzuki[,**], M. Ikawa[*,***], K. Ueji[***], T. Matsumuro[*,***], M. Ito[*], Y. Ohyama[***], Y. Tanaka[***], Y. Kanaoka[****], M. Uno[****], J. Takeya[*,**,***]*

[*]Pi-Crystal, Japan
[**]Organo-Circuit, Japan
[***]Univ. of Tokyo, Japan
[****]Osaka Res. Inst. of Ind. S&T, Japan

This paper presents novel fabrication process of active-matrix LED displays applying solution-processed single-crystal organic TFTs with the mobility around 10 cm^2/Vs, using transfer method of organic TFTs and mounting LED chips onto a large flexible printed circuit sheet.

AMD6 - 3: 11:25 ***Invited*** **Label-Free and Antibody-Free Protein Detection Based on Organic TFTs**

T. Minami

Univ. of Tokyo, Japan

A label-free and antibody-free detection of proteins has been achieved using an organic thin-film transistor (OTFT)-based sensor functionalized with artificial receptors. The OTFT responds to protein recognition behavior of the receptor. The demonstration of the protein detection could pave the way to the development of disposable and portable bio-sensing systems.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:20 **Tachibana Conference Hall**

AMD7: Novel Display Devices

Chair: K. Kimura, Sony, Japan
Co-Chair: M. Inoue, Huawei Tech. Japan, Japan

AMD7 - 1: 13:50 ***Invited*** **Nanocarbon Based Light Sources and Detectors for Integrated Optoelectronics**

H. Maki[*,**]

[*]*Keio Univ., Japan*
[**]*JST PRESTO, Japan*

We report the light sources and photodetectors based on nanocarbon materials such as carbon nanotubes and graphene. These optoelectronic devices, with the advantages of small footprint, room-temperature operation and integration on silicon, can enable novel architectures for photonic and optoelectronic integrated devices.

AMD7 - 2: 14:15 ***Invited*** **Monolithically Integrated Supercapacitors and Electorolyte-Gated Transistors**

F. Soavi, C. Santato[*]

Univ. di Bologna, Italy
[*]*Polytechnique Montréal, Canada*

We report on the combination of several functional properties in semiconducting films interfaced to a wide range of electrolytes, such as modulation of the electrical conduction in the electrolyte-gated transistor configuration and electrochemical energy storage (supercapacitor). The monolithic integration of the transistor and supercapacitor functions generates the TransCap device.

AMD7 - 3 14:40 **Techniques in Pixel and Peripheral Circuit Design to Achieve High PPI in AMOLED Display**

Y. Song, H. Zhu, X. Zhu, X. Huang

Kunshan Govisionox Optoelect., China

Some particular designs are introduced to optimize LTPS and OLED design on pixel and peripheral circuit to achieve high PPI. To make the design more compact and effective, specific techniques are implemented. A high PPI AMOLED display fabricated by this technique has been successfully demonstrated.

AMD7 - 4: 15:00 ***Invited*** **Pulse I-V Approach for Quantitative Analysis of Defects and Charge Trapping in Amorphous Oxide Semiconductor Thin Film Transistor**

S. Jeon

Korea Univ., Korea

Understanding defects of amorphous oxide semiconductor thin film transistor is very crucial to the successful development of oxide thin-film devices. Here we present pulse I-V approach for basic transistor analysis and quantitative analysis of defects and charge trapping in amorphous oxide semiconductor thin film transistor.

----- Break -----

15:30 - 16:40 **Tachibana Conference Hall**

AMD8: High Resolution

Chair: C. Santato, Polytechnique Montréal, Canada
Co-Chair: K. Takatori, Tianma Japan, Japan

AMD8 - 1: 15:30 ***Invited*** **New Pixel Driving Circuit Using Self-Discharging Compensation Method for High-Resolution OLED Microdisplays on a Silicon Backplane**

K. Kimura, T. Tanaka, N. Toyomura[*]*, H. Kitagawa*[*]

Sony, Japan
[*]*Sony Semiconductor Solutions, Japan*

A novel 4T2C current-source type pixel circuit is proposed to realize a high-resolution 7.8-μm pixel pitch OLED microdisplay. The pixel circuit compensates its Vth variation of the driving transistor internally to achieve high luminance uniformity. 0.5-in. Quad-VGA and 1.25-in. Wide-Quad-XGA microdisplays with the proposed compensation architecture are also presented.

AMD8 - 2: 15:55 ***Invited*** **Magneto-Optical Spatial Light Modulator Driven by Spin Transfer Switching for Electronic Holography**

N. Funabashi, H. Kinjo, K. Aoshima, D. Kato, T. Usui, S. Aso, K. Kuga, T. Mishina, K. Machida, T. Ishibashi[*]*, H. Kikuchi*

NHK, Japan
[*]*Nagaoka Univ. of Tech., Japan*

We have developed a magneto-optical spatial light modulator driven by spin transfer switching (spin-SLM) for realizing electronic holography. The spin-SLM which has the pixel layout of 100×100 or 1000×1000 with 2 μm pixel pitch was fabricated and shown successful display of two-dimensional images.

AMD8 - 3 16:20 **New Pixel Circuit with Current-Bias Voltage-Programmed Structure to Fast Compensate for Threshold Voltage Variations of LTPS TFTs for AMOLED Displays**

L.-R. Chen, C.-M. Lu, M.-Y. Deng, Y.-S. Lin, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This work presents a pixel circuit adopting low-temperature polycrystalline-silicon thin-film transistors (LTPS-TFTs) composed of 5T2C for active-matrix organic light-emitting diode (AMOLED) displays. The proposed circuit can effectively compensate for VDD IR-drop and threshold voltage variation with current-bias voltage-programmed structure, also preventing the flicker phenomenon on displays.

Author Interviews
17:00 – 17:40

Supporting Organizations:
Technical Committee on Electronic Information Displays, Electronics Society, IEICE
Thin Film Materials & Devices Meeting

Workshop on FPD Manufacturing, Materials and Components

Wednesday, December 6

13:10 - 14:30 **Sakura Hall 1**

FMC1: Manufacturing and Measurement Technologies

Chair: R. Yamaguchi, Akita Univ., Japan
Co-Chair: T. Nonaka, Merck PM, Japan

FMC1 - 1: 13:10 ***Invited*** **Micro-Transfer Printing of RGB Light Engines for Emissive Displays**

A. J. Trindade, E. Radauscher, S. Bonafede*, D. Gomez*, T. Moore*, C. Prevatte*, B. Raymond*, A. Fecioru, B. Fisher*, K. Ghosal*, D. Kneeburg*, M. Meitl*, C. Bower**

X-Celeprint, Ireland
**X-Celeprint, USA*

The use of small scale inorganic LEDs (iLEDs) as light emitters will shape the evolution of emissive displays. Light engines were mass transferred using micro-Transfer Printing (μTP) with precision and speed while offering advanced manufacturing capabilities such as flexible substrate integration and display repair capabilities.

FMC1 - 2 13:30 **Contact Resistance Reduction Using Linear Ion Source PVD System in LTPS Backplane**

Y.-C. Tsai, P. Kurunczi, J. Grillmayer, M. Hanika**, J. Olson**

Appl. Materials Taiwan, Taiwan
**Appl. Materials Varian Semiconductor Equipment, USA*
***Appl. Materials, Germany*

Applied Materials has developed a Gen 6 linear ion source PiVot® PVD system that removes oxidized TiOx and deposits ITO continuously for reducing the contact resistance without additional chemical treatment. With our pre-clean process, we reduced contact resistance by 80% and improved contact resistance uniformity by 60%.

FMC1 - 3 13:50 **Advanced Half-Tone Photolithography Using Four-Mask Technology for G8.6 Large Size TFT-LCDs**

A.-T. Cho, J. Hsu, K. Fan, F.-Y. Yang, Y.-Q. Tian, Q.-H. Mo, Z. Liu, F.-X. Long, B.-T. Ge, Y.-J. Hsu, C.-H. Chang, C.-F Chen, W. Chen, Y. Lu

Chongqing HKC Optoelect. Tech., China

Advanced four-mask process a-Si TFT array manufacturing method and good TFT stability is presented in this paper. We used an optimum half-tone mask transmittance and half-tone photoresist for the four-mask process architecture. We used the half-tone technology and less concentration wet etchant to attained small a-Si tail and n+-Si tail.

FMC1 - 4 14:10 **Optical Measurement Methods for Flexible OLED Elements with Arbitrary Geometric Curvature**

K. Käläntär[,**], S. Maeda[*]*

[*]CEBRA, AIST, Japan

[**]Global Optical Solutions, Japan

New emerging flexible OLEDs have variety of features that boost their applications. Their issues are closed up and novel assessment methods are researched for flexible OLEDs with single geometric curvature. The new assessment methods are discussed for the flexible OLEDs that are limited to monochromatic, polychromatic and pseudo-white emissions.

----- Break -----

14:50 - 16:05 **Sakura Hall 1**

FMC2: Display Film Technologies

Chair: I. Amimori, A51Tech, Japan
Co-Chair: K. Käläntär, Global Optical Solutions, Japan

FMC2 - 1: 14:50 ***Invited*** **Large Area Interference Lithography and Seamless Patterning Innovations**

J. Mick, C. Stöver, V. Boerner, T. Kraus, O. Humbach

temicon, Germany

Micro- and nanostructures on very large areas could be fabricated using Interference Lithography. However, processing on conventional flat surfaces consequently results in high-volume production of film with at least one seamline. We have developed an approach to transfer flat surface processes onto curved, convex surfaces without any seamline.

FMC2 - 2 15:10 **Curable Coating Material Technologies for OLED Display**

K. Noda, J. Hikida, Y. Tadokoro, K. Misumi, D. Shiota

Tokyo Ohka Kogyo, Japan

Recently, materials for OLED display panel are demanded to have several multi-properties. For example, thermal resistance, transparency, and elongation are required for flexible substrate. On the other hand, they should be cured at low temperature considering light-emitting element stability. We have developed the materials such as high transparent polyimide varnish.

FMC2 - 3
15:30

Development of Crystalline COP for Optical Film Application

S. Komoto, T. Murakami, K. Yoda, K. Inoue, M. Kikukawa
Zeon, Japan

We have developed optical films using a new type of crystalline Cycloolefin Polymer (COP). It shows good mechanical properties and high birefringence. We think that Crystalline COP film is suitable for a touch sensor substrate of a flexible device. And it can be designed as a thin retardation film.

FMC2 - 4 **Withdrawn**

FMC2 - 5L
15:50

Excellent Image Visibility of New Display Using Quantum Dot Color Filter and In-Cell Polarizer under Bright Ambient Light

N. Koma, H. Kato, T. Ishinabe[*]*, H. Fujikake*[*]
Polatechno, Japan
[*]*Tohoku Univ., Japan*

We report a new display that uses a quantum dot color filter and an in-cell polarizer. The new display provides high image quality under ambient light. We confirmed the effectiveness of the new display in experiments.

Author Interviews
16:20 – 17:00

EXHIBITION

12:40 – 18:00 Wednesday, Dec. 6
10:00 – 18:00 Thursday, Dec. 7
10:00 – 14:00 Friday, Dec. 8
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
Free admission with your registration name tag

Thursday, December 7

9:00 - 10:20 **Sakura Hall 1**

FMC3: Display Optics for AR/VR

Special Topics of Interest on AR/VR and Hyper Reality

Chair: K. Käläntär, Global Optical Solutions, Japan
Co-Chair: H. Yamamoto, Utsunomiya Univ., Japan

FMC3 - 1: 9:00 ***Invited*** **3D Display for Augmented Reality**

B. Lee, S. Lee, J.-Y. Hong, C. Jang

Seoul Nat. Univ., Korea

In immersive and realistic augmented world, users may interact with virtual objects that are integrated to the real world. 3D information of the virtual objects should be fully reconstructed so that users could not recognize artifacts of the virtual objects. Here, several 3D display technologies for augmented reality are introduced.

FMC3 - 2: 9:20 ***Invited*** **Hologram Synthesis for Near to Eye Displays**

J.-H. Park

Inha Univ., Korea

Holographic near to eye displays provide users with true focal cue, removing vergence accommodation conflict which is one of the major causes of the fatigue. In this talk, our recent computer generated hologram technique to synthesize hologram contents for the near to eye display is presented.

FMC3 - 3 **Withdrawn**

FMC3 - 4 10:00 **Optical Design of Directional Projection Screen Using Diverted Corner Cube Array**

K. Käläntär[,**], K. Wako[*], R. Ohtera[*], Y. Ishitaka[***], M. Kano[***], T. Uchida[*]*

[*]Nat. Inst. of Tech., Sendai College, Japan
[**]Global Optical Solutions, Japan
[***]Tohoku Univ., Japan

A novel directive reflector was studied for projection screen. The directivity characteristic was accomplished by applying an alternate hollow corner cube retroreflector that controls the screen reflection direction and the diffusion pattern. The novel screen possesses high luminance reflection characteristic that can preserve the power consumption of the projector.

----- Lunch -----

13:10 - 14:25 **Sakura Hall 1**

FMC4/FLX5: Roll-to-Roll Manufacturing Technologies

Chair: A. Fujita, JNC, Japan
Co-Chair: Y. Mishima, JAPERA, Japan

FMC4/FLX5 - 1: 13:10 ***Invited*** **Development of Printed Electronics Device by Nano-Scale Roll to Roll Patterning**

T. Tanaka, M. Abe, N. Ito, K. Okuno, T. Hitomi, K. Komatsu, M. Oshikata, M. Ataka[*]*, T. Kishiro*[*]*, S. Matsui*[**]*, M. Okada*[**]

Asahi Kasei, Japan
[*]*Holon, Japan*
[**]*Univ. of Hyogo, Japan*

Asahi-Kasei has been developing Seamless Roller Mold as a printing stamp, then demonstrated Transparent Conductive Film(TCF) by using high resolution printing technology for large area touch sensors. We will show the fabrication process of SRM and show printed samples on flexible substrate.

Also presented in Innovative Demonstration Session (see p. 227)

FMC4/FLX5 - 2 13:30 **Flexible Transparent Electrodes for Large-Area Printed Electronics**

T. Muto, T. Hara, W. Morita, T. Izumi, K. Nagamoto

Lintec, Japan

Fabrication of transparent electrodes consisted of a stack of ITO, metal grid, and gas barrier films is described. The film electrodes have smooth surface morphology and low surface resistivity. Performance of the thin film devices formed on the electrodes was enhanced from ITO films by its electrical properties.

FMC4/FLX5 - 3 13:50 **Novel Direct Imaging Exposure System with High Productivity for Flexible Substrate in Roll-to-Roll Method**

Y. Kito, M. Hori, Y. Hayashida, T. Suzuki, H. Kajiyama, H. Komiyama, T. Watanabe, T. Shimoyama, T. Kurashige, Y. Ishigaki, S. Nakayama, M. Kato

Nikon, Japan

We developed a novel exposure system for mass production, advancing the main specifications of the proof-of-concept prototype that we reported at IDW '16. New system achieved a resolution of 6μm and an overlay accuracy of less than ± 3μm under productivity comparable to that of a 1st-generation FPD lithography system.

FMC4/ FLX5 - 4L 14:10 **Microwave-Assisted Rapid Synthesis of Carbon Nanotubes Covalently Conjugated with Sulfonated Polyaniline for Enhancing Stable Dispersion of Aqueous Conductive Inks**

P.-C. Wang, T.-J. Tsai, H.-L. Liao

Nat. Tsing Hua Univ., Taiwan

Sulfonated polyaniline was covalently conjugated to carbon nanotubes by microwave-assisted polymerization. The aqueous dispersion based on CNTs covalently functionalized with sulfonated polyaniline was used as the medium for oxidative chemical polymerization of 3,4-ethylenedioxythiophene. The transparent electrodes fabricated by spray-coating using the resultant conductive ink gave ~90 s/cm conductivity.

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster **FMCp1: FPD Manufacturing, Materials and Components**

FMCp1 - 1 **Development of Colorants for Wide-Color Gamut Color Filter Photoresist**

S.-J. Yang, D. M. Lee, J. H. Park, J. J. Kim

LG Chem, Korea

In order to display images close to natural colors, WCG color filter photoresist is one of the most important components in flat panel display devices. In this paper, the development direction and some results for the WCG colorant will be discussed.

FMCp1 - 2 **Withdrawn**

FMCp1 - 3 **Dispersion and Optical Properties of QDPR (Quantum Dot Photo Resist)**

D. Li, L.-X. Chen, H.-H. Chen, Y.-J. Lee

Shenzhen China Star Optoelect. Tech., China

We have studied the dispersity and optical properties of Quantum dot in Photo Resist system, factors affecting dispersion, fluorescence intensity and reliability were found, with a series of attempts .This paper shares some of our experience during our exploration.

FMCp1 - 4 **Design of Optimized OCR Slit-Nozzle for Lamination of Foldable OLED Display with Various Shapes**

B.-C. Lee, D.-S. Hong[*]*, W.-S. Park*[*]*, K.-Y. Han*

Dankook Univ., Korea
[*]*Inha Univ., Korea*

As the display is advanced, it's expected that square-shaped display will develop into various shape. In this case, since the width of substrate isn't uniform, it's difficult to use the conventional slit nozzle. So, we found an optimal nozzle structure that can be used for lamination process of foldable display.

FMCp1 - 5 **To Specialize an Attenuated Phase Shift Mask in DUV Broadband Illumination**

M. Hakko, N. Yabu, M. Ando, N. Izumi, K. Nagano

Canon, Japan

We have focused on use of broadband Deep UV (DUV) illumination to achieve high resolution and productivity of flat panel displays. Specifically, regarding 1.5 μm hole pattern, binary mask cannot give sufficient DOF. To specialize attenuated phase shift mask in DUV achieves to obtain sufficient DOF.

FMCp1 - 6 **TFT Characteristics Improvement by Using Modified Single Slit Mask**

G. Shi, D. Xu, Q. Shen, Y. Wang, J. Zhang, N. Zhao, R. Zhou, Z. Zhang, J. Chen, Y. Youn, S. Lee

BOE HF, China

This paper introduced modified single slit mask (MSM). By using this technology, we can not only solve the PR remain in the conditional single slit mask, but also enhance the TFT electrical characteristics in large TFT device, this kind of large TFT device is normally used in GOA device.

FMCp1 - 7 **Material Deformation by Using New 3 GeV Synchrotron Light Source**

T. Abukawa, W. Yashiro, T. Ejima, M. Watanabe, N. Nishimori, S. Miura, M. Takata, H. Hama

Tohoku Univ., Japan

Synchrotron Radiation (SR) facilities around the world have been recognized as a premier research tool for Nano Technology as well as industrial application including display device technology. A new SR facility, Synchrotron Light in Tohoku, Japan (SLiT-J), has been projected since 2011. Current status and perspectives are being presented.

FMCp1 - 8 **TFT Fabrication Process Using Imprint Lithography for Roll-to-Roll OLED Display Manufacturing**

S. Kim, J. Choi, H. Kim, S. Cho
Sungkyunkwan Univ., Korea

We fabricated oxide TFT with W/L=100/50 μm using 4 imprinted stack resin mask. We used only dry process for dry etching to pattern. The characteristics of the fabricated TFT was as followings: threshold voltage was 1.3 V, subthreshold voltage was 0.77 V/decade, and mobility was 3.8 cm^2/V.

FMCp1 - 9 **Design of LED Lighting for Multi-View Display Application**

Y.-M. Weng, C.-C. Chiu, F.-L. Hsiao
Nat. Changhua Univ. of Education, Taiwan

We designed a two-dimensional photonic crystal periodic air holes array in triangular lattices on LED surface. The shapes of light distribution relate to wavelength and air holes radius. The split angle is particularly significant at a particular radius at different wavelengths. The results of research can apply to LED lighting.

FMCp1 - 10L **Withdrawn**

FMCp1 - 11L **Withdrawn**

I-DEMO
(Innovative Demonstration Session)

Live demonstrations
of emerging information display technologies
by oral and poster presenters
Thursday, Dec. 7, 2017
15:00 – 18:00
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
See page 227 for details

FMCp1 - 12L **Influence of UV-Ozone Treatment on Properties of Poly(3,4-ethyenedioxythiophene)-Tetramethacrylate Prepared on Various Substrate Materials**

S. Tsuji, K. H. Kim, Y. Abe, M. Kawamura, T. Kiba

Kitami Inst. of Tech., Japan

Poly(3,4-ethylenedioxythiophene)-tetramethacrylate (PEDOT-TMA) ultrathin films were prepared on various substrate materials (silicon, quartz, FTO coated glass, ITO coated glass). PEDOT-TMA had high transmittance through all wavelength region of 200-1100 nm. After UV-Ozone treatment, it showed high transmittance and superhydrophilicity regardless of substrate materials.

FMCp1 - 13L **Electrooptical Property of Polymer Stabilized Reverse Mode Cell by Nonuniform UV Irradiation**

R. Sasaki, R. Yamaguchi

Akita Univ., Japan

Polymer stabilized reverse mode cells are prepared by irradiating with UV light through a line-and-space photomask. The polymer density is unevenly distributed in the cell and lower polymer density results in a lower threshold voltage than that prepared using uniform irradiation. High polymer density parts contribute to a mechanical resistance.

15:00 - 18:00 **Exhibition Hall**

Poster FMCp2: Aerial Imaging Optics

Special Topics of Interest on AR/VR and Hyper Reality

FMCp2 - 1 **Omnidirectional Aerial Display with AIRR by Using Multifaceted Beam Splitters**

S. Onose[*], H. Yamamoto[,**]*

[*]Utsunomiya Univ., Japan
[**]JST ACCEL, Japan

This paper proposes an optical design to form an aerial image all around a central viewing region. Our method makes it easy to seamless omnidirectional aerial display and large-size scalability by use of multifaceted beam splitters.

FMCp2 - 2 **Constructing a Sound System As If Sound is Coming from Aerial Image**

K. Fujii, N. Kurokawa, K. Kawai, S. Morita, K. Shimose, R. Kujime, H. Yamamoto

Utsunomiya Univ., Japan

This paper proposes that constructing a sound system that gives a feeling as if sound is coming from an aerial image formed with AIRR. A vibration speaker is attached to a beam splitters or a retro-reflector and use them as speakers to realize the sound coming from the aerial image.

FMCp2 - 3L **Comparisons of Aerial Image Sharpness Formed with AIRR by Use of Retro-Reflectors Made of Glass Beads with Different Refractive Indices**

K. Onuki, H. Yamamoto

Utsunomiya Univ., Japan

This paper reports comparisons in sharpness of aerial images formed with aerial imaging by retro-reflection (AIRR) by use of glass-beads retro-reflectors of which refractive index is 1.9, 2.0, and 2.2. We have measured and compared contrast-transfer functions of aerial image.

15:00 - 18:00 **Exhibition Hall**

Poster FMCp3: Components for Automotive

Special Topics of Interest on Automotive Displays

FMCp3 - 1 **12.3-in. Free-Form Automobile Display with 2BG+R System for Wide Color Gamut**

H. Wu, I.-H. Hsieh, Y. Fu, D. Hsiao

AU Optronics, Taiwan

We have developed a 12.3" free-form display concept enables various in-vehicle designs. By using 2BG+R (It was called 2 blue chip, one green chip and red phosphor). From simulation, the 2BG+R solution in NTSC color gamut is ~6% wider than BG+R. The final module is about 110% NTSC color gamut.

Friday, December 8

13:50 - 15:10 **Meeting Room 3**

FMC5: Electrode Material and Photoresist Technologies

Chair: T. Tomono, Toppan Printing, Japan
Co-Chair: T. Araki, Osaka Univ., Japan

FMC5 - 1: 13:50 ***Invited*** **Enhanced Electrical Durability and Mechanical Stretchability of Ag Nanowire-Based Transparent Electrodes by Nanometer-Thick Metal Plating**

T. Araki, Y. Noda, A. Takemoto, S. Yoshimoto, T. Uemura, T. Sekitani

Osaka Univ., Japan

Ag nanowires (AgNWs) have emerged as a promising nanomaterial for high conductive and high optical transparent electrode. However, AgNW-based components failed on high current. Here, we introduce a fabrication process of uniform plating on AgNW to enhance electrical durability and stretchability in keeping transparency.

FMC5 - 2 14:10 **ITO/Ag Alloy/ITO Structure as Alternative to ITO for Display Electrode**

Y. Toshimori, K. Umemoto, Y. Shirai, I. Shiono, S. Zhang, S. Nonaka

Mitsubishi Materials, Japan

We have developed the original Ag alloy for ITO/Ag/ITO multilayer as alternative to ITO for display electrode. This Ag alloy enables to form stable ultra-thin film, which is important for transparent ITO/Ag/ITO structure. This technology is expected to be applied to various emerging devices such as flexible displays.

FMC5 - 3 14:30 **Identification of Copper Compound Produced in Dry Etching Process under Different Atmosphere and its Removal via a Simple Solution Treatment**

Z.-C. Zhou, H. Xia, F. Long, Z.-W. Tan, X.-B. Hu, X.-W. Wei, W.-W. Zhang, J.-H. Chen, L.-Q. Shi, S. Li, S. Chen, J. Li

Shenzhen China Star Optoelect. Tech., China

A systematic study about the ingredient and morphology change on copper surface under distinct plasma treatment was performed. The results showed that dry etching process would easily influence the copper surface if suitable protective layers were absence. To handle this issue, one useful solution process was proposed.

FMC5 - 4 14:50 **Mechanism of Complex Reliability of Colorant Material for Wide Color Gamut**

A. Kim, S. Ji, J. Kwon, B. Ahn, S. Han, M. Kwak, J. Lee, M. Jun, I. Kang

LG Display, Korea

Color characteristic of green color filter photoresist is degraded in the real liquid crystal display panel under high temperature, high humidity and strong light environments. The mechanism of degradation is structural deformation due to the weak bound between zinc of green pigment G58 and water, which has been experimentally verified.

----- Break -----

15:30 - 16:30 **Meeting Room 3**

FMC6: Glass Material Technologies

Chair: Y. Inoue, Corning Japan, Japan
Co-Chair: K. Tamai, Asahi Glass, Japan

FMC6 - 1: 15:30 ***Invited*** **Application of Glass in Electronic Displays**

K. Hayashi

Asahi Glass, Japan

Glass has been used in the electronic displays from the beginning, that is, the invention of cathode ray tube. In this paper, applications of the glass for modern displays, such as substrates for higher resolution displays, protection of mobile displays and realization of well-designed televisions are described.

FMC6 - 2 15:50 **High Bending Strength Chemically Tempered Cover Glasses for Mobile Display Devices**

Y. Fujiwara, I. Kashima, N. Uemura

Asahi Glass, Japan

Bending strength is one of the most important properties for the thinner cover glasses for mobile display devices in order to prevent the breakage of glass in use. Recently, the high bending strength of both Face and Edge of cover glasses was achieved by our new process.

FMC6 - 3: 16:10 ***Invited*** **Anti-Reflection and Anti-Glare Surface Treatment on Cover Glass for Automotive Interior Applications: Ambient Contrast Consideration**

K. Long, T. Ishikawa, C.-C. Li, A. Lesuffleur

Corning, USA

We investigated optical properties of cover glass with AR and AG treatments with diffused and specular reflectance, and transmission haze. We propose methods to evaluate the ambient contrast ratio taking into account the viewer's experience in Auto Interior applications.

Author Interviews
17:00 – 17:40

Supporting Organizations:
Japan Electronics Packaging and Circuits Association
Japan Society of Colour Material
The Japanese Research Association for Organic Electronics Materials
The Japanese Society of Printing Science and Technology
RadTech Japan
The Society of Photography and Imaging of Japan
The Technical Association of Photopolymers, Japan

Reception

Wednesday evening
Dec. 6, 2017
18:30 – 20:30
Zuiun (2F)
Sendai Shozankan
See page 15 for details

Workshop on Inorganic Emissive Display and Phosphors

Wednesday, December 6

14:50 - 16:00 **Meeting Room 4**

PH1: Phosphors for General

Chair: J. Silver, Brunel Univ. London, UK
Co-Chair: R.-J. Xie , NIMS, Japan

PH1 - 1: 14:50 ***Invited*** **Highly Efficient Laser-Phosphor Light Source for Projector**

H. Morita, Y. Maeda, I. Kobayashi, Y. Sato, T. Nomura, H. Kikuchi

Sony, Japan

We investigated laser-phosphor light source. We focused on the refractive index gap between phosphors and matrix to improve the light extraction efficiency. We calculated relationship between refractive index gap and light extraction efficiency by lay trace simulator. And we also evaluate the new phosphor wheel with high light extraction efficiency.

PH1 - 2 **Withdrawn**

PH1 - 3 15:40 **Formation of Nanophosphors Using Novel Water Assisted Solid State Reaction**

K. Toda, S.-W. Kim[*], T. Ishigaki, T. Hasegawa[**], Y. Abe, Y. Shibuta, K. Uematsu, M. Sato, Y. Kudo[***]

Niigata Univ., Japan
[*]Korea Inst. Ceramic Eng. & Tech., Korea
[**]Kochi Univ., Japan
[***]N-Luminescence, Japan

We reported novel soft chemistry for the preparation of nanophosphors. Novel water assisted solid state reaction (WASSR) method is very simple and can synthesize many phosphor materials just by storing or mixing of raw materials added a small amount of water at low temperature.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 9:50 **Meeting Room 3**

PH2: Phosphors for Lighting Application
Special Topics of Interest on Lighting and Quantum Dot Technologies

Chair: X. Liu, Nat. Univ. of Singapore, Singapore
Co-Chair: T. Kusunoki, Dexerials, Japan

PH2 - 1: 9:00 ***Invited*** **Micro Grain Analysis in the Ce:YAG and Sapphire Co-Crystal Phosphor**

S. Kubota, K. Nakagome, M. Matsukura, Y. Anzai, Y. Furukawa

Oxide, Japan

Based on the Monte Carlo ray trace simulation, quantitative micro grain analysis in the blue laser excited Ce:YAG and sapphire co-crystal phosphor is reported relevant to the excitation absorption enhancement, the fluorescence light spread in the grain structure, the improved thermal conductivity, and the emission extraction efficiency after facet etching.

PH2 - 2: 9:25 ***Invited*** **Towards High-Performance Solution-Processed Light Emitting Didoes Based on Quantum Dots**

Y. Jin

Zhejiang Univ., China

In the past few years, efficiency and lifetime of quantum-dot light-emitting diodes (QLEDs) achieved tremendous progresses. Here we review our activities associated with QLEDs, including material chemistry of charge-transporting layers and optimization and mechanism studies of prototype devices.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster PHp1: Phosphors for General

PHp1 - 1 **Characteristics of Nonpolar ZnO Films Grown on R-Sapphire Substrates Using Catalytically-Generated High-Energy H_2O**

M. Ikeda, S. Ono, Y. Adachi, R. Tajima, A. Kato, K. Yasui

Nagaoka Univ. of Tech., Japan

Optical properties of nonpolar ZnO films grown on r-plane sapphire substrates through the reaction between dimethylzinc (DMZn) and high-temperature H_2O were investigated. The PL spectra indicated anisotropy in polarization between the directions parallel and perpendicular to the c-axis.

PHp1 - 2 **See-Through Phosphor Screens for Display Applications**

T. Kohmoto, M. Ohta, Y. Hirai, S. Ozawa, I. Fujieda, W. Watanabe

Ritsumeikan Univ., Japan

We have fabricated see-through phosphor screens. When excited by an intensity-modulated light, they display images. They might be applied for a head-up display and a volumetric 3D display and their potential advantages are a wide viewing range and a high contrast ratio under illumination, respectively.

PHp1 - 3 **Formation of Photonic Crystal Cavity in SOI Substrate and Emission Characteristics of Quantum Dots**

T. Hayashi, T. Matsutomi, K. Watanabe, Y. Tamayama, A. Kato, K. Yasui

Nagaoka Univ. of Tech., Japan

To increase the light emission intensity from quantum dots, a photonic crystal cavity was fabricated on a SOI substrate using an electron beam lithography. The ion dose quantity was optimized in order to fabricate the photonic crystal cavity in the thin top Si and buried oxide layers precisely.

PHp1 - 4 **Different Transparent and Conductive Substrates Effect on the Structural and Optical Properties of ZnO Nanorods**

C. Li, Q. Zhang, L. Xie

Kochi Univ. of Tech., Japan

The ZnO nanorods were fabricated on the different transparent and conductive substrates by a multiple annealing process. It was found that the vertically alignment of ZnO nanorods with higher transmittance depends on the crystallinity of substrates. The strong green emission peak was observed from obtained ZnO nanorods .

PHp1 - 5L **Withdrawn**

PHp1 - 6L **Single Phase Preparation of Eu Doped $Sr_4Al_{14}O_{25}$ Afterglow Phosphor by Boron-Free Synthesis Method**

K. Hada, H. Kominami, K. Hara, Y. Nakanishi

Shizuoka Univ., Japan

$Sr_4Al_{14}O_{25}$:Eu,Dy phosphor showed high stability and brightness. It has been explored the method to prepare single phase $Sr_4Al_{14}O_{25}$:Eu phosphor with NH_4Cl as a flux instead of boron oxide. $Sr_4Al_{14}O_{25}$ phase was obtained by using NH_4Cl, and $Sr_4Al_{14}O_{25}$:Eu emission was obtained mainly.

PHp1 - 7L **Luminescent Properties of Alkaline-Earth Metal Substituted $Sr_2MgSi_2O_7$:Eu Phosphors**

M. Ohkawa, H. Kominami, K. Hara, Y. Nakanishi

Shizuoka Univ., Japan

$Ca_XSr_{(2-X)}MgSi_2O_7:Eu^{2+}$ for afterglow phosphor by changing Ca ratio was investigated to aim for improvement of better visual sensitivity and phosphorescent property. In addition, $(Ca,Sr)_2MgSi_2O_7:RE^{3+}$ (RE = Dy, Tm and Sm) phosphors were prepared and investigated the formation of the trap level.

PHp1 - 8L **Atomic Distribution of $ZnAl_2O_4$ Thin Film Prepared by Thermal Diffusion of ZnO on Sapphire Substrate**

K. Kijima, T. Ito, H. Kominami, Y. Nakanishi, K. Hara

Shizuoka Univ., Japan

$ZnAl_2O_4$ thin-film for ultraviolet emitting phosphor was prepared by deposition of ZnO on c-sapphire substrate and thermal diffusion. $ZnAl_2O_4$ phase was formed by annealing process, however excess annealing occurred thinner $ZnAl_2O_4$ layer because of Zn removal. The correct thickness and atomic distributions of the film were confirmed by FE-SEM measurement.

PHp1 - 9L **Luminescent Properties of Deep Red Emitting Mn^{4+}-doped $(La,Y)_2Mg(IV)O_6$ Phosphors**

Y. Kato, H. Kominami, K. Hara, Y. Nakanishi

Shizuoka Univ., Japan

$La_2MgTi_{0.99}O_6:Mn^{4+}_{0.01}$ was prepared by substituting Y in La-site, and Ge or Si in Ti-site in the crystal. Replacing La with Y, PL peak was shifted to shorter. PL intensity was improved by substituting with Ge. Using vacuum ultraviolet for excitation, broad emission spectrum was obtained by Si substitution.

15:00 - 18:00 **Exhibition Hall**

***Poster* PHp2: Phosphors for Lighting Application**

Special Topics of Interest on Lighting and Quantum Dot Technologies

PHp2 - 1 **Light Extraction from a Laser-Pumped Phosphor Layer with a Remote Reflector**

M. Ohta, I. Fujieda

Ritsumeikan Univ., Japan

A phosphor layer emits light in both forward and backward directions when excited by a laser beam. A reflector attached to the phosphor reverses the forward emission, which then propagates the material. The self-absorption loss during this process is alleviated by a patterned phosphor layer with a remote reflector.

PHp2 - 2L **Mixed Fluoride Based Nanophosphors Synthesized Using a Hydrothermal Method for Photodynamic Therapy of Malignant Tumors**

A. M. Dorokhina[,**], V. V. Bakhmetyev[*], M. M. Sychov[*], H. Kominami[**], K. Hara[**], Y. Nakanishi[**], H. Mimura[**]*

[*]St. Petersburg Inst. of Tech., Russia
[**]Shizuoka Univ., Japan

Finely dispersed $NaGdF_4$:Eu and YF_3:Yb,Er phosphors are synthesized by hydrothermal method in ethylene glycol medium and effect of hydrothermal treatment on their phase composition, dispersity and luminescent performances is studied. Phosphors synthesized by using this method allow the preparation of stable colloid solutions and can be used for photodynamic therapy.

PHp2 - 3L **Improved Photostability of Tetramethyl Orthosilicate-Modified InP/ZnS Quantum Dots**

T. Watanabe, Y. Iso, T. Isobe, H. Sasaki[*]

Keio Univ., Japan
[*]Shoei Chem., Japan

InP/ZnS QDs shelled by silica derived from tetramethyl orthosilicate were prepared under hydrophobic condition. Silica shelled QDs showed higher photostability than original QDs. This was because silica shell suppressed QD oxidation by oxygen in air.

Supporting Organizations:
The 125th Research Committee on Mutual Conversion between Light and Electricity, Japan Society for Promotion of Science
Phosphor Research Society, The Electrochemical Society of Japan

Workshop on OLED Displays and Related Technologies

Wednesday, December 6

13:10 - 14:40 **Main Hall**

OLED1: OLED Displays and Devices

Chair: H. Kuma, Idemitsu Kosan, Japan
Co-Chair: T. Fukuda, Saitama Univ., Japan

OLED1 - 1: *Invited* 13:10 High Performance Full Color AMOLED Microdisplays for AR/VR

T. Ali, E. Donoghue, I. Khayrullin, I. Wacyk, K. Tice, F. Vazan, O. Prache, Q. Wang, L. Sziklas, A. Ghosh

eMagin, USA

We present eMagin's full color high brightness AMOLED microdisplays fabricated with new RGB direct pattern technology on WUXGA and 2K×2K resolution backplanes with >5,000 cd/m^2 and enhanced wide color gamut (133% sRGB). These developments are aimed at next-generation AR and VR applications. Electrical and optical test results will be presented.

OLED1 - 2 13:30 Head-Mounted Display Optical Simulation by Using an OLED Panel with Quasi-Crystal Structure

Y.-D. Chen, K.-D. Chang[*]*, C.-Y. Li, J.-W. Pan, K.-Y. Cheng*[*]

Nat. Chiao Tung Univ., Taiwan
[*]*ITRI, Taiwan*

Organic light-emitting diodes (OLEDs) with a quasi-crystal (QC) structure are analyzed and applied in a head-mounted display (HMD) system in this study. We adopt a hybrid simulated method to evaluate the light extraction efficiency (LEE) and far-field pattern in the air, and study the relationship between them.

OLED1 - 3: *Invited* 13:50 High Performance Organic Light-Emitting Diode Using Exciplex-Triplet Energy Transfer Technology and Its Application

S. Seo, S. Shitagaki, N. Ohsawa, H. Inoue, M. Takahashi, K. Suzuki, D. Kubota, S. Yamazaki

Semiconductor Energy Lab., Japan

Organic light-emitting diodes (OLEDs) utilizing energy transfer from an excited complex (exciplex) to a phosphorescent dopant simultaneously achieve extremely high quantum efficiency, low drive voltage, and long lifetime. This paper reviews such a device architecture named "exciplex-triplet energy transfer" (ExTET) and introduces OLED displays with the ExTET technology.

OLED1 - 4L 14:10 **Novel Transparent Oxide Semiconductor, Zinc Silicates, for Electron Injection/Transport Layers in OLEDs**

H. Hosono[*], N. Nakamura[,**], H. Yang[*], J. Kim[*]*

[*]Tokyo Tech, Japan
[**]Asahi Glass, Japan

Highly transparent zinc silicate thin films with a work function of 3.5 eV and electron mobility of 1 cm^2/Vs were developed for EIL/ETL. These materials form an Ohmic contact with Al and ITO. The origin of such exceptional properties and application to inverted tandem OLED are reported.

OLED1 - 5L 14:25 **Low Temperature Formation of SiNx Encapsulation Films by Remote Plasma Enhanced Chemical Vapor Deposition**

S. Higashi, M. Wei, T. Kanamaru

Hiroshima Univ., Japan

SiNx films for encapsulation of organic layers were formed by remote plasma enhanced chemical vapor deposition (RPECVD). Lowering the deposition temperature to 80°C decreases film density, nevertheless, the water vapor transmission rate (WVTR) significantly decreases to below 1×10^{-6} $g/m^2/day$ by increasing the fixed charge density as high as 6.5×10^{12} cm^{-2}.

----- Break -----

14:50 - 16:20 **Main Hall**

OLED2: OLED Materials

Chair: Y. Kijima, Huawei Techs., Japan
Co-Chair: T. Wakimoto, Merck PM, Japan

OLED2 - 1: 14:50 ***Invited*** **Current Understanding of Mechanism of Thermally Activated Delayed Fluorescence: RISC beyond S-T Energy Gap**

T. Hosokai, H. Matsuzaki, H. Nakanotani[*], C. Adachi[*]

AIST, Japan
[*]Kyushu Univ., Japan

A mechanism of thermally activated delayed fluorescence (TADF) beyond the ordinary discussion of reverse intersystem crossing (RISC) determined by the energy gap between excited singlet (S_1) and triplet (T_1) states is introduced. A new design strategy of highly efficient TADF materials will also be proposed.

OLED2 - 2: 15:10 ***Invited*** **Towards Commercialization of High-Efficiency Blue in OLEDs**

T. Baumann, D. Zink

CYNORA, Germany

After introducing thermally activated delayed luminescence (TADF) conceptually, we give a status report concerning blue OLEDs based on this technology, which includes the presentation of several new blue TADF-based emitters, reaching >20% EQE at 1000 nits with lifetimes LT97 of >90 h.

OLED2 - 3: 15:30 ***Invited*** **Effect of Energy Transfer on Operational Lifetimes of Organic LEDs**

H. Fukagawa, Y. Iwasaki, T. Shimizu

NHK, Japan

This study focuses on operational lifetime of OLEDs which is of great significance for practical applications. The operational lifetimes of phosphorescent OLED are demonstrated to be dominated by Förster resonance energy transfer rate from the host to the dopant by analyzing the device characteristics of several OLEDs utilizing similar hosts.

OLED2 - 4L: 15:50 ***Invited*** **Development of Printed, High-Performance Polymer TFTs Towards Low-Cost Backplane Production**

A. Morley, G. Lloyd, M. Charbonneau[*], D. Locatelli[*], S. Lombard[*], C. Laugier[*], L. Tournon[*], S. Bain, M. James, T. Wakimoto[**]

Merck Chems., UK
[*]CEA, France
[**]Merck PM, Japan

We present Merck's new formulation and material developments enabling high-throughput techniques to be used for cost-effective electronic circuitry and backplane production. Performance at TFT array level greater than 2 cm^2/Vs is demonstrated at Gen1 scale and 50 ppi resolution, using a combination of conventional photopatterning steps and direct gravure printing.

OLED2 - 5L 16:05 **Photo-Degradation of Hole Transport Materials Studied by LDI-TOF Imaging**

S.-C. Dong, C. W. Tang[,**]*

[*]Hong Kong Univ. of S&T, Hong Kong
[**]Univ. of Rochester, USA

LDI-TOF imaging was utilized to map the material composition changes in UV-degraded thin films of amine-based hole transport materials. Byproducts resulted from C-N bond cleavages were successfully identified even when their mass signals overlap with fragments induced by laser bombardment.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:20 **Main Hall**

OLED3: OLED Advanced Technology (1)

Chair: T. Shimizu, NHK, Japan
Co-Chair: T. Ikuta, JNC, Japan

OLED3 - 1: 9:00 ***Invited*** **Importance of Chamber Environment for Stable OLEDs**

H. Fujimoto[,**], T. Suekane[***], K. Imanishi[***], S. Yukiwaki[*], H. Wei[***], K. Nagayoshi[*], M. Yahiro[*,**,****], C. Adachi[*,**,****]*

[*]Fukuoka i3-Ctr. for Organic Photonics & Elect. Res., Japan
[**]Kyushu Univ., Japan
[***]Sumika Chem. Analysis Service, Japan
[****]Inst. of Sys. Info. Tech. & NanoTech., Japan

We evaluated the influence of impurities in the vacuum chamber used for device fabrication on the lifetime of OLEDs and found a correlation between lifetime and the amount of impurities. Our results suggest that vacuum chamber environment impacts lifetime and reproducibility.

OLED3 - 2 9:20 **Analysis for Carrier Behavior of OLED Device with Pixel-Defining Layer by Impedance Spectroscopy**

T. Naganuma, C.-C. Ma, T. Sasaki, T. Uemura, M. Adachi

Japan Display, Japan

We investigated the carrier injection properties of an OLED device with a pixel-defining layer (PDL) by impedance spectroscopy. Comparing the devices with and without the PDL, we clarified that PDL induces leakage through the highly conductive layer of the device, which affects the OLED property.

OLED3 - 3 9:40 **The Atmosphere Dependence of Annealing for Anode of OLED**

Y. Hayashi, R. Mori, Y. Shirai, S. Komiyama, I. Shiono, S. Zhang

Mitsubishi Materials, Japan

The influence of annealing atmosphere on the optical characteristic of ITO and Ag alloy stacked layer was evaluated for the anode of OLED. It was found that the reflectivity was improved by anneal in N_2, and the degree of improvement differed according to the type of Ag alloy.

OLED3 - 4 10:00 **Highly Reflective Semi-Transparent Cathode for Highly Efficient Top Emission OLED Devices**

S. K. Kim, M. J. Park, M. G. Song, J. H. Kwon
Kyung Hee Univ., Korea

In this work, we report a new highly reflective semi-transparent cathode unit. Our new cathode shows transmittance of 60% and reflectance of 32%. The fabricated blue and yellow TEOLEDs with new cathode exhibit 3.1 and 90.0 cd/A, respectively. These results have the enhancement efficiency accordance with cathode.

----- Break -----

10:40 - 12:00 **Main Hall**

OLED4: OLED for Lighting Applications
Special Topics of Interest on Lighting and Quantum Dot Technologies

Chair: S. Naka, Univ. of Toyama, Japan
Co-Chair: K. Monzen, Nissan Chem. Inds., Japan

OLED4 - 1: 10:40 ***Invited*** **High-Efficiency and Stable Light-Emitting Diodes Based on Quantum Dots**

X. Yang, F. Cao
Shanghai Univ., China

This study reports highly efficient and stable quantum dot light-emitting diodes (QLEDs) based on solution processed metal-oxide films as hole injection layer (HIL). The best-performing device with Cu:NiO HIL exhibits superior performance compared to the state-of-the-art PEDOT:PSS-based QLEDs.

OLED4 - 2 11:00 **Development of High Transmittance, Low Sheet Resistance and High Thermal Stability Transparent Cathode Technology**

S. Ootsu, K. Tani, T. Suzuki
Konica Minolta, Japan

With the surge for top emission OLED, development of transparent cathode with high transmittance and low resistance is awaited. We developed our proprietary organic material that have strong interaction with Ag. Using this material, transmittance and sheet resistance were significantly improved. In addition, we could also achieve high thermal stability.

OLED4 - 3
11:20

Enhancement of Out-Coupling Efficiency on OLED with the Improved Charge Balance Using ZnO Nanoparticle Dispersed Electron Transport Layer

S.-J. Park, H.-J. Kim, S.-H. Jang, K.-Y. Lee, Y.-J. Kim

Yonsei Univ., Korea

We propose new method for the enhancement of electron mobility by developing a novel layer structure and the coating process of ETL dispersed with ZnO NPs. Our new ETL layer was prepared with the uniform dispersion of ZnO NPs and the OLED devices show the enhanced performance.

OLED4 - 4
11:40

High Efficiency Large Area White Organic Light-Emitting Diodes Using Phosphorescent Materials — Degradation and Stability Improvement

M. Seetharaman, A. Mohan, A. Awasthi, S. Bindu, G. Garg, J. Meenakshinathan, K. Manohara, M. Balakrishnan, M. Katiyar

Indian Inst. of Tech., India

Large area white phosphorescent OLED lighting panels of different sizes were fabricated on rigid and flexible glass with power efficiencies varying from 30 to 48 lm/W. Operational lifetime performance and degradation were investigated. Blue phosphorescent dopant was found responsible for short operational lifetime. Hybrid WOLED with improved lifetime was developed.

Also presented in Innovative Demonstration Session (see p. 227)

----- Lunch -----

13:10 - 14:25 **Main Hall**

OLED5: OLED Advanced Technology (2)

Chair: T. Komatsu, JOLED, Japan
Co-Chair: Y. Sakai, Mitsubishi Chem., Japan

OLED5 - 1
13:10

Hyper Spectral Photometry Technology

Y. Izaki, T. Okasaki, K. Komatsu, K. Nishimura, M. Higashimura, Y. Kamei, S. Fujii

Topcon Technohouse, Japan

We developed 2D spectroradiometer which can perform spectral measurement of chip-size light-emitting surface and pixel of OLED, LCD and Micro LED at high resolution. Measurement examples of color uniformity and defect detection using spectral image are introduced.

OLED5 - 2 13:30 **Vision Assessment of OLED Wall-Paper Display and Curved Quantum Dot LCD**

Q.-L. Wu, Y.-T. Hsiao, H.-S. Chen, P.-L. Sun, R. Luo

Nat. Taiwan Univ. of S&T, Taiwan

Two psychophysical experiments for comparing an OLED wall-paper display (OWP) with a curved QD-LCD were conducted. Experiment 1 used real displays for the visual comparison. Experiment 2 used a VR head-set to simulate a living room for the investigation. The results indicated that the OWP is superior to the QD-LCD.

OLED5 - 3 13:50 **Potential Cardiac Autonomic Derangement by Oscillatory OLED Light**

E. Yuda, H. Ogasawara, Y. Yoshida, J. Hayano

Nagoya City Univ., Japan

Possibility of cardiac autonomic derangement by oscillatory OLED light was examined. While exposure to oscillatory (0.1 Hz) light caused no significant changes in any autonomic indices of heart rate variability (HRV), it increased the peak HRV power around 0.1 Hz, suggesting resonance in heart rate with oscillatory light.

OLED5 - 4L: 14:10 ***Invited*** **Vertically-Stacked Polychromatic OLED and Three-Dimensionally Integrated Organic Electronics Enabled by the Technology**

T. Tsujimura, K. Omata, T. Yagi[*], K. Sato, T. Hakii[*], K. Ando[*], T. Miyasaka[*]

Konica Minolta Pioneer, Japan

[*]Konica Minolta, Japan

Vertically-stacked OLED was developed using highly conductive/ transmissive silver intermediate electrode. An equation to control the film continuity was obtained and verified by three parameters. The structure could bring about various merits to display structures. Combining with non-emissive organic devices, new functionality on the OLED displays can be obtained.

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* OLEDp1: OLED Poster**

OLEDp1 - 1 **Different Pretreatment Effects on the Hydrophobicity of Inkjet Printing Pixel Define Layer**

J. Tang[,**], X.-X. Zhang[*,**], Y.-W. Liu[*,**], Z.-S. Liu[*,**], J.-S. Im[*,**]*

[*]Nat. Eng. Lab., China
[**]Shenzhen China Star Optelect. Semiconductor Display Tech., China

Hydrophobic surface of PDL prepared by organic hydrophobic photoresist material is applied to Inkjet printing AMOLED. We discuss some pretreatments on PDL, the hydrophobicity is destroyed by UV light and plasma ashing. While the other pretreatments have little impact. A prototype of IJP-AMOLED was demonstrated with high hydrophobicity PDL.

OLEDp1 - 2 **A Study on Self-Healing for Full Recovery against Scratches on OLED Display Surface**

D. H. Jang, B. M. Park, K. Y. Han, K. H. Kwon[*], M. Ree[*]

Dankook Univ., Korea
[*]Pohang Univ., of S&T, Korea

Self-healing polymer is one of the representative system of biological self-healing and repair in nature. It is a functional material that heals scratches and damages from the external environment itself to recover the original function.

OLEDp1 - 3 **Novel Silane Core Hosts for Highly Efficient Blue Thermally Activated Delayed Fluorescence OLEDs**

J. S. Moon, S. W. Kim, J. H. Kwon

Kyung Hee Univ., Korea

We report three new host materials containing silane core with carbazole as a donor and pyridine as an acceptor moiety. They have proper triplet energies available to apply with blue thermally activated delayed fluorescence. Fabricated devices show maximum external quantum efficiency of 18.8%.

OLEDp1 - 4 **A New Treatment Method to Prevent Dark Spots in Flexible Organic Light-Emitting Diodes**

B. M. Park, K.-S. Kim, K.-Y. Han

Dankook Univ., Korea

We investigated the characteristics of hydrophobic-based polymer (HPP) film for thin film encapsulation (TFE) on organic light-emitting diode (OLED). HPP films exhibited excellent permeation barrier properties of the water because of hydrophobic and low surface energy. In OLED devices, HPP was observed to prevent dark spot growth of emitting area.

OLEDp1 - 5 Color Shift and Jagged Edge Solutions in Freeform LCD and OLED

Z. Xu, K. Xi, B. Lin, X. Li, J. Liu, F. Qin

Shanghai Tianma Microelect., China

This paper promote a novel BM block pattern design method to solve color shift and jagged edge display in Freeform LCD and OLED. In this paper, I take TN, IPS, RGBW and OLED for examples to state my method. Good agreement with experiment is obtained in products mass production.

OLEDp1 - 6 Study of Organic Light-Emitting Diodes Efficiency with Binary Fluorescence Dye Photo Resist of Color Conversion

S. Kim, S. Lee, Y. Kim, M. Kwak, J. Lee, M. Jun, I. Kang

LG Display, Korea

We suggested additional layer of binary FD (fluorescence dye) as photo-resist (PR) between white OLED and color layer. By energy transfer mechanism in two components, this binary dye system shows BT.2020 coverage of 90% and 15% higher luminous efficacy in comparison with conventional single dye system.

OLEDp1 - 7 Analysis of Indium Diffusion Phenomenon in OLED

H. Anamizu, T. Sasaki, H. Seki, M. Toyokawa[*]

Hachinohe Inst. of Tech., Japan
[*]ANOVA, Japan

In future, it is necessary to further extend the reliability of OLED. In this paper, it shows that indium diffusion in the device is a cause of deterioration of OLED and can be suppressed by selecting the acid in the etching process.

OLEDp1 - 8L Efficient Hole-Buffering Layer for PLEDs: A 1,2,4-Triazolyl Derivative with Multi-Imine Groups

Y. Chen, C.-Y. Lin, S.-F. Lin

Nat. Cheng Kung Univ., Taiwan

A new hole-buffering material TAZS, consisting of 1,2,4-triazolyl core and three imine groups, were prepared and applied in polymer light-emitting diodes to promote charge balance. Inserting TAZS between hole-injecting PEDOT:PSS and emitting layers effectively buffer holes to enhance charge recombination ratio and emission efficiency.

OLEDp1 - 9L Large-Area Flexible OLED Fabricated by Full Roll-to-Roll Processes from Transparent Electrode to Encapsulation

S. M. Cho, C. Kim, E. Jung, G. Y. Han

Sungkyunkwan Univ., Korea

Large-area flexible OLED panels were successfully fabricated by a roll-to-roll vacuum evaporation method. The OLED panels were fabricated on silver-nanowire (AgNW) transparent electrodes prepared on polyethylene terephthalate (PET) film by a roll-to-roll process.

Also presented in Innovative Demonstration Session (see p. 227)

OLEDp1 - 10L **Improvement in Power-Conversion Efficiency of OPV Cells Using UV-Modified Surface Patterning Method**

W. Mizuguchi, Y. Iimura

Tokyo Univ. of A&T, Japan

We have improved the power conversion efficiency (PCE) of organic photovoltaics (OPV) by using selective deposition of pentacene on a UV-modified patterned surface. We clarify OPV samples with controlled pn junction structure shows large improvement in PCE, which may be due to increase in dissociation ratio of photo-created excitons.

15:00 - 18:00 **Exhibition Hall**

***Poster* OLEDp2: OLED/LIT Poster**

Special Topics of Interest on Lighting and Quantum Dot Technologies

OLEDp2 - 1 **High Efficiency and Long Lifetime Electron Transporting Materials for OLED Devices and Lighting Applications**

H.-L. Huang, P.-W. Hsu, C.-C. Lai, C.-J. Lin

eRay Optoelect. Tech., Taiwan

A series of new electron transporting materials with good thermal stability were designed and developed. The devices of these ETs applied in fluorescent blue devices, exhibited high efficiency and long lifetime with efficiency of 10.8 - 11.2 cd/A and the LT95 lifetime is around 245 - 400 h under 1000 cd/m^2.

OLEDp2 - 2L **Withdrawn**

OLEDp2 - 3L Efficiency Enhancement for Patterned Quantum Dot-Converted White OLED Display Using Photoresist Dispersed TiO_2

H.-J. Kim, J.-H. Kim, Y.-H. Kim, M.-S. Kwak*, J.-H. Lee*, Y.-J. Kim*

Yonsei Univ., Korea
**LG Display, Korea*

We applied TiO_2 nanoparticles to patterned quantum dot (QD)-converted white OLED display to enhance the optical efficiency using scattering effect. In experimental data, optical intensity of red light in white OLED was increased by 32.1% with only QD layer and 52% with both QD and TiO_2 layers.

Supporting Organizations:
The Japan Society of Printing Science and Technology
The Society of Photography and Imaging of Japan

Workshop on 3D/Hyper-Realistic Displays and Systems

Wednesday, December 6

14:50 - 16:10 **Tachibana Conference Hall**

3D1/DES2: 3D Display in AR/VR and Hyper Reality

Special Topics of Interest on AR/VR and Hyper Reality

Chair: T. Koike, Hosei Univ., Japan
Co-Chair: H. Okumura, Toshiba, Japan

3D1/DES2 - 1: 14:50 ***Invited*** **Development of 55-in. 8K-3D IPS LCD with 3D Polarization Filter**

J. Maruyama, R. Oke, T. Murakoso, I. Hiyama, Y. Kato, Y. Umezawa[*], T. Sato[*], T. Takahashi[*], H. Yamashita[**], K. Tanioka[**], T. Chiba[**]

Panasonic Liquid Crystal Display, Japan
[*]Arisawa Manufacturing, Japan
[**]Kairos, Japan

We have developed the world's first (*) 8K-3D IPS -LCDs with a 3D polarization filter. In addition to super-high resolution of 8K, it provides a sense of depth by stereo-vision. It enables 8K-3D surgical systems for endoscopic and microscopic surgeries. (* As of March 2017, our study)
Also presented in Innovative Demonstration Session (see p. 227)

3D1/DES2 - 2: 15:10 ***Invited*** **A Virtual Reality Display Based on Cluster-Eye Image Stitching**

H. Yen, C. Lin, G.-D. J. Su

Nat. Taiwan Univ., Taiwan

In this paper, we present a virtual-reality display which combines the principles of optical cluster eyes and insects' compound eyes. The system consists of two curved lens arrays to focus the image on the retina. The thickness of our optical system is less than 30 mm and it provides a field of view of up to 150° per eye. Using a 3D printer, the design is demonstrated experimentally.

3D1/DES2 - 3 15:30 **Holographic Augmented Reality Head-Mounted Display with RGB Full HD Microdisplay**

Y.-T. Kim, J. Seo, W. Seo, G. Sung, J.-S. Chung, B. Shin, C.-K. Lee, J. An, S. Kim, H. Song, Y. Kim, H. Kim, C.-S. Choi, Y. Kim, K. Won, S.-H. Lee, C. Yoo, H.-S. Lee, S. Hwang

Samsung Elect., Korea

We realized a holographic AR head-mounted display with RGB full HD microdisplay. We confirmed the real augmented reality which perfectly matches virtual images to the real world. Further, the pixel mapping algorithm based on multi-layer in computer generated holography processing is proposed for the holographic image enhancement.

3D1/ DES2 - 4 15:50 **An Augmented Reality Display System**

X. Ma, N. Wu, X. Liu, Q. Zeng, X. Zhang
BOE Tech. Group, China

Augmented Reality (AR) is a technique that add additional information to real world. We are concerned with the implementation of the drive scheme and the signal processing section. In the paper we will describe optical design, drive scheme, pixel distortion correction and compensation in three aspects.

Author Interviews
16:20 – 17:00

Thursday, December 7

15:00 - 18:00 **Exhibition Hall**

***Poster* 3Dp1: 3D and Hyper Reality Systems**

3Dp1 - 1 **Fast System Calibration of Multi-Camera for Foot Scanner**

D.-Y. Lai, W. Huang, Y.-L. Liu, T.-H. Lin
Nat. Taiwan Univ. of S&T, Taiwan

This paper presents a fast system calibration of multi-camera that allows you to quickly calibrate multi-cameras at the same time. Once the camera is used in the system, it is necessary to be calibrated, whether it is used for image recognition or scan reconstruction. We utilize known-size block for calibration.

3Dp1 - 2 **Inner Profile Reconstruction Pipes Using Dual Omni-Directional Mirror and a Laser**

C.-M. Kuo, T.-H. Lin
Nat. Taiwan Univ. of S&T, Taiwan

Nowadays, inner profile measurement is widely used in automotive and surveillance industries. As a scanning instrument, its size can be minimized to be an ear-duct scanner for medical application and earphone market. To serve the need, we propose a prototype of inner profile scanner for obtaining 3D surface in pipes.

3Dp1 - 3 **Manipulating Perceived Depth on Kinetic Depth Effect by Image Switching**

I. Kanayama, S. Suyama, H. Mizushina
Tokushima Univ., Japan

We have successfully manipulated order and magnitude of perceived depth using Kinetic Depth Effect (KDE) by switching two images repeatedly. Although perceived depth order is ambiguous on KDE, we stabilized depth order when two-image movements have identical and vertical direction, and manipulated perceived depth by changing combination of movement amplitude..

3Dp1 - 4 **A Flexible Pipeline from a Multi-View Camera to an Integral 3D Display**

T. Oooka, K. Takahashi, K. Hara[*], M. Katayama[*], M. Kawakita[*], T. Fujii

Nagoya Univ., Japan
[*]NHK, Japan

We have developed a flexible pipeline from a multi-view camera to an integral 3D display. The camera is used to obtain not only multi-view images but also depth maps from each viewpoint with the aid of structured illumination. The foreground object can be extracted and displayed with desired pop-out.

Also presented in Innovative Demonstration Session (see p. 227)

3Dp1 - 5 **The Implement of Head-Mounted Display Based on Curved Holographic Combiner**

C.-C. Yang[*], W.-K. Lin[,**], B.-S. Lin[**], W.-C. Su[*]*

[*]Nat. Changhua Univ. of Education, Taiwan
[**]Nat. Chiao Tung Univ., Taiwan

In this study, we used holographic optical element (HOE) to design a head-mounted display (HMD) system. A simple imaging system was employed to produce a virtual image. An HOE as a combiner was employed to guide the image into human eye. The distortion caused by HOE was analyzed and compensated.

3Dp1 - 6 **A 2x2 Waveguide Holograms Attached on LCD Panel for a Multi-Function Display**

W.-T. Liu[*], W.-K. Lin[,**], B.-S. Lin[**], W.-C. Su[*]*

[*]Nat. Changhua Univ. of Education, Taiwan
[**]Nat. Chiao Tung Univ., Taiwan

This research presents a display system which offers 2D information via a liquid crystal display and simultaneously offers 2×2 3D images via a waveguide and 4 holograms. The human-computer interaction function was practiced by using the touch panel. The device can display these 4 holographic 3D images without crosstalk.

Also presented in Innovative Demonstration Session (see p. 227)

3Dp1 - 7 **Color Compact Head-Mounted Holographic Display Using Laser Diodes**

H. Kubo, Y. Oguro, Y. Sakamoto

Hokkaido Univ., Japan

We designed a compact color head-mounted holographic display (HMHD) using laser diodes as a confirmed proof-of-concept device. Our test indicate that it will be the smallest and lightest color HMHD in the world. It is brighter and has a higher resolution than a conventional HMHD.

Also presented in Innovative Demonstration Session (see p. 227)

3Dp1 - 8 **The Combination of the Dynamic 3D Display System and 2D Liquid Crystal Display**

W.-K. Lin[,**], B.-S. Lin[*], W.-C. Su[**]*

[*]Nat. Chiao Tung Univ., Taiwan
[**]Nat. Changhua Univ. of Education, Taiwan

In this paper, a hybrid display was designed to offer 2D image via a liquid-crystal display (LCD) and offer a holographic 3D image via a spatial light modulator (SLM). The position of the 3D image can be moved by finger touch. The computer-human interface was practice by leap motion.

3Dp1 - 9 **An Efficient Backlight Design for Directional Backlight Autostereoscopic Display**

K. Li, X. Chen, Y. Zhou, H. Zhang, C. Chen[*], H. Fan[*], J. Wang, J. Zhou

Sun Yat-Sen Univ., China
[*]Guangzhou Midstereo Tech., China

The design requirement has a great difference between 2D display and autostereoscopic display. An efficient backlight is designed for directional backlight autostereoscopic display. With suitable light guide, reflector and diffuser, the system realized high luminance, low crosstalk, full resolution and good uniformity.

Also presented in Innovative Demonstration Session (see p. 227)

3Dp1 - 10 **Optical Plate-Free Low Signal-to-Noise 3D Display Using Micro Striped-LED Arrays**

H. Shim, W. Jang, K. Lee, D. Lee, Y. Kim, S. Kim, B. Han

Korea Photonics Tech. Inst., Korea

We substituted parallax barrier-BLU with micro striped-LED arrays to form autostereoscopic viewing zone for 3D displays, thereby eliminating optical-plate and simplifying the module structures. Developed display size is ~4" in diagonal and is composed of several micro striped-LED sources arrayed longitudinally by bonding package.

3Dp1 - 11 **Using Higher Resolution and Lower Bit-Depth Panels for Stacked-Layer Light-Field Display**

Y. Kobayashi, K. Takahashi, T. Fujii

Nagoya Univ., Japan

We propose a stacked-layer light-field display consisting of higher-resolution and lower bit-depth panels as the layers than the conventional. The higher resolution decreases the blurriness of an object with a large amount of pop-out. The lower bit-depth of the layers reduces the total number of bits of the display.

3Dp1 - 12 **Enhancement of Depth of Field in Integral Imaging System by Liquid Crystal Coaxial Bifocal Lens Array**

W.-Y. Lu, B.-H. Song, C.-J. Hsu[*]*, C.-R. Sheu*

Nat. Cheng Kung Univ., Taiwan
[*]*Nat. Changhua Univ. of Education, Taiwan*

A proposed method to enhance the depth of field (DoF) in integral imaging system is demonstrated that a liquid crystal (LC) coaxial bifocal lens array (CBLA) is used to generate two central depth planes. The improvements of DoF are compared between the LC CBLA and the conventional LC lens array.

3Dp1 - 13L **Examination of Computation and Subjective Test Result for Depth Distance in Integral Photography**

A. Nagano, Y. Katayose, S. Yano, M.-C. Park[*]

Shimane Univ., Japan
[*]*KIST, Korea*

The integral photography was generated from a multi-view stereoscopic image in the case of setting the fixation point. The distortion of depth distance was examined using a computation method and subjective evaluation. As a result, the linearity of the depth distance is kept around the fixation point.

3Dp1 - 14L **Coding Performance of Integral 3D Images Using Multiview Images with Depth Map**

K. Hara, H. Watanabe, M. Kano, M. Katayama, T. Fujii[*]*, M. Kawakita, T. Mishina*

NHK, Japan
[*]*Nagoya Univ., Japan*

To develop video coding for integral 3D images, we subjectively evaluated compression performance obtained when coding all multiview images and coding fewer images including depth maps. The results suggest that coding fewer multiview images, including depth maps, is a better way to obtain high compression performance than coding all images.

3Dp1 - 15L **Pseudo-Focus Position Change in Bifocal LC Lens by Changing Polarization Angle**

R. Sasaki, H. Mizushina, S. Suyama

Tokushima Univ., Japan

The bifocal liquid-crystal lens can change its pseudo-focus position by rotating polarizer. This change is derived from confusion of converging and diverging lights from two focuses like caustic plane of aberration. Even at middle polarization angle of two focuses, pseudo-focus position is changed to almost middle of two focuses.

3Dp1 - 16L **High-Speed and High-Definition 3-D Holographic Movie Playback Using SSD and DMD without the Use of Cache Memory**

N. Takada, M. Tao, H. Sannomiya, T. Sakaguchi, Y. Maeda, H. Nakayama[*], M. Oikawa, T. Kakue[**], T. Shimobaba[**], T. Ito[**]

Kochi Univ., Japan
[*]Nat. Astronomical Observatory of Japan, Japan
[**]Chiba Univ., Japan

We propose high-speed 3-D holographic movie playback including the reproduction of computer- generated holograms from the compression data stored in solid state drive. Consequently, we succeeded to playback high-definition movie of the 3-D object comprising about 900,000 points at 30 fps by using spatiotemporal division electroholography.

3Dp1 - 17L **Real-Time Electroholography of 3D-Gradation Movie Using Bit Planes Based on Binary-Weighted Computer-Generated Holograms and Multiple GPU Cluster System**

T. Sakaguchi, N. Takada, H. Sannomiya, H. Ito, M. Fujiwara, Y. Maeda, M. Oikawa, T. Kakue[*], T. Shimobaba[*], T. Ito[*]

Kochi Univ., Japan
[*]Chiba Univ., Japan

We propose real-time electroholography to reconstruct 3D-gradation movie by using a multiple bit planes based on binary-weighted computer-generated holograms and a multiple-graphics-processing-unit cluster system. Consequently, we succeeded to reconstruct real-time 3D-gradation movie comprising 7850 points at 77 fps.

3Dp1 - 18L **Real-Time Spatiotemporal Division Multiplexing Electroholography Using a GPU Cluster**

M. Oikawa, N. Takada, H. Sannomiya, T. Sakaguchi, H. Nakayama[*], T. Kakue[**], T. Shimobaba[**], T. Ito[**]

Kochi Univ., Japan
[*]Nat. Astronomical Observatory of Japan, Japan
[**]Chiba Univ., Japan

We demonstrated real-time electro-holographic movie reconstruction using spatiotemporal division multiplexing technique on a GPU cluster including 13 GPUs connected through InfiniBand network. We succeeded to display reconstructed 3-D movie consisting of 477,511 object points at 31 fps.

3Dp1 - 19L **Real-Time Electroholography Using Multiple GPU Cluster System with a Single Spatial Light Modulator and Gigabit Ethernet Network**

H. Sannomiya, N. Takada, T. Sakaguchi, Y. Maeda, H. Nakayama[*], M. Oikawa, T. Kakue[**], T. Shimobaba[**], T. Ito[**]

Kochi Univ., Japan
[*]Nat. Astronomical Observatory of Japan, Japan
[**]Chiba Univ., Japan

For the practical use of real-time electroholography, we propose the multi-GPU cluster system with 13 GPUs (NVIDIA GeForce GTX TITAN X) and gigabit ether- net network. Finally, we succeed to display reconstructed 3-D movie consisting of 95,949 object points at about 30 fps.

15:00 - 18:00 **Exhibition Hall**

Poster 3Dp2: Aerial Imaging Systems
Special Topics of Interest on AR/VR and Hyper Reality

3Dp2 - 1 **Aerial Hollow-Face Illusion with AIRR**

N. Kurokawa, K. Fujii, S. Ito, H. Yamamoto

Utsunomiya Univ., Japan

We have realized an aerial 3D display that evokes hollow face illusion, in which the perception of a concave mask of a face appears as a normal convex face. The depth-inverted 3D image of a projection-mapped 3D object is formed with AIRR (aerial imaging by retro-reflection).

3Dp2 - 2 **3D Lighting for Hyperspectral Imaging of Leaf Group by Use of Aerial Imaging Optics**

K, Kawai, R. Kujime, T. Okamoto, H. Yamamoto

Utsunomiya Univ., Japan

This paper proposes a lighting method aimed for hyperspectral imaging of plant leaves. In order to eliminate shadows, a 3D-controlled light illuminates the region of interest by use of aerial imaging optics, including double-layered arrays of rectangular mirror (WARM), a parabolic mirror, and aerial imaging by retro-reflection (AIRR).

3Dp2 - 3 **Omnidirectional Aerial Display for Medaka**

E. Abe, S. Onose, H. Takeuchi[*], E. Watanabe[**], Y. Kamei[**], H. Yamamoto

Utsunomiya Univ., Japan
[*]Okayama Univ., Japan
[**]Nat. Inst. for Basic Biology, Japan

This paper reports application of an omnidirectional aerial display for biology. The omnidirectional aerial screen surrounded a cylindrical water tank. A medaka in the water tank reacts to the surrounding aerial images. Because the surrounding image is shown on a flat panel, the biologist can easily change stimulus.

3Dp2 - 4 **Aerial DFD Display with AIRR**

Y. Terashima, S. Suyama[*]*, H. Yamamoto*

Utsunomiya Univ., Japan
[*]*Tokushima Univ., Japan*

This paper reports a method to give aerial image depth. Our proposed design combine two Aerial imaging by retro-reflection(AIRR). We used Depth-Fused 3D(DFD) to give aerial image depth. First of all, observers are surprised to observe aerial image. Furthermore, they are surprised to observe aerial 3D image.

3Dp2 - 5 **Influence of Decreasing Motion Parallax Widths in Arc 3D Display on Perceived Depth Degradation by Decreasing Visual Acuity of One Eye**

Y. Awata, H. Mizushina, S. Suyama

Tokushima Univ., Japan

Effectiveness of small but smooth motion parallax even at fixed head has been clarified for improving perceived depth degradation by increasing visual acuity difference of both eyes. We can successfully estimate quantitatively how small smooth motion parallax is needed for improving the perceived depth degradation.

3Dp2 - 6 **Large Viewing Zone of Multi-View Fresnel Arc DFD Display**

W. Kinoshita, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We have proposed a new Multi-View Fresnel Arc DFD display. Arc DFD display has a longer viewing zone. By fusing Multi-View display, wide horizontal viewing zone can be obtained. Fresnel Arc 3D display can successfully suppress the problem of vertical disparity in conventional Arc 3D display.

3Dp2 - 7 **Compact Layered Multi-View Display Using Arc 3D Display as Directional Backlight**

S. Koyama, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We propose compact layered multi-view display using Arc 3D displays as directional backlights and confirm the principal conditions. Our proposed directional backlights do not interfere each other and has small degradation to rear image quality even when the backlights are layered. This indicates the possibility of compact layered multi-view display.

3Dp2 - 8 **Development of 35-in. Tabletop Display with Wide Viewing Angle Using Projection-Based Light Field Display Technology**

W. Jang, H. Shim, D. Lee, J. Park

Korea Photonics Tech. Inst., Korea

Several micro projectors are used to project their own images onto the local screen regions, generating entire images by stitching several individual images. Multiple CG (computer-generated) images for 3D display are pixel re-aligned by light field authoring tools and played by computer server through the 8 projectors.

3Dp2 - 9 **Haptic Feedback by Electromagnetic Array on See-Through Light Field Display with Beam Splitter**

T. Ohashi, T. Koike

Hosei Univ., Japan

We describe a light field display which presents tactile feedback when operating with a fingertip by using magnetic force. The display can present pulled feeling which was difficult to express by conventional methods.

3Dp2 - 10 **Single-Pixel Imaging on Aerial Display with AIRR**

S. Morita, S. Onose, M. Sasaki, H. Yamamoto

Utsunomiya Univ., Japan

Single pixel imaging is a technique to obtain an image without a camera. This paper proposes a method to detect finger position on an aerial display without using a camera. A retro-reflector in the AIRR (aerial-imaging by retro-reflection) system works for aerial image forming and single pixel imaging.

3Dp2 - 11L **Comparison of Image Quality of Aerial Image Formed with Aerial Image Techniques by Viewing Angle**

N. Kawagishi[,**], H. Yamamoto[*,***]*

[*]Utsunomiya Univ., Japan
[**]Yazaki, Japan
[***]JST, Japan

This paper reports on experimental results on aerial image quality for a variety of viewing angle. We have measured the contrast transfer function curves in three types of aerial image techniques, which are AIRR, AIP, and DCRA. Furthermore, sharpness change by viewing angle is investigated each aerial image techniques.

3Dp2 - 12L **Enlarging Viewing Distance and 3D Image Depth at Large Edge-Based DFD Display by Blurring Edge Parts**

Y. Nagao, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We have developed long-viewing-distance Edge-based DFD display with deep 3D image by blurring edge-part image. Enlarging viewing distance makes it easier to fuse front and rear images to one depth image in DFD display. We successfully solve these problems by blurring edge-part images in long viewing distance.

Friday, December 8

9:00 - 10:20 **Hagi Conference Hall**

3D2: Light Field and Multiview

Chair: H. Saito, Keio Univ., Japan
Co-Chair: R. Kujime, Utsunomiya Univ., Japan

3D2 - 1: 9:00 ***Invited*** **Cameras for Light Field Imaging**

J.-Y. Son, H. Lee, J. Kim, J.-A. Byeon, D.-H. Kim[*]

Konyang Univ., Korea
[*]ETRI, Korea

Light field imaging requires many different view images with small disparity between images. For the imaging, an aperture sharing camera is introduced, and its imaging characteristics are analyzed both theoretically and experimentally, and compared with those of a plenoptic camera along with other cameras for the multiview image acquisition.

3D2 - 2: 9:20 ***Invited*** **3D TV Based on Spatial Imaging**

M. Kawakita

NHK, Japan

An integral three-dimensional (3D) method based on spatial imaging can reproduce natural 3D images by using a high-definition display with high-density pixels and a lens array. We report the latest research results for an integral 3D TV system using ultra-high definition video technologies and multiple display devices.

3D2 - 3 9:40 **3D Camera Unit Used for Conventional 2D Endoscopes**

Y. Takaki[,**], T. Fukui[*], Y. Takaki[*]*

[*]Tokyo Univ. of A&T, Japan
[**]Nagano Municipal Hospital, Japan

A technique to convert conventional 2D endoscopes into 3D endoscopes by adding a 3D camera unit is proposed. It provides a low-cost solution for introducing 3D endoscopes into hospitals because commonly-used optical and electronic devices can be used. The experimental system was constructed and the subjective evaluation was conducted.

3D2 - 4
10:00

Modular Autostereoscopic Multi-View Display

F. Mukhtarov, S. Han

Samsung Elect., Korea

We proposed new type of autostereoscopic multi-view 3D display based on static lenticular lens array and oscillating modules with self-emitted elements. Due to continuous movement of light sources, forming shape and position of viewing zones can be controlled electronically by choosing right timing and duration of pixels light emission.

----- Break -----

10:40 - 11:55 **Hagi Conference Hall**

3D3: Emerging Technologies

Chair: S. Yano, Shimane Univ., Japan
Co-Chair: M. Date, NTT, Japan

3D3 - 1:
10:40

Invited **Augmented Visualization of Reality from Collection of Images**

H. Saito

Keio Univ., Japan

The amount of images captured by various devices is extremely increasing. The collection of various images can augment visual reality based on multi-dimensional visual information analysis for providing intuitive understanding. I will show some preliminary example research directions based on the collection images.

3D3 - 2
11:00

Depth-Fused 3D on Aerial Thermal Display

R. Kujime[,**], H. Yamamoto[*,**]*

[*]Utsunomiya Univ., Japan
[**]JST ACCEL, Japan

We propose a method of forming volumetric thermal aerial image similar to depth-fused 3D (DFD). Thermal aerial image can be formed by use of a crossed-mirror array (CMA). We form volumetric thermal aerial image using by technique of DFD, that is, only two layered thermal aerial images are needed.

3D3 - 3
11:20

Glasses-Free 3D Augmented Reality System Based on a Naked-Eye 3D Display Combined with a Semi-Transparent Mirror

A. Zhang, J. Chen, Y. Zhou, K. Li, H. Zhang, H. Fan[*], P. Krebs, J. Zhou

Sun Yat-Sen Univ., China
[*]Midstereo, China

A glasses-free augmented reality (AR) system is developed on the basis of the autostereoscopic display technology and the semi-transparent technique. The most significant advantage of such a 3D AR system is that the viewer needn't wear an extra glasses or helmet any more, and the picture resolution is of 1080P.

3D3 - 4L 11:40 **Optimal Parameters of AR Image Rendering for an Optical See-Through HMD**

Y.-T. Hsiao, H.-P. Chien, P.-L. Sun

Nat. Taiwan Univ. of S&T, Taiwan

AR images of an optical see-through HMD are normally unrealistic as their color appearance does not in accordance with the scene. To solve this problem, A rendering model with optimal parameters derived from a psycho-visual experiment is proposed to improve fidelity of the AR images.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Hagi Conference Hall**

3D4: Holography

Chair: J.-Y. Son, Konyang Univ., Korea
Co-Chair: Y. Ichihashi, NICT, Japan

3D4 - 1: 13:50 ***Invited*** **1 µm-Pitch Pixel Structure Using Dielectric Shield Walls in Liquid Crystal Spatial Light Modulators for Electronic Holographic Displays**

Y. Isomae[,**], Y. Shibata[*], T. Ishinabe[*], H. Fujikake[*]*

[*]Tohoku Univ., Japan
[**]Res. Fellow of JSPS, Japan

The requirements in designing 1-µm-pitch liquid crystal spatial light modulator are evaluated for electronic holographic displays with wide field of view. The pixel structure using dielectric shield walls enables individual pixel driving. We also discuss the relation between reconstructed images and optical phase distribution in the small pixels.

3D4 - 2 14:10 **Quality Analysis of Light-Wave Distributions Considering Transmission Errors for Wireless Transmission System of Computer-Generated Hologram**

K. Yamaguchi, Y. Sakamoto[*]

Tokyo Univ. of Sci., Suwa, Japan
[*]Hokkaido Univ., Japan

This paper proposes a system model for wireless transmission of CGH (Computer-Generated Holograms), and quality of light-wave distributions considering wireless transmission errors are analyzed by using computer simulations. CGH data is transmitted based on the IEEE 802.11a standard system, and SNR of light-wave distributions reconstructed from transmitted CGH is evaluated.

3D4 - 3
14:30

GPGPU Accelerating Technique for Calculation of Horizontal Scanning Holographic Display

S. Honda, M. Nakaoka, Y. Takaki, M. Namiki

Tokyo Univ. of A&T, Japan

We accelerate the calculation of Horizontal Scanning Holography using GPGPU. After implementing some speeding up methods: optimization of data division and applying the existing accelerating method, we realized the execution speed is about 67.0x higher than non-accelerating on CPU and the calculation time for generating at about 6 FPS.

3D4 - 4
14:50

HOE-Based Screen for Virtual-Image Projection and Scene Capture

T. Nakamura[,**], S. Kimura[***], K. Takahashi[***], Y. Aburakawa[***], S. Takahashi[*], S. Igarashi[*], M. Yamaguchi[*]*

[*]Tokyo Tech, Japan
[**]JST PRESTO, Japan
[***]NTT DoCoMo, Japan

We propose a screen using the holographic optical element that works as an off-axis mirror, which enables virtual-image projection and scene capture. The system can be used for interactive aerial display for more attractive visual communication. We also propose blur-compensation methods and integrate them into a system.

Also presented in Innovative Demonstration Session (see p. 227)

----- Break -----

15:30 - 16:25 **Hagi Conference Hall**

3D5: Autostereoscopic Display

Chair: H. Yamamoto, Utsunomiya Univ., Japan
Co-Chair: H. Mizushina, Tokushima Univ., Japan

3D5 - 1
15:30

Comparison for the Image Quality Assessment of Multi-View 3D CG Images and 5K Images Based on S-CIELAB Color Space

N. Kawabata

Chiba Univ., Japan

In this paper, we assessed subjective quality of 3D CG images by H.265/HEVC with both multi-view parallax barrier and 5K high-definition retina, and then, we analyzed them, and classified by Support Vector Machine. Next, we assessed objective quality by measuring luminance by S-CIELAB color space, and color difference by CIEDE2000.

3D5 - 2
15:50

Full HD Autostereoscopic Display Based on Time-Multiplexed Parallax Barrier with Adaptive Time-Division

H. Kakeya, A. Hayashishita, M. Ominami

Univ. of Tsukuba, Japan

In this paper we propose an autostereoscopic display with adaptive time-division multiplexing parallax barrier. When time-division triplexing is applied in place of the conventional time-division quadruplexing parallax barrier, the image becomes brighter without destroying stereoscopy.

Also presented in Innovative Demonstration Session (see p. 227)

3D5 - 3 **Withdrawn**

3D5 - 4L
16:10

Color Moiré and Resolution Analysis of Multiple Integral Three-Dimensional Displays

H. Sasaki, N. Okaichi, H. Watanabe, M. Kano, M. Miura, M. Kawakita, T. Mishina

NHK, Japan

When flat-panel devices are used in integral three-dimensional (3D) displays, there is a problem of color moiré occurrence by a subpixel structure. We analyze color moiré reduction and resolution improvement in the case of synthesizing 3D images by multiple displays and theoretically clarify what kind of improvement effects they have.

Author Interviews
17:00 – 17:40

EXHIBITION

12:40 – 18:00 Wednesday, Dec. 6
10:00 – 18:00 Thursday, Dec. 7
10:00 – 14:00 Friday, Dec. 8
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
Free admission with your registration name tag

Workshop on Applied Vision and Human Factors

Wednesday, December 6

13:10 - 13:20 **Shirakashi Conference Room**

Opening

Opening Remarks
13:10

S. Uehara, Asahi Glass, Japan (VHF Chair)
H. Shibata, Fuji Xerox, Japan (UXC Chair)

13:20 - 14:45 **Shirakashi Conference Room**

VHF1/UXC1: Human Factors

Chair: Y. Hisatake, Japan Display, Japan
Co-Chair: Y. Andoh, Fuji Xerox, Japan

VHF1/ UXC1 - 1: 13:20 ***Invited*** **Displays for Reading and Writing: Learning from Cognition on Paper**

H. Shibata

Fuji Xerox, Japan

This paper provides several remarks for new directions of future displays for reading and writing which are learned from cognitive experiments on paper and displays.

VHF1/ UXC1 - 2 13:45 **Visual Resolution Quantization for Sub-Pixel Rendering Design**

Y. L. Chen, Y. R. Zhang, Y. B. Yang

Wuhan China Star Optoelect. Tech., China

Sub-pixel rendering (SPR) is a pixel design technique. The transformation of pixel arrangement and shape causes the spec problems of pixel quantity definition and perceived image quality. A psychophysical method was adapted along with plenty of images as stimulus. The resolution spec can be inferred through the visual resolution results.

VHF1/ UXC1 - 3 14:05 **Subtle Flickering Polychromatic SSVEP Visual Stimuli for Human-Computer Interaction**

Y.-Y. Chien, F.-C. Lin, H. O.-Yang. Hui, Y.-C. Chang, J. K. Zao, Y.-P. Huang, H.-P. D. Shieh

Nat. Chiao Tung Univ., Taiwan

Steady-state visual evoked potential (SSVEP) is one of the most effective brain electrical signals in human-computer interaction (HCI). This study reduced the discomfort from the flickers of visual stimuli by means of high-frequency polychromatic LED-/LCD-based stimuli, and showed that both of them could induce distinct SSVEP responses with subtle flickers.

VHF1/ UXC1 - 4 14:25 **Full-HD Autostereoscopic Display for Myopia Rehabilitation**

H. Zhang, K. Li, X. Chen, A. Zhang, Y. Zhou, H. Fan[*], J. Wang, J. Zhou

Sun Yat-Sen Univ., China
[*]Guangzhou Midstereo Tech., China

With a high-quality autostereoscopic display, special 3D video was supplied to 10 myopias each day in ten days. Most of them acquired a remarkable progress at the eyesight test. The finding suggests 3D may not damage the health of user, and can be a therapeutic approach of myopia.

----- Break -----

14:50 - 16:20 **Shirakashi Conference Room**

UXC2/VHF2: Education and Reading

Chair: E. Amasawa, Univ. of Tokyo, Japan
Co-Chair: Y. Hisatake, Japan Display, Japan

UXC2/ VHF2 - 1: 14:50 ***Invited*** **Tablet Use in Elementary Schools from Ergonomic Aspect**

T. Shibata, K. Sato[,**], T. Horita[**]*

Tokyo Univ. of Social Welfare, Japan
[*]Tokoha Univ., Japan
[**]Tohoku Univ., Japan

Elementary school students have difficulty in viewing tablet screens primarily because of the screen glare. Almost, one in three students complains of physical fatigue after using tablets. The experiment reveals that anti-glare films could make writing and drawing on tablets a comfortable experience in addition to preventing the screen glare.

UXC2/ VHF2 - 2: 15:15 ***Invited*** **A Development of Universal Design Font and Evaluation of Legibility on Display**

H. Yaguchi

Tokyo Denki Univ., Japan

In recent years, Japanese society ages rapidly, product development based on the concept of Universal Design (UD) has been gaining momentum. In this paper, we will show that UD fonts are effective to increase legibility on electric display and review the design conditions with UD philosophy.

UXC2/ VHF2 - 3 15:40 **Relationships Between Reading Speed and Eye Movement Parameters**

J. Kobayashi[,**], T. Kawashima[**]*
[*]*Dai Nippon Printing, Japan*
[**]*Future Univ. Hakodate, Japan*

We analyzed the relationship between reading rate and eye movement parameters in normal reading without skimming. We found that reading rates of approximately 1200 characters/minute are possible even in normal reading and the main eye movement parameter involved in the difference in reading rates is forward saccade length.

UXC2/ VHF2 - 4 16:00 **Preferred LDR to HDR Image Conversion for HDR Displays**

Y.-Z. Lai, P.-L. Sun
Nat. Taiwan Univ. of S&T, Taiwan

Visual preference of different LDR to HDR image conversion methods are tested psycho-visually with a HDR display using different types of image. The results show that simple tone scaling performed well.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:20 **Sakura Hall 2**

VHF3: Special Session on Color Vision
Special Topics of Interest on Wide Color Gamut and Color Reproduction

Chair: Y. Imai, Mitsubishi Elec., Japan
Co-Chair: K. Hirai, Chiba Univ., Japan

VHF3 - 1: 9:00 ***Invited*** **An Introduction of New CIE Colorimetric Systems, CIE2006LMS and CIE2015XYZ**

H. Yaguchi
Chiba Univ., Japan

Recently CIE has developed two physiological based colorimetric systems. One is based on spectral sensitivities of the cone so called cone fundamentals, another is XYZ type colorimetric system based on cone fundamentals. Outlines of two colorimetric systems and their applications to industrial fields are introduced.

VHF3 - 2 9:40 **Investigation of the Helmholtz-Kohlrausch Effect in Using Laser Projectors**

C. Jin, J. Wang, J. Yang, Y. Tian*, F. Wang, X. Huang, H. Wang, X. Li, W. Liu**

Southeast Univ., China
**Hisense Elec., China*

Two perception experiments were conducted to investigate the Helmholtz-Kohlrausch (H-K) effect in laser projectors. The result quantified the H-K effect degree and suggested that luminance requirement for laser projectors with larger gamut can be lower compared to projectors with smaller gamut. The accuracy of three prediction models was verified.

VHF3 - 3 10:00 **Individual Differences in Chromatic Perception: Continuous Variation from Dichromacy to Trichromacy**

S. Hira, M. Nakamichi, K. Kanari, Y. Karakama, H. Fukuda*, M. Ayama*, S. Ohtsuka*

Kagoshima Univ., Japan
**Utsunomiya Univ., Japan*

Individual differences in chromatic perception of both color-normal and color-deficient observers are investigated by MDS (Multidimensional-Scaling). The results show that (1) the constellations of colors (word based) slightly depend on color sense, however, (2) those by color charts move from concave-shaped in dichromacy to oval-shaped in trichromacy.

----- Lunch -----

13:10 - 14:30 **Sakura Hall 2**

VHF4: Motion Image Quality and Sickness

Chair: N. Hiruma, NHK-ES, Japan
Co-Chair: S. Uehara, Asahi Glass, Japan

VHF4 - 1: 13:10 ***Invited*** **Moving Image Quality: Visual Ergonomics, Requirements and Evaluation with an 8K 120 Hz LCD**

T. Kurita, R. Oke, J. Maruyama*, S. Mima***

NHK Media Tech., Japan
**Panasonic Liquid Crystal Display, Japan*
***Keisoku Giken, Japan*

After a review of visual ergonomics and requirements on moving image quality, a subjective evaluation test which was recently conducted using a latest 8K 120 Hz LCD with blinking backlight is reported. Effect of moving- image-quality improvement by short temporal-aperture and high frame-rate is confirmed on 8K system.

VHF4 - 2
13:35 **Guiding Principles for High-Quality Moving Picture in FFS Mode Mobile Displays Using LCs with Negative Dielectric Anisotropy**

A. Ling, Q. Yue, Y. Zeng, L. Fang, M. Li, L. Wu, P. Shen, J. Li, C. Tseng

Xiamen Tianma Microelect., China

The mechanisms of motion blur and motion discoloration for negative LC-based FFS displays are demonstrated by theoretical analysis. To achieve high quality moving picture, the maximum gray to gray response time is confined to 16.6 ms. According to the experimental results, the difference of RGB rising time under 5 ms is required.

VHF4 - 3
13:55 **Numerical Rating of Motion Image Quality on Latest 4K TVs Using Viewing-Distance-Free Robust Approach**

I. Kawahara

FairSpec, Japan

Evaluation of motion image quality is optimized, securing reliability by checking responses in a wide range of resolution and speed, while maximizing efficiency by introducing an effective-rate criteria which defines required combination of resolution and speed. TVs are rated with scores like “2.0” or “120” for real 120 Hz performance.
Also presented in Innovative Demonstration Session (see p. 227)

VHF4 - 4L: ***Invited*** **Amount of Visual Rotation as the**
14:15 **Determinant of VIMS for Ergonomic Guidelines**

H. Ujike, H. Watanabe

AIST, Japan

We examined the effects of visual rotation amount on visually induced motion sickness (VIMS) severity in two experiments. The results indicate that VIMS severity can be linearly related to visual rotation amount within a limited stimulus period, regardless of different temporal distribution of visual rotation, while viewing condition was consistent.

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster **VHFp1: Applied Vision and Human Factors — Automotive Application**
Special Topics of Interest on Automotive Displays

VHFp1 - 1 **Development of a Device to Improve the Attention Level while Driving Using Vibrators**

H. Maruyama, M. Yamada

Tokai Univ., Japan

In order to support safe driving, it is important for the driver to maintain a high level of attention. For that purpose, we developed a vibration presentation device to refocus the driver’s attention during driving, and carried out an experiment to evaluate the device.

15:00 - 18:00 **Exhibition Hall**

***Poster* VHFp2: Applied Vision and Human Factors — Virtual Reality**

Special Topics of Interest on AR/VR and Hyper Reality

VHFp2 - 1 **Legibility of Color Text in Outdoor Environment for Optical See-Through HMD**

Y.-J. Lin, P.-L. Sun

Nat. Taiwan Univ. of S&T, Taiwan

High legibility of text information is vital to an optical see-through HMD for AR related applications. However, in an outdoor environment, bright and complex scene would greatly reduce their legibility. Hence, a series visual experiments were conducted to summaries the rules of text placement and text rendering for the type of applications.

15:00 - 18:00 **Exhibition Hall**

***Poster* VHFp3: Applied Vision and Human Factors**

VHFp3 - 1 **Quantitative Evaluation of the Mura from Perceived Luminance Using the 2D Contrast Sensitivity Function Filter**

S. W. Jung

LG Display, Korea

The mura is one of the defects which are very difficult to quantify. That is a key issue for the display manufactures. To quantify it, the perceived luminance adopted a spatial concept has to be concerned. At this paper we introduce a quantitative method about the mura using 2D contrast sensitivity function on the spatial frequency.

VHFp3 - 2 **Evaluation Method of Transflectance for Transparent Displays**

K. Mo, B. Choi, S. Jeong, G. Lim

LG Display, Korea

Two display attributes, transmission and reflection, are the most important factor in transparent displays. Therefore, two types of measuring methods must be defined for sure and be used as appropriate ways. We suggest a method of transflectance measurement that is applying to transmittance and reflectance simultaneously.

VHFp3 - 3 **Analysis of Head Movement and Eye Movement While Gazing Image from Short Distance**

S. Mochiduki, A. Tanaka, M. Yamada

Tokai Univ., Japan

We analyzed head movement and eye movement when viewing 4K resolution images under 9 different conditions. As a results, gazing point were different for the “subject front condition” and the “front condition” for the left and right viewing locations, and viewing distance appeared to have an influence on this tendency.

VHFp3 - 4 **Fatigue Evaluation by Paralanguage Recognition and Gazing-Point Analysis**

M. Suganuma, Y. Kurosawa, S. Mochiduki, Y. Hoshino, M. Yamada

Tokai Univ., Japan

With the aging society in Japan, many hospitals and nursing homes require more nurses. If it were possible to determine patients’ condition from their everyday behavior, it could reduce nurses’ burden and improve patients’ quality of life. In this study, we collected bio-information in an effort to comprehend participants’ fatigue.

VHFp3 - 5 **Line Drawing Image Segmentation Using Constrained Delaunay Triangulation**

X. Liu, H. Mori, F. Toyama, K. Shoji

Utsunomiya Univ., Japan

Freehand line drawings almost have open-loop lines which are perceived to be closed. We developed a method for line drawing image segmentation which can handle such apparent open-loop lines using the constrained Delaunay triangulation. Experimental results show the effectiveness of our proposed method.

VHFp3 - 6 **Shadowing and Highlighting for Colorized Freehand Line Drawings Based on Reference Images and Users' Preferences**

S. Kurata, H. Mori, F. Toyama, K. Shoji

Utsunomiya Univ., Japan

We proposed a method for shadowing and highlighting for colorized line drawings that are generated from freehand line drawings and underlying reference images and evaluated the proposed method with parameters used by subjects. About the evaluation, we investigated the relationship between shadowing-highlighting and user’s habit.

VHFp3 - 7 Sea Foggy Image Haze Removal Algorithm Based on Image Fusion

S.-L. Liu, Y.-F. Wang, H.-Y. Wang, Y.-F. Jin[,**], S.-S. Syu[*,**], M.-J. Jou[*,**], P.-Y. Lu[*,**]*

Dalian Univ. of Tech., China
[*]Shenzhen China Star Optoelect. Tech., China
[**]Nat. Eng. Lab., China

Sea images are usually affected by fog due to richness of water vapor over the sea surface, leading to the dynamic range reduction of images. To obtain clear images that can be well displayed on AMOLED screen, we propose a novel defogging method based on image fusion strategy.

VHFp3 - 8 Pseudo High Dynamic Range Imaging Based on Image Enhancement

S.-L. Liu, Y.-F. Wang, H.-Y. Wang, Y.-F. Jin[,**], S.-S. Syu[*,**], M.-J. Jou[*,**], P.-Y. Lu[*,**]*

Dalian Univ. of Tech., China
[*]Shenzhen China Star Optoelect. Tech., China
[**]Nat. Eng. Lab., China

We proposed a pseudo high dynamic range (PHDR) imaging algorithm based on image enhancement, which can effectively enhance the image details in both bright and dark regions. It was shown that the algorithm provides good perceptual quality just like that of HDR image.

VHFp3 - 9L New Metric for Display Resolution Evaluation Based on Human Visual Perception

K. Choi, B. Min, J. Kim, S. Choi

Samsung Elect., Korea

This study aims to propose a new metric for resolution evaluation based on human visual perception. We evaluated various types of TV display with different types of pixel structure. Proposed metric will compensate the current resolution evaluation by using structural similarity based image quality assessment.

Also presented in Innovative Demonstration Session (see p. 227)

VHFp3 - 10L Development of a Novel Accurate Analysis System Regarding Information Processing Within the Gaze Point

T. Kushima, M. Suganuma, S. Mochiduki, M. Yamada

Tokai Univ., Japan

We propose an experiments system to control display information exactly, as well as display time, and inspect the result of past reading research, with the aim of being at the forefront research in the e–book era.

Thursday, December 7

15:00 - 18:00 **Exhibition Hall**

***Poster* VHFp4: Applied Vision and Human Factors — Color Vision**

Special Topics of Interest on Wide Color Gamut and Color Reproduction

VHFp4 - 1L **Performance Measurement of RGB Displays with Degenerate Colors**

J. L. Bergquist

Consult., Japan

The combined color and lightness performance of RGB displays with and without degenerate colors are measured and compared in terms of color volume. It is shown that the volume of degenerate systems is significantly smaller and that color volume is a useful metric.

VHFp4 - 2L **Measured Values of the Helmholtz-Kohlrausch Effect for Natural Images and Scrambled Pixel Images**

D. Takasu, S. Hashimoto, H. Aoyanagi[*], H. Takamatsu[*], Y. Shimodaira, G. Ohashi

Shizuoka Univ., Japan
[*]NEC Display Solutions, Japan

In this study, subjective-evaluation experiments for measuring the Helmholtz-Kohlrausch effect using natural images and scrambled pixel images are conducted, and the results are compared with values calculated using the estimation equation proposed by Nayatani et al. for natural images.

VHFp4 - 3L **Evaluation of Color Perception Using Narrow Band Color Projection Display**

M. Takaya, K. Shoji[*], J. Shimizu

Nat. Inst. of Tech., Numazu College, Japan
[*]Hamamatsu Photonics, Japan

Here, we evaluate color perception for narrow band color stimulus. As demonstrated by the results from psychophysical experiments, for the color blue, the characteristics of younger subjects tend to be different from those of older subjects.

Friday, December 8

9:00 - 10:20 **Sakura Hall 2**

VHF5: Display Measurement and Evaluation

Chair: J. Penczek, NIST, Univ. of Colorado, USA
Co-Chair: S. Uehara, Asahi Glass, Japan

VHF5 - 1
9:00

Thirty Years of Viewing Angle Measurement Instruments Based on Fourier Optics

P. Boher, T. Leroux
ELDIM, France

The paper explains the technical bases of Fourier Optics Technology (OFT) for viewing angle measurement and the evolution of the ELDIM systems over the years. Last generation instrument can be used on a robotic arm and offers a quality control cost effective solution for any kind of display.

VHF5 - 2
9:20

Spectrometer-Enhanced Imaging Colorimeter for Display Testing in Production Lines

M. Wolf, J. Neumeier, M. E. Becker
Instr. Syss., Germany

We introduce a novel measurement device combining a high-resolution RGB camera with a spectroradiometer for fast and accurate evaluation of lateral variations of chromaticity and luminance. The paper provides an analysis of its performance when applied to state-of-the-art LC and OLED displays under the timing constraints of display production lines.

VHF5 - 3
9:40

Simplified Method to Quantify Sparkling of Antiglare Display without Image Processing and Its Application

M. Hayashi
Daicel, Japan

The simple and accurate method to quantify magnitude of sparkling phenomenon, caused by antiglare treatment of display surfaces, was investigated, which excellently corresponds to the sensory evaluation by eyes. The evaluation system was utilized to design and prepare a low-sparkling antiglare morphology.
Also presented in Innovative Demonstration Session (see p. 227)

VHF5 - 4
10:00

Reduction of Visual Fatigue in Displays by Surface Treatments

Y. Yang, H. Cui, Y. Yang, P.-H. Lung, Y. Zhang[*]

Wuhan China Star Optoelect. Tech., China
[*]China Nat. Inst. of Standardization, China

Anti-reflection (AR) and anti-glare (AG) surface treatments on cover glass (CG) reduce the reflection and glare, resulting in improved legibility and less visual fatigue for readers. Visual ergonomics on normal display panel showed that CG with both AR and AG performed best for readers subjectively.

Also presented in Innovative Demonstration Session (see p. 227)

----- Break -----

10:40 - 12:00 **Sakura Hall 2**

VHF6: High Dynamic Range and Image Quality

Chair: N. Hiruma, NHK-ES, Japan
Co-Chair: Y. Hisatake, Japan Display, Japan

VHF6 - 1
10:40

Picture Level Control Method for Super Large-Area Display

T. Yamamoto[,**], T. Okada[*], T. Usui[*], Y. Fujisaki[*], T. Onoye[**]*

[*]NHK, Japan
[**]Osaka Univ., Japan

A new picture level control method is proposed for a super large-area display, which has to limit luminance due to the power limit when bright images are reproduced. The proposed method well reproduces bright and dark areas on the display.

VHF6 - 2
11:00

Key Subject Evaluation Factors of HDR Image Quality Based on LCD and OLED Comparison

J. Wang, H. Wang, X. Li, Q Sun[*], K. Jia[*], S. Zhang[*]

Southeast Univ., China
[*]China Elect. Standarization Inst., China

A perception experiment is designed and conducted to compare the high dynamic range (HDR) performance between OLED and LCD in different evaluation items as well as the overall image quality. Correlation analysis was done among each single item to find the most important factor affecting viewers' preference to HDR scenes.

VHF6 - 3
11:20

Viewing Angle Color Evaluation of QLED and OLED HDR Displays Using Lab and ICtCp Color Spaces

P. Boher, T. Leroux, P. Blanc[*]

ELDIM, France
[*]Labs. d'Essai de la FNAC, France

High Dynamic Range (HDR) and Wide Color Gamut (WCG) displays require adapted color measurements analysis. In the following we evaluate the viewing angle dependence of the color gamut and color volume of two HDR/WCG displays, one QLED TV and one OLED TV using L*a*b* and ICtCp color spaces.

VHF6 - 4
11:40

CIELAB-Metric Color Volume for HDR Displays

K. Masaoka
NHK, Japan

An extended CIELAB color space is used to compute the color volume of an HDR/WCG display. For practicality, it is suggested to use a combination of conventional display metrics based on colorimetry to evaluate HDR/WCG gamut sizes rather than a single-valued color volume metric tied to a color appearance space.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Sakura Hall 2**

VHF7: Ergonomics for Automotive Applications

Special Topics of Interest on Automotive Displays

Chair: Y. Endo, Asahi Glass, Japan
Co-Chair: Y. Imai, Mitsubishi Elec., Japan

VHF7 - 1:
13:50

Invited **Human Centered HMI for the Future Automobile**

M. Akamatsu
AIST, Japan

ICT have been introduced in automobiles for these twenty years and automated driving system is a hot topic now. Role of in-vehicle HMI is changing and human centered design becomes important because in-vehicle information becomes complex. History of in-vehicle HMI is reviewed and HMI for driving automation system is discussed.

VHF7 - 2:
14:20

Invited **Automotive Displays: Visual Ergonomics and Measurements**

K. Blankenbach, T. Fink[*], U. Krueger[**], M. Zobl[***]
Pforzheim Univ., Germany
[*]Porsche, Germany
[**]TechnoTeam, Germany
[***]BMW Group, Germany

Automotive displays have unique requirements in terms of optical performance, longevity in harsh environment and mass production of 100,000's per year. CE displays set the pace and premium automotive displays have to follow in short time despite long development cycles. We present challenges & solutions for optical measurements.

VHF7 - 3 14:50 **Response Time and Viewing Angle Behavior of Liquid Crystal Displays versus Temperature**

P. Boher, T. Leroux, T. Bignon
ELDIM, France

Two LCD displays, one TN and one IPS are measured at different temperatures using Fourier optics viewing angle and response time measurement systems. Liquid crystal optical index, birefringence and rotational viscosity variations due to temperature affect the LC cell rotation and consequently the viewing angle and response time behaviors.

----- Break -----

15:30 - 16:55 **Sakura Hall 2**

VHF8: Virtual Reality

Special Topics of Interest on AR/VR and Hyper Reality

Chair: H. Ujike, AIST, Japan
Co-Chair: S. Uehara, Asahi Glass, Japan

VHF8 - 1: 15:30 ***Invited*** **Optical Instrument Requirements for Measuring Near-Eye Displays**

J. Penczek[,**], P. A. Boynton[**]*
[*]Univ. of Colorado, USA
[**]NIST, USA

The necessary optical system design features for proper near-eye display measurements are reviewed, as well as the appropriate methods to evaluate characteristics like field of view and eye box.

VHF8 - 2 15:55 **VR Experience Player for Subjective Evaluations of Visual VR Content**

T. Järvenpää, P. Eskolin, M. Salmimaa
Nokia Techs., Finland

The requirements and details of an example VR player implementation designed for subjective evaluations of different visual VR experiences are described. The player application is built using a game engine and has a wide cross-platform VR system support. The player has successfully been used in various VR experience evaluations.

VHF8 - 3 16:15 **Methods for Subjective Evaluations of Visual VR Experience**

M. Salmimaa, T. Järvenpää, H. Toukomaa
Nokia Techs., Finland

Standardized image quality evaluation methods form good basis for the virtual reality (VR) experience evaluations. However, some VR content playback specific features may require modifications to the established methods. We have examined different methods for subjective evaluations of VR experience. Some modifications are proposed and discussed alongside three experiment designs.

VHF8 - 4
16:35 **Effect of Projection Mapping on Haptic Perception of Texture**

K. Hirai, T. Katsunuma, T. Horiuchi
Chiba Univ., Japan

This paper investigated effects of projection mapping on haptic perception of texture. We developed a frequency-modulated projection mapping technique for controlling visual appearance of real texture surfaces. Then we conducted subjective experiments using our projection mapping technique. The experimental results showed haptic perception was significantly affected by visual modulation.

Author Interviews
17:00 – 17:40

Supporting Organizations:
Technical Committee on Electronic Information Displays, Electronics Society, IEICE
Technical Group on Information Display, ITE

Workshop on Projection and Large-Area Displays and Their Components

Thursday, December 7

10:40 - 10:45 **Sakura Hall 1**

Opening

Opening Remarks
10:40

S. Ouchi, Hitachi, Japan

10:45 - 12:00 **Sakura Hall 1**

PRJ1: Automotive / Display Application

Special Topics of Interest on Automotive Displays

Chair: S. Shikama, Setsunan Univ., Japan
Co-Chair: S. Yamaya, Nippon Seiki, Japan

PRJ1 - 1: ***Invited*** **Projection-Type Three-Dimensional Displays**
10:45 **with Holographic Screen Fabricated by Wavefront Printer**

K. Wakunami

NICT, Japan

Several kinds of projection-type three-dimensional displays are introduced. All display systems were developed by using holographic optical elements as the specially designed optical screens fabricated by wavefront printing technique. In this presentation, stereoscopic 3D display, lightfield display and holographic display are demonstrated with the optical reconstructions.

PRJ1 - 2 **Performance Characterization of Delay Response**
11:05 **Time with Wearable Displays**

T. Fujiwara, T. Kosaka, H. Nagasaka, S. Ouchi

Hitachi, Japan

Recently, more and more demands are increasing to adapt AR/VR/MR technologies to industrial domains. In this paper, we report measurement method for AR latency time of popular HMD. With the result of measurement, time range is 50-70 millisecond. We should improve the latency time over 50% for comfortable AR experiences.

PRJ1 - 3
11:25

Bi-Functional Automotive Headlamps for Adaptive Driving Beam and Low Beam Realizing Achromatic Illumination by Using a Light Guide

M. Nagayoshi, T. Himi, S. Fujita, M. Ohta, K. Shimada, T. Shimano

Hitachi, Japan

New optical system using a light guide for an adaptive driving beam (ADB) headlamp with integrated high beam and low beam units and without moving parts is presented that drastically reduces chromatic aberration at the low beam cutoff line.

PRJ1 - 4L
11:45

2-Plane Head-Up Display by Single DLP-PGU

S. Sekiya, K. Morohashi, T. Kawai, T. Tsuchida

Nippon Seiki, Japan

In this paper, future evolution of the image plane in automotive HUD is discussed. We disclose 2-Plane HUD that is HMI (Human Machine Interface) in a vehicle with high cognition and practical package volume, and its design result with single DLP-PGU.

12:00 - 12:21 **Sakura Hall 1**

Short Presentation PRJp1: Projection Displays

All authors of poster papers for the PRJp1 session will give 3-minute oral presentations with no discussion time.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster PRJp1: Projection Displays

PRJp1 - 1

Simulation of the Projection Mapping to a Directional Volumetric Display

M. Ikeda, A. Shiraki, H. Nakayama[*]*, R. Hirayama, T. Kakue, T. Shimobaba, T. Ito*

Chiba Univ., Japan
[*]*Nat. Astronomical Observatory of Japan, Japan*

A method to design "a 3D object containing multiple 2D information patterns", which can exhibit different motion pictures to different directions, has been developed. In this study, we aim for realization of a simulator for a practical projection system to a directional volumetric display.

PRJp1 - 2 **Projecting Prompter Information via a Common Information Screen with AIRR**

T. Okamoto, T. Kobori, R. Kujime, H. Yamamoto
Utsunomiya Univ., Japan

We have developed a novel prompter projection system, which shows a secret image to a limited position over a screen that shows a common image for all viewers. AIRR (aerial imaging by retro-reflection) and our designed optical setups project the secret image to a viewer's eye unnoticeably for other viewers.

PRJp1 - 3 **Viewing Angle Analysis and Light Source Shielding on Both-Sided Aerial Display with AIRR**

K. Shimose, K. Kawai, H. Yamamoto
Utsunomiya Univ., Japan

We propose a both-sided aerial display with AIRR, which shows two different aerial images on the same plane above a beam splitter. We have analyzed the viewing angle of the both-sided aerial display. Then, we design an optical setups to make the light source display invisible.

PRJp1 - 4 **Halving Aerial Display Thickness by Use of a Parallax Barrier**

T. Kobori, S. Onose, T. Okamoto, H. Yamamoto
Utsunomiya Univ., Japan

This paper proposes a novel optical design to halve the thickness of aerial display. While the size of the light source display and the aerial image are the same in conventional aerial imaging methods, our design doubles the aerial screen size by use of a parallax barrier and a mirror.

PRJp1 - 5 **The Projection Lens Design for a Hemisphere Screen**

F.-N. Wang[*], W.-K. Lin[,**], B.-S. Lin[**], W.-C. Su[*]*
[*]Nat. Changhua Univ. of Education, Taiwan
[**]Nat. Chiao Tung Univ., Taiwan

In our study, we have successfully presented a hemisphere projection system by designing a lenses group. By using this system, the flat image can be projected on hemisphere shell screen. This system can offer observers more realistic viewing experience. We discuss the performance of the lens group in this paper.

PRJp1 - 6L **Evaluation of Propagation Distance of Visible Light Through Human Skin for 3D Projection Screen**

E. Katumata[*], T. Yamazaki[*], S. Kiyama[*], A. Kuroda[,**], S. Maeda[*]*

[*]Tokai Univ., Japan
[**]Kuroda Consulting, Japan

The propagation distance of visible light through human skin depends on the wavelength of light. This optical property gives us the sense of depth. Using this property, we have developed a calculation-free 2D-to-3D automatic conversion projection screen.

PRJp1 - 7L **Light Field Display Using Multi-Projectors Based on Splicing Algorithm**

K. Ma[,**], R. Pei[*,**], Z. Geng[*], Z. Zhang[*]*

[*]Univ. of Chinese Ac. of Scis., China
[**]Chinese Ac. of Sci., China

We present a light field reconstruction algorithm based on splitting-splicing theory increasing number of viewpoints without increasing the number of projectors, which can adjust the distance of two adjacent view images for higher 3D sensation.

Friday, December 8

9:00 - 10:20 **Sakura Hall 1**

PRJ2: Standardization

Chair: S. Ouchi, Hitachi, Japan
Co-Chair: M. Kurashige, Dai Nippon Printing, Japan

PRJ2 - 1: 9:00 ***Invited*** **Recent Achievement of Standardization Activities for Head-Mounted Displays**

K. Hyodo, S. Uehara[*], H. Ujike[**], S. Ouchi[***], K. Oshima[****], H. Watanabe[**], M. Kurashige[*****]

Konica Minolta, Japan
[*]Asahi Glass, Japan
[**]AIST, Japan
[***]Hitachi, Japan
[****]Otsuka Elect., Japan
[*****]Dai Nippon Printing, Japan

Despite rapid expansion of head-mounted display (HMD) market, until now there is no practical standard way of evaluating those HMDs. Several standardizations organizations, such as IEC, start their activities to change that. Through this talk, we would like to explore recent achievement in the field of standardization activities for HMDs.

PRJ2 - 2
9:20 **Impact of Color Speckle on Display Measurement Standardization**

J. Kinoshita

Osaka Univ., Japan

International standardization of measuring methods of color speckle is ongoing. Color speckle gives a big impact on the measurements of laser displays because it does not exist on the display screen, but on retina. The impact on optical and image quality measuring methods is reviewed and discussed.

PRJ2 - 3
9:40 **Measurement Method of Eye-Box Characteristics for AR/VR Eyewear Display by Two-Dimensional Measurement Equipment with Optical Attachment**

*K. Tsurutani[*1,*2], M. Yamada[*1,*2], K. Oshima[*1,*3], S. Uehara[*1,*4], Y. Sato[*1,*5], K. Inoguchi[*1,*6], H. Oka[*1,*7], H. Wakemoto[*1,*8], M. Kurashige[*9], M. Cho[*1,*10], S. Ouchi[*1,*11]*

*[*1] JEITA, Japan*
*[*2] Konica Minolta, Japan*
*[*3] Otsuka Elect., Japan*
*[*4] Asahi Glass, Japan*
*[*5] Color Link,Japan*
*[*6] Canon, Japan*
*[*7] JVCKENWOOD, Japan*
*[*8] Japan Display, Japan*
*[*9] Dai Nippon Printing, Japan*
*[*10] Fujifilm, Japan*
*[*11] Hitachi, Japan*

To measure eye-box characteristics of eyewear displays, we have developed an optical attachment to two-dimensional luminance colorimeters that can measure 2-D luminance and chromaticity distributions on the plane perpendicular to the optical axis. Luminance and chromaticity based on differences in pupil size and position were calculated and eye-box characteristics evaluated.

PRJ2 - 4
10:00 **Viewing-Angle Characteristics of Speckle Contrast among Different Types of Screens**

M. Kurashige, K. Ishida, S. Kubota

Dai Nippon Printing, Japan

Four samples of projection screens and a diffuse reflectance target were illuminated by coherent light of SHG laser through a diffuser. Speckle contrast of each sample was measured as changing measurement angle. Angular characteristics of speckle contrast were different when the diffuser was fixed and moved.

----- Break -----

11:00 - 12:00 **Sakura Hall 1**

PRJ3: Digital Cinema and Projection Mapping

Chair: S. Shikama, Setsunan Univ., Japan
Co-Chair: H. Hatanaka, Ushio, Japan

PRJ3 - 1 **Withdrawn**

PRJ3 - 2: 11:00 ***Invited*** **Lamps, Phosphors and Lasers: The Past, Present and Future of Digital Cinema**

M. Perkins, A. Koebel

Christie Digital Syss., Canada

The first generation of digital-cinema projectors was deployed into movie theaters using xenon lamps, initially the only viable illumination technology. Today, cinema has a new set of illumination technologies to choose from. With laser and laser-phosphor, cinema-projection engineers have an entirely new set of design decisions to make.

PRJ3 - 3 11:20 **Native 4K HDR Projector with Laser Light Source**

T. Furukawa, T. Aizaki, K. Maeno, S. Kikuma, Y. Arihara, T. Iwasa, Y. Kojima

JVC KENWOOD, Japan

4K resolution and HDR (High Dynamic Range) are required for projectors in order for its image quality to become closer to reality. 0.69-in. diagonal 4K LCOS device and high-efficiency compact optical engine with laser light source was developed. As a result, a native 4K HDR projector for consumer use was commercialized.

PRJ3 - 4 11:40 **Lifetime Evaluation of 638 nm Dual Stripe Broad Area Laser Diode for Display Application**

K. Kuramoto, S. Abe, M. Miyashita, T. Nishida, T. Yagi

Mitsubishi Elec., Japan

Lifetime of newly developed 638 nm dual stripe broad area laser diode was evaluated. The acceleration factor of mean time to failure (MTTF) due to catastrophic optical mirror degradation was experimentally estimated. By using the factor, MTTF was estimated to be 23.5 K hours under 2.1 W, CW.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Sakura Hall 1**

PRJ4: Wearable Technology

Special Topics of Interest on AR/VR and Hyper Reality

Chair: K. Ohara, Texas Instrs., Japan
Co-Chair: T. Hashizume, Seiko Epson, Japan

PRJ4 - 1: 13:50 ***Invited*** **Display Unit Using Laser Scanning Device**

T. Matsuda, S. Onoe, Y. Seo, S. Ouchi
Hitachi, Japan

We are developing projector system with scanning fiber device and its control system. Our novel scanning systems of scanning fiber device provide high resolution, uniform brightness, rectangular display area, which are difficult matters of conventional scanning fiber device.

PRJ4 - 2: 14:10 ***Invited*** **Enhancing Both Logical and Emotional Abilities with Information and VR/AR Technologies Suitable for Infant Development**

S. Ohtsuka
Kagoshima Univ., Japan

The academic abilities of students in Japan and US have declined dramatically with the overwhelming consumption of graphic, and thus fragmented, information. We describe the importance of providing children electronic materials appropriate for their age from the perspective of development; logical information and reality of visual stimuli.

PRJ4 - 3: 14:30 ***Invited*** **Every Aspect of Advanced Retinal Imaging Laser Eyewear: Principle, Free Focus, Resolution, Safety, and Medical Welfare Applications**

M. Sugawara, M. Suzuki, M. Ishimoto, K. Hasegawa, N. Miyauchi
QD Laser, Japan

Retinal Imaging Laser Eyewear has a miniature laser projector inside the frame which provides the wearer with digital image information through the pupil using the retina as a screen. This paper describes every aspect of this compact universal-design eyewear from its principle, focus-free imaging, resolution, safety to medical welfare applications.

PRJ4 - 4 14:50 **Optical Design of Non-Telecentric Projection Lens for an LED Illumination System**

C.-K. Lo, W.-S. Sun[*]*, J.-W. Pan, P.-S. Hu*
Nat. Chiao Tung Univ., Taiwan
[*]*Nat. Central Univ., Taiwan*

A newly designed non-telecentric projection lens is proposed for a mini-projector with LED light sources. It consists of six spherical lenses. The zoom ratio is 1.1, and the throw ratio could operate at 1.23. Using this non-telecentric projection zoom lens, a very sharp image could be achieved with low cost.

----- Break -----

15:30 - 16:45 **Sakura Hall 1**

PRJ5: Holographic Device

Chair: D. Cuypers, imec & Ghent Univ., Belgium
Co-Chair: T. Hayashi, Okamoto Glass, Japan

PRJ5 - 1: 15:30 ***Invited*** **Aerial Interaction with Holograms of Insensible Frequency towards Generating Audio, Visual, and Haptic Feedback in the Three Dimensional Space**

Y. Ochiai[,**]*

[*]Univ. of Tsukuba, Japan
[**]Pixie Dust Techs., Japan

We introduce our case studies on aerial interaction methods that utilizes holograms of insensible frequency towards generating Audio, Visual, and Haptic contents in three-dimensional space. We employed Computer Generated Hologram for calculation and rendered with ultrasound by phased array and femtoseconds laser induced plasma by Spatial Light Modulators.

PRJ5 - 2 15:50 **Enlarge the Exit Pupil Size with Homogenous Luminance Output in Holographic Waveguide Display System**

A. Liu, Y. Zhang, Y. Weng, B. Wang[*]

Southeast Univ., China
[*]China Elect. Standardization Inst., China

Planar waveguide structure can be expanded exit pupil easily to get a big eye-box of the near-eye display. A physical model of planar waveguide is built and an improved distributed function of diffraction efficiency for out-coupled grating is proposed with considering the whole view angles in FOV.

PRJ5 - 3 16:10 **Light Beam Manipulation with Liquid Crystal Based Micro-Optical Components**

D. Cuypers, X. Shang, H. D. Smet

imec & Ghent Univ., Belgium

Refractive micro-optical structures combined with liquid crystal are used for various electrically controllable manipulations of light beams. Both linear and circular structures as well as nematic and cholesteric liquid crystals are explored to obtain fast switching, polarization independent devices.

PRJ5 - 4L 16:30 **High Optical Efficiency RGB Light Mixing Technique for Head Mounted Display**

*T. Kuno, T. Kawamura, T. Takaiwa**

Hitachi, Japan
**Hitachi Chem., Japan*

We developed Separation Integrator as a RGB light mixing device for small optical engine of HMDs and pico projectors. Separation Integrator can reduce size and cost of optical engines. We demonstrated that its optical efficiency was expected to be higher than that of a dichroic mirror.

Author Interviews
17:00 – 17:40

Supporting Organizations:
Consortium of Visual Laser Diode Applications
Laser Display and Lighting Conference
Laser Display Technology Research Group, Optical Society of Japan
Laser Society of Japan
Technical Group on Information Display, ITE

IDW Best Paper Award

IDW Outstanding Poster Paper Award

These awards will go to the most outstanding papers selected from those presented at IDW '17.
The 2017 award winners will be announced on the IDW website: http://www.idw.or.jp/award.html

Workshop on Electronic Paper

Wednesday, December 6

13:10 - 13:15 **Meeting Room 3**

Opening

Opening Remarks
13:10

K. Hashimoto, E Ink Japan, Japan

13:15 - 14:25 **Meeting Room 3**

EP1: New Applications for e-Paper

Chair: G. Zhou, South China Normal Univ., China
Co-Chair: Y. Hotta, Ricoh, Japan

EP1 - 1: 13:15 ***Invited*** **Applications of Electrophoretic Displays in Architecture and Design**

P. G. Apen

E Ink, USA

Electrophoretic displays (EPDs) are an extremely versatile form of electronic paper. The paper describes using EPD films for entirely new applications such as autonomous architectural tiles. Tile configurations and properties are highlighted along with the novel integration strategies used.

EP1 - 2: 13:40 ***Invited*** **Solid-State Reflective Displays (SRD) for Video-Rate, Full Colour, Outdoor Readable Displays**

C. Talagrand, G. Triggs, L. Bandhu, S. Garcia-Castillo, B. Broughton, H. Bhaskaran, P. Hosseini*

Bodle Techs., UK
**Univ. of Oxford, UK*

Solid State Reflective displays (SRD) have been proposed as a new route for next generation reflective displays. We present the first optical measurements of a combined RGBW states, together with a simulated black state. These results demonstrate the feasibility of a future high performance, video capable, full colour, SRD display.

EP1 - 3 14:05 **Highly Reflective Electrostatic Shutter Display**

E. Schlam, J. Finch, J. Koskulics

New Visual Media Group, USA

The only viable technology for digital billboards, LED, must be run very bright, consuming energy, and is also very heavy and expensive. Our technology is a very low cost, low power, simple electronic shutter array and independent reflector. It therefore allows independent optimization of each.

Also presented in Innovative Demonstration Session (see p. 227)

----- Break -----

14:50 - 16:00 **Meeting Room 3**

EP2: Various Technologies for e-Paper

Chair: S. Maeda, Tokai Univ., Japan
Co-Chair: Y. Toko, Stanley Elec., Japan

EP2 - 1: 14:50 ***Invited*** **Progress in Electro-Fluidic Displays: Key Materials and Processes**

R. Zhou[*], Y. Deng[,**], Y. Dou[*], Y. Guo[*], H. Li[*], H. Jiang[*], B. Tang[*], A. Henzen[*], G. Zhou[*,**,***]*

[*]South China Normal Univ., China
[**]Shenzhen Guohua Optoelect. Tech., China
[***]Ac. of Shenzhen Guohua Optoelect., China

Electro-fluidic display (EFD) based on the electro-wetting principle is one of the most promising reflective paper-like displays with full color, high contrast, video speed and flexibility. This paper presents the recent progresses on several key aspects of this EFD technology, especially about new material, structure and process.

EP2 - 2: 15:15 ***Invited*** **Review on Electro-Phoretic E-Paper Development**

B.-R. P. Yang

Sun Yat-Sen Univ., China

Electro-phoretic dipsplay (EPD) has been prevailing the E-reader market. More and more actual paper applications will be replaced by EPD. This report intends to review the EPD knowledge learnt over the last decade, hope to solicit or inspire more researchers to create more innovative ideas for future E-paper applications.

EP2 - 3 15:40 **E-Paper Touch System for IoT Safety and Security Using Status LEDs for Visible Light Data Transmission**

S. Otten, K. Blankenbach

Pforzheim Univ., Germany

Developing and operating Internet of Things (IoT) devices is challenging without a display. We report on an add-on device with 3.8-in. e-paper touch display for visualizing IoT data using status LEDs (of IoT devices) for visible light communication. We compare several e-paper and other display technologies for reflectance and CR.

Author Interviews
16:20 – 17:00

Thursday, December 7

10:40 - 11:30 **Meeting Room 3**

EP3: Novel Color e-Paper Technologies

Chair: N.-S. Roh, Samsung Display, Korea
Co-Chair: M. Wang, Lab. 126, USA

EP3 - 1: 10:40 ***Invited*** **The Color + Video Revolution of Electronic Paper**

*R. J. Fleming, S. Peruvemba, S. Fergusun, B. Sadlik, T. Johansson**

CLEARink Displays, USA
**CLEARink Displays, Canada*

This paper review the progress of novel electrophoretic type display with video level switching speeds and high reflected brightness brought about by the exploitation of total internal reflectance from embedded optical structures. The increased reflected brightness is standard color filter arrays can be used to produce full color reflective displays.

EP3 - 2: 11:05 ***Invited*** **Skin-Like Full-Color Plasmonic Reflective Displays**

D. Chanda

Univ. of Central Florida, USA

Tuning plasmonic light absorption with liquid crystal (LC), the color reflected from a nanostructured surface can be changed as a function of voltage. The engineered plasmonic surface allows complete LC reorientation and maximum overlap between plasmonic fields and LC, enabling large tunability across the entire visible spectrum.

11:30 - 11:45 **Meeting Room 3**

Short Presentation PRJp1: Electronic Paper

All authors of poster papers for the EPp1 session will give 3-minute oral presentations with no discussion time.

----- Lunch -----

13:10 - 14:30 **Meeting Room 3**

EP4: Advanced Electrochromic Displays

Chair: N. Kobayashi, Chiba Univ., Japan
Co-Chair: M. Higuchi, NIMS, Japan

EP4 - 1: 13:10 ***Invited*** **Enhancement of Black Mode State Using Three-Dimensional Nano Branches in Electrochromic Device**

J.-L. Lee, J. Y. Park
POSTECH, Korea

We reviewed the state-of-the-art ECD technologies. Several kinds of ECD such as WO_3, Ag, and ITO electrodes were studied. Three-dimensional nano branches of electrochromic devices (ECDs) are effective in absorbing incident photons via localized surface plasmon resonance in comparison with two-dimensional nanostructured electrodes.

EP4 - 2 13:35 **A Multicolor Electrochromic Display Having Hybrid Capacitor Configuration with Carbon Electrode**

Z. Liang, K. Nakamura, N. Kobayashi
Chiba Univ., Japan

In this paper, we designed a novel multicolor electrochromic (EC) device having hybrid capacitor electrochromic device based on 4,4'-biphenyl dicarboxylic acid diethyl ester and phenothiazine molecule with carbon electrode. The EC properties of the device were analyzed and discussed for the possibility to multicolor representation.

EP4 - 3 13:55 **The Relationship between Response Characteristics and Particle Size in the Nanoparticle-Based Fast-Response Electrochromic Electrode**

Y. Watanabe, K. Suemori, S. Uemura
AIST, Japan

We investigated the response characteristics of a nanoparticle-based porous electrochromic (EC) electrode for fast-response EC display. In this work, it was revealed that the particle size of the porous film is one of the key factors controlling the EC response speed of dye-modified porous EC electrode.

EP4 - 4L 14:15 **Electrochromic Devices with Metallo-Supramolecular Polymer**

M. Higuchi
NIMS, Japan

A metallo-supramolecular polymer film shows electrochromism based on the redox of metal ions in the presence of electrolyte. Electrochromic display sheets cuttable with scissors have been fabricated with metallo-supramolecular polymer by utilizing high stability of the polymer film to air and moisture.

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* EPp1: Electronic Paper**

EPp1 - 1L **Performance and Impressions of Paper/ LCD Tablet/ e-Paper in a Reading and Writing Task as a Typical Study Scene by Pupils**

*N. Ota, K. Eguchi, M. Omodani, T. Mouri**

Tokai Univ., Japan
**Canon, Japan*

We have evaluated performances and subjective impressions of paper, LCD tablet, and e-Paper during a task of reading and writing on each medium. The order of correct answer rate and processing speed and most of subjective impression was Paper > e-Paper > LCD tablet.

EPp1 - 2L **Emissive and Reflective Dual-Mode Display with Switchable Two-Color Emission Based on Twisting-Ball Display**

Y. Komazaki, T. Torii

Univ. of Tokyo, Japan

In this work, we have developed a novel emissive and reflective dual-mode display with switchable two-color emission utilizing twisting-ball display and inorganic electroluminescence (EL). Developed display enabled yellow-green/green reflective colors which were switchable by DC voltage and green/blue-green emissive colors switchable by biased AC voltage.

EPp1 - 3L **Novel Electrochemical Modulation Device Enabling Control Between Transparent, Mirror, Black, and Light Emission State**

S. Tsuneyasu, M. Kawara, K. Enomoto, K. Nakamura, N. Kobayashi

Chiba Univ., Japan

We demonstrated that dual mode display device based on electrochemiluminescence (ECL) and electrodeposition-based electrochromic system. The ECL was observed from the device under application of AC voltage; whereas modulation of its transmittance based on Ag electrodeposition was also achieved when DC voltage was applied to the device.

EPp1 - 4L **Flexible SnO_2 Electrodes Prepared by Spray Deposition Processes for Ag Deposition-Based Three-Way EC Device**

H. Suzuki, W. Fujimoto, K. Suzuki, Y. Henmi, Y. Seki, T. Sasaki, K. Pak, S. Seki, T. Suenaga, K. Kumagai, T. Satoh[*]*, T. Uchida*[*]

Nat. Inst. of Tech., Sendai College, Japan
[*]*Tokyo Polytechnic Univ., Japan*

This study presents flexible tin oxide (SnO_2) electrodes by a spray-CVD process. This electrode surface was modified with SnO_2 particles deposited by a spray-mist deposition process. The electrodes were used to fabricate an Ag deposition-based three-way electrochemical (EC) device transforming into three optical states - transparent, mirror and black.

EPp1 - 5L **Improvement of Memory Properties of Ag Deposition-Based Electrochromic Device by Introducing Ion Exchange Membrane**

S. Kimura, K. Nakamura, N. Kobayashi

Chiba Univ., Japan

We reported Ag deposition-based multicolor electrochromic device. However, the electrochromic device had poor color retention property because of dissolution of deposited Ag metal by Cu^{2+} ion. Here, we introduced anion exchange membrane to separate Cu^{2+} from deposited Ag metal. The improved device achieved longer retention time of colored state.

Friday, December 8

9:00 - 10:05 **Meeting Room 4**

UXC5/EP5: E-book and Education

Chair: M. Mori, Hosei Univ., Japan
Co-Chair: K. Hashimoto, E Ink Japan, Japan

UXC5/EP5 - 1: 9:00 ***Invited*** **Visual Awareness Performance in Reading Texts on Paper versus Tablet among Indonesian Elementary School Children**

S. D. Mardiyani, N. Higuchi, T. Enomae

Univ. of Tsukuba, Japan

The use of digital or Information and Communication Technology (ICT) devices as educational aids is expanding. This study focuses on the comparison between paper and digital media by conducting a proofreading test. The test results revealed no significant performance differences. However, after separating misspelled words under error patterns, paper helped children find such errors efficiently.

UXC5/ EP5 - 2: 9:25 ***Invited*** **Are E-Books Actually Green? The Role of E-Reader in Changing Reading Patterns and Environmental Impact in Book Reading Activities**

E. Amasawa[*], T. Ihara[*], K. Hanaki[,**]*

[*]Univ. of Tokyo, Japan
[**]Toyo Univ., Japan

We comparatively assessed environmental impact of paper book reading and e-book reading with an e-reader. We first investigated interchangeability of the reading experience of paper books and e-books through a web survey and an experiment, and computed environmental impact of book reading activities of consumer segments.

UXC5/ EP5 - 3L: 9:50 ***Invited*** **Cognitive Load of Handwriting and Typing: The Impact for Memorization in a Dual Task Method**

H. Shibata, K. Omura

Fuji Xerox, Japan

This paper describes experiments to compare the cognitive load of handwriting and typing using a dual task method. We found that the cognitive load of handwriting was lower than that of typing and typing interfered memorization more than handwriting. This tendency did not differ among persons with different typing skill.

----- Break -----

Author Interviews
12:00 – 12:40

IDW ’17 Tutorial in Japanese

Organized by SID Japan Chapter
Tuesday, Dec. 5, 2017
13:00 – 18:00
Shirakashi Conference Room
(3F, Conference Bldg.)

Sendai International Center
Detailed information will be announced at
http://www.sid-japan.org/

Workshop on MEMS and Emerging Technologies for Future Displays and Devices

Thursday, December 7

13:10 - 13:15 **Hagi Conference Hall**

Opening

Opening Remarks
13:10

M. Nakamoto, Shizuoka Univ., Japan

13:15 - 14:55 **Hagi Conference Hall**

MEET1: Micro/NanoDisplays and Nanotechnology Application

Chair: P. Kathirgamanathan, Brunel Univ. London, UK
Co-Chair: K. C. Park, Kyung Hee Univ., Korea

MEET1 - 1: ***Invited*** **OLED on CMOS: What about Thinning and**
13:15 **Curving?**

T. Maindron, B. Chambion, A. Vandeneynde, S. Gétin, M. Provost, A. Suhm, P. Peray, M. Zussy, J. Dechamp

CEA-LETI, France

In this work, we will use the technical background for CMOS thinning of CEA-LETI (historically developed for Through Silicon Via technology) to realize curved (1D) OLED-based microdisplays. This feature can allow significant innovation on the system/application because it will help to redesign simpler and lighter optical engine systems.

MEET1 - 2: ***Invited*** **On-Chip Polyaniline Electrochromic**
13:35 **Microdisplay for Disposable Bio-Sensing Chip**

T. Tsukamoto, Y. Zhu, S. Tanaka

Tohoku Univ., Japan

We developed an on-chip electrochromic micro-display for a disposable bio-sensing chip. A fully-functionalized demonstration system combining with a on-chip battery and CMOS devices was developed. The device could be successfully operated in a NH_4Cl solution and the measured data could be transmitted by using the on-chip display.

MEET1 - 3: 13:55 ***Invited*** **Micro-LEDs: How It Happened and Where to Go?**

Z. Liu[,**], K. Zhang[*,**], C. Qiu[*], H. S. Kwok[**], X. Sun[*]*

[*]Southern Univ. of S&T, China
[**]Hong Kong Univ. of S&T, Hong Kong

Micro-LEDs are great candidate for many applications such as the next generation displays. In this paper we report the design and fabrication of active matrix Micro-LEDs including GaN Micro-LED array, AM backplane and flip-chip integration. Current control current source (CCCS) was used for better pixels uniformity and display quality.

MEET1 - 4: 14:15 ***Invited*** **Development of Nano-Phosphors Films for Polymer Protection and Plant Growth**

G. R. Fern, J. Silver, K. Tarverdi, T. G. Ireland, F. Meng, Z. Dehouche

Brunel Univ. London, UK

Thin films of phosphors have been prepared for use in light conversion applications, primarily for use in horticultural applications. A method for optimizing the film loading has been shown using a crystalline silicon photovoltaic cell.

MEET1 - 5 14:35 **A Planar Field Emission Electron Source Using Highly-Crystalline Single-Walled Carbon Nanotubes in a Triode Structure with Under-Gate Electrodes**

S. Kumon[,**], N. Shimoi[**]*

[*]DOWA Holdings, Japan
[**]Tohoku Univ., Japan

We have developed and successfully established a planar cathode using highly-crystalline single-walled carbon nanotubes as field emitters in a triode structure with an under-gate electrode. The cathode has been fabricated with coating of the ink dispersed the carbon nanotubes, and achieved to obtain the homogeneous and stable planar electron emission.

Author Interviews
14:55 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* MEETp1: Quantum Dots and Nanotechnologies**

Special Topics of Interest on Lighting and Quantum Dot Technologies

MEETp1 - 1 **Improved Efficiency of Light-Emitting Diodes Using InP/ZnSe/ZnS Quantum Dots and Mg-Doped Zinc Oxide**

H. Sasaki, T. Fukuda, N. Kamata, Z. Honda

Saitama Univ., Japan

In light-emitting diodes with InP-based quantum dots (QDs), one problem is that the potential difference bet-ween zinc oxide and InP-based QD layer is large. In this study, we demonstrated the improved efficiency of InP-based device with multi-shell QDs and Mg-doped zinc oxide layer.

MEETp1 - 2 **Withdrawn**

MEETp1 - 3 **Criterions and Constrains for the Fundamental Analytical Solutions of Interlaced Microstructures for Display Element and LED**

C.-J. Ou, J.-F. Qian, Z.-Y. Shih, M.-Y. Huang, K.-Y. Chen, Y.-C. Chien

Hsiuping Univ. of S&T, Taiwan

This report explores the analytical formulations and prove the feasibility and robustness of the interlaced prism structure for display application. Expressions are derived for numerical implementation, and methodology for sensitivity analysis is also presented.

MEETp1 - 4 Simultaneous Optimization of LED Angular Apodization and Spatial Locations for Performance Metric of Lighting Display

C.-J. Ou, M.-Y. Huang, S.-R. Yang, M.-J. Liu, F.-R. Lin, J.-F. Qian, C.-Y. Ou[*]

Hsiuping Univ. of S&T, Taiwan
[*]Taichung Municipal Taichung Second Senior High School, Taiwan

Based on the transient factor between the near field area source and the far field point source approach, a reliable illuminating spreadsheet is developed for LED lighting and various kinds of lamp device with specific apodization pattern.

MEETp1 - 5 Prelude for Hyper-Geometric Function of Cosine n^{th} Apodization and the Application to Display LED Encapsulates

C.-J. Ou, Z.-Y. Shih, K.-S. Hsu, K.-Y. Chen, C.-F. Chang, P.-X. Huang

Hsiuping Univ. of S&T, Taiwan

Analytical solution with Hypergeometric function for the light source is derived, and is capable to bring reasonable balance of the directional extraction energy that is given out from the LED die and the contours of the encapsulates.

MEETp1 - 6 Alcohol-Soluble Quantum Dots for Lighting and Display

Z. Bai, D. Han, X. Zhang, Y. Ge, S. Chang, H. Zhong

Beijing Inst. of Tech., China

Alcohol-soluble quantum dots, with unique solubility and hydroxyl-terminated ligands, exhibit “green” processability, organic solvent resistance, tunable electrical band gap and multiple reaction sites on surface. Thus, alcohol-soluble quantum dots possess notable performance and processing superiorities in on-chip and remote structure WLEDs as well as QLEDs for lighting and display devices.

MEETp1 - 7L Core-Shell Structure Ratio of the Quantum Dots $CuGaS_2$ / ZnS and the Light-Emitting Properties

R. Itoh, J. Nagakubo[*], T. Ban, S. Yamamoto

Ryukoku Univ., Japan
[*]ULVAC, Japan

In this study, Cu-Ga-S_2/ZnS quantum dots (QDs) with a core-shell structure using Ga instead of In were attempted. QDs were evaluated as a function of core-shell structure ratio photoluminescence. Also used to characterize the QDs was energy dispersive X-ray spectroscopy.

15:00 - 18:00 **Exhibition Hall**

Poster **MEETp2: Novel Materials and Components**

MEETp2 - 1 **Microscopy with Micro-Projector Display for Inspection of Hydrogen Production Rate with TiO_2 Electrode Cell**

C.-J. Ou, R.-Y. Lan, C.-R. Ho*, K.-S. Hsu, M.-J. Liu, S.-R. Yang, C.-F. Chang, H.-H. Kuo*

Hsiuping Univ. of S&T, Taiwan
**Feng Chia Univ., Taiwan*

This report reveals the using of the microdisplay device as illuminators as a platform to explore the optimal combination of the TiO_2 compounds for the Hydrogen generating. Stabilities and the adaptation of the spectrum and the energy generating metrics is included in this measurement scheme.

MEETp2 - 2 **Fabrication of High Performance Electron Beam with Functional Silicon Coated CNT Cold Cathode**

J. S. Kang, J. H. Kim, K. C. Park

Kyung Hee Univ., Korea

We developed high performance electron beam with carbon nanotube cold cathode with functional silicon coating. The resistance of CNT emitter attributed on electron emission current. With optimized functional silicon coating thickness, we achieved the emission current of 20.5 mA in the small emission area of 0.08 cm^2.

MEETp2 - 3 **Fabrication of Wide Bandgap Anode Layer for Deep UV Lighting with CNT Cold Cathode Electron Beam**

S.T. Yoo, J. S. Kang, K. C. Park

Kyung Hee Univ., Korea

We developed enhanced deep UV generation process with wide bandgap anode layer and carbon nanotube cold cathode electron beam (C-beam) as excitation source. We developed high performance wide bandgap anode using anode buffer layer of SiO_2 and obtained enhanced UV emission peaks at 226 and 244 nm.

MEETp2 - 4 **Morphological Properties of Nickel Hydroxide Nanosheets Prepared by Solution Growth**

M. Mikami, K. H. Kim, Y. Abe, M. Kawamura, T. Kiba

Kitami Inst. of Tech., Japan

Nickel hydroxide ($Ni(OH)_2$) mixed with nickel carbonated hydrate ($NiCO_3 \cdot 6H_2O$) was prepared via a facile solution process at 95 °C for 3 h using nickel acetate tetrahydrate ($Ni(CH_3COO)_2 \cdot 4H_2O$) and hexamethylenetetramine ($C_6H_{12}N_4$) without any additional reagents. 2-dimensional (2D) nanosheets were interconnected each other, which led to form the curved and nanolayered structures.

MEETp2 - 5 Design and Preparation of Optical Film for Viewing Angle Control

Q. Feng, Y. Wang, C. Wu, H. Yin, G. Lv*

Hefei Univ. of Tech., China
**Hefei BOE Display Lighting, China*

In automotive, railway, and airplane, a LCD is usually installed with certain angle to orient the display image to viewers. The paper designs a freeform microstructure that is prepared with direct-writing lithography. The practical backlight with such film is tested with the maximum luminance happening at 19.2°.

MEETp2 - 6 Synthesis of Zinc-Aluminum Layered Double Hydroxide and Their Structural Properties

S. Motoyama, K. H. Kim, Y. Abe, M. Kawamura, T. Kiba

Kitami Inst. of Tech., Japan

We investigated structural properties of zinc-aluminum layered double hydroxide (Zn-Al LDH) prepared by simple wet-chemical process. After drying at 90°C, Zn-Al LDH with NO_3^- anion had the hexagonal-shaped nanosheets with diameter of 1-3 μm. After annealing at 500°C, zinc oxide (ZnO) mixed with zinc aluminum oxide ($ZnAl_2O_4$) was achieved.

MEETp2 - 7 Phase Recovery from Axial Diffraction Patterns Using Ptychographical Iterative Engine

Y. Wagatsuma, T. Shimobaba, T. Kakue, T. Ito

Chiba Univ., Japan

We propose a method for the phase recovery of a three-dimensional object from axial diffraction patterns using ptychographical iterative engine. The phase recovery using conventional phase retrieval methods under spherical illumination is difficult. The proposed method can retrieve the phase of an object under both planar and spherical wave illuminations.

MEETp2 - 8 Tunable Tamm Plasmon Devices by Liquid Crystals

H.-C. Cheng, Y. Lu, K.-P. Chen, S.-C. Jeng

Nat. Chiao Tung Univ., Taiwan

The Tamm plasmon (TP) is a plasmonic resonance at the interface between a photonic crystal (PC) and a metal. A tunable TP is proposed by filling liquid crystals (LCs) in the gap between the metal and the PC. The resonance of TP is tuned by changing the phase of LCs.

MEETp2 - 9 System Dynamic Approach for the Multi-Physics Analysis of Micro-LED

C.-J. Ou, M.-J. Liu, S.-R. Yang, F.-R. Lin, P.-X. Huang, R.-J. Yan

Hsiuping Univ. of S&T, Taiwan

System dynamic approach for the analysis of thermal transmission of the Micro-LED device is demonstrated. Sensitivities and stabilities of the LED thermal management with the related multi-physical phenomena are brought out, and the appropriate recommendation for the design parameters are provided.

MEETp2 - 10 High Performance Active-Matrix Reflective Display Using by Low Driving Voltage PDLC Technology

C.-H. Chen, T.-L. Lin, J.-T. Lien

Chunghwa Picture Tubes, Taiwan

In this paper, we have succeeded to develop a 10.1-in. Active-Matrix Reflective Display using by low driving voltage polymer-dispersed Liquid crystal (PDLC) technology. The display mode is Reflective. In addition, there are some advantages, such as, polarizer free, backlight free and satisfied with active-matrix TFT, and so on.

MEETp2 - 11 Design and Research of a Vehicle Mounted Curved Surface Screen

R. Chen, H. Zhou, Z. Zhang, L. Fang, J. Chen, S. Wu, J. Kang, X. Zhou, P. Shen, J. Li

Xiamen Tianma Microelect., China

For the sake of vehicle mounted curved screens, we considered the existence of possible risk in the design phase, such as the ability of charging, uneven brightness and PS extrusion leakage. After the sufficient experimental verification and simulation confirmed, we launched the first LTPS vehicle mounted curved surface screen.

Also presented in Innovative Demonstration Session (see p. 227)

15:00 - 18:00 **Exhibition Hall**

Poster MEETp3: Emerging Process Technologies
Special Topics of Interest on Oxide-Semiconductor TFT

MEETp3 - 1 Influence of Ar/O_2 Plasma on Solution Processed Ga Doped IZTO TFTs

M. N. Naik, B. R. Naik, C. Avis, J. Jang

Kyung Hee Univ., Korea

We studied the effect of plasma treatment on the surface of Ga doped IZTO TFTs with and without Ar/O_2 plasma. TFTs with treatment exhibits better characteristics than untreated one, with an increase in μ_{lin} (from 7.96 ± 5.52 to 24.64 ± 8.06 $cm^2V^{-1}\,s^{-1}$), decrease in SS (from 192.9 ± 39.55 to 179.28 ± 44.43 mV/dec), and decrease hysteresis from (0.21 ± 0.15 to 0.197 ± 0.24 V).

Friday, December 8

9:00 - 10:20 **Main Hall**

MEET2: Novel Materials and Components

Chair: M. Esashi, Tohoku Univ., Japan
Co-Chair: H. Zhong, Beijing Inst. of Tech., China

MEET2 - 1: 9:00 ***Invited*** **Plastic Packaging Recycling Using Intelligent Separation Technologies for Materials (PRISM): The Use of Long-Persistence Phosphors**

J. Silver, G. R. Fern, P. G. Harris, P. Marsh, K. Tarverdi

Brunel Univ. London, UK

A new approach overcoming problems of interfering fluorescence (from plastic bottles and their labels) in the automated recycling of plastic bottles using intelligent separation technologies is described. The method utilizes delayed fluorescence from long persistence phosphors. This facile approach can be used on existing recycling lines at little extra cost.

MEET2 - 2: 9:20 ***Invited*** **Fabrication of High Performance Electron Beam for Electron Microscope Applications**

H. R. Lee, K. C. Park

Kyung Hee Univ., Korea

We developed high performance electron beam with carbon nanotube cold cathode for high resolution electron microscope application. With a 3×3 nine emitters, we measured more than 100 hrs operation life in DC mode and obtained beam resolution of 77 μm with phosphor screen.

MEET2 - 3: 9:40 ***Invited*** **Organic-Inorganic Composite Particles for Imaging Probes**

H. Yabu

Tohoku Univ., Japan

Recently, we developed a method to fabricate organic-inorganic composite particles comprised of polymers and inorganic (or metal) nanoparticles. Furthermore, gold nanoparticle decorated spherical particles, which enhances Raman scattering signals from adsorbed molecules, have been prepared by using this method. We applied this particle for a dispersive imaging probe.

MEET2 - 4 **Combining Polymer Containing Phosphors with**
10:00 **Laser Diodes for Horticultural Applications**

J. Silver, G. R. Fern, T. G. Ireland, A. Salimian, K. Tarverdi
Brunel Univ. London, UK

Methods of incorporating phosphor particles in polymers are reported. The phosphor particles in the polymer films had their light emitting properties assessed under laser diode excitation. The polymer film/ phosphors performance was evaluated for horticultural applications. Phosphors were chosen to enable different emission spectra to match particular plant requirements.

----- Break -----

Evening Get-Together with Wine

Tuesday, Dec. 5, 2017
18:00 – 20:00
Café Leaf
(1F, Conference Bldg.)
Sendai International Center
(Sponsored by Merck Performance Materials Ltd.)

Reception

Wednesday evening
Dec. 6, 2017
18:30 – 20:30
Zuiun (2F)
Sendai Shozankan
See page 15 for details

10:40 - 12:20 **Main Hall**

MEET3: Fundamental Components and Process Technologies

Chair: J. Silver, Brunel Univ. London, UK
Co-Chair: T. Maindron, CEA-LETI, France

MEET3 - 1: *Invited* Electron Transparent Graphene for Field Emission Applications **10:40**

W. I. Milne[,**], T. Hallam[***], G. Duesberg[***], C. Li[****], W. Lei[****], B. P. Wang[****], M. T. Cole[*]*

[*]Univ. of Cambridge, UK
[**]Tokyo Tech, Japan
[***]Trinity College Dublin, Ireland
[****]Southeast Univ., China

Herein we present graphene as a possible candidate for a variety of field emission applications. The atomically thin, ordered structure of graphene has exceptionally high attainable aspect ratios - potentially higher even than that of CNTs - whilst defective edge terminations render it superior to metallic nanowires for such applications.

MEET3 - 2: *Invited* Sensors Based on Thin Film Bulk Acoustic Wave Resonators: From Fabrication to Applications in Chemical and Biological Analysis **11:00**

M. DeMiguel-Ramos, G. Rughoobur[*], N. Rajabalina[**], S. Hamzehlou[**], J. M. Escolano[***], E. Iborra[***], A. J. Flewitt

Univ. of Cambridge, UK
[*]MIT, USA
[**]Univ. of the Basque Country, Spain
[***]Universidad Politécnica de Madrid, Spain

Thin film bulk acoustic wave resonators (FBARs) have interesting applications in the fields of gas, chemical and biological sensing owing to their high sensitivity and high integration potential. We present the latest advancements in the fabrication of FBARs and experiments using the devices for chemical and biological sensing applications.

MEET3 - 3: 11:20 ***Invited*** **Open Collaboration Based on Hands-On Access Fabrication Facility for MEMS**

M. Esashi, K. Totsu

Tohoku Univ., Japan

Companies can easily access and utilize a hands-on access fabrication facility in Tohoku University for their prototyping or small-volume production. They can access a lot of technology and know-how accumulated and can be assisted by skilled engineers. More than 200 companies are using the facility.

MEET3 - 4 11:40 **MEMS-Based Retinal-Imaging System for Visual Health Monitoring**

N. Kaushik, T. Sasaki, Y. Takahashi, T. Nakazawa, K. Hane

Tohoku Univ., Japan

We report on imaging of retina by laser scanning confocal microscopy. A MEMS based scanner was used to miniaturize the system size to fit into a wearable glass. Retina/fundus of pig's eye was imaged successfully. Results demonstrate it's potential in personal monitoring of eye diseases.

MEET3 - 5 12:00 **Excellent Temperature Sensing Device with Coplanar a-IGZO TFT Ring Oscillator**

A. Rahaman, M. M. Hasan, Y. Chen, J. G. Um, M. M. Billah, J. Jang

Kyung Hee Univ., Korea

We demonstrate an excellent ring oscillator temperature sensor consisting of coplanar a-IGZO TFTs. The rate of frequency change is 10 kHz/°C. Because of its high rate of frequency change with temperature variation, the sensor can be widely used for temperature measurement on thin film and in the liquid.

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:30 **Main Hall**

MEET4: EL Quantum Dots Technologies

Special Topics of Interest on Lighting and Quantum Dot Technologies

Chair: W. Milne, Univ. of Cambridge, UK
Co-Chair: S. Chen, Southern Univ. of S&T, China

MEET4 - 1: *Invited* All Inorganic QLED with Metal-Oxide Electron and Hole Injection Layers
13:50

J. Jang, H.-M. Kim

Kyung Hee Univ., Korea

This paper reviews the all-inorganic processed quantum-dot light emitting diodes (QLEDs). All inorganic QLEDs with the interface treatment to reduce the exciton quenching exhibits the current efficiency of 7.3 cd/A and power efficiency of 2.3 lm/W. These performances are much improved compared to those of QLED without the interface treatment.

MEET4 - 2: *Invited* Displays Using Quantum Dot Color Conversion by Inkjet Printing of Quantum Dot Inks
14:10

R. Tangirala, A. Smith, S. Kan, C. Hotz, H. Kim, R. Kempt, T. Miki[*]*, S. Yoshihara*[*]*, T. Kizaki*[*]*, A. Ishizuka*[*]*, I. Kiyoto*[*]

Nanosys, USA
[*]*DIC, Japan*

Quantum dot color conversion layers have potential to revolutionize displays by improving efficiency and color gamut. To achieve these changes, QDs have to be deposited at sub-pixel pitch. Here we report on the fabrication and characterization of QD inks, as well as films made from inkjet deposition of these materials.

MEET4 - 3: *Invited* Efficient QLEDs with Novel Structures
14:30

S. Chen

Southern Univ. of S&T, China

Various device structures including top-emitting, microcavity, inverted, tandem, transparent, full-solution vacuum-free processed QLEDs will be talked. Charge balance is carefully optimized in these structures. In addition, we show that by substituting the problematic ZnO with $Zn_xMg_{1-x}O$, our recently developed tandem QLEDs exhibit efficiency over 100 cd/A (23.5%).

MEET4 - 4: ***Invited*** **Quantum-Dot Electroluminescence to**
14:50 **Achieve Saturated Colors for Rec.2020 Compatibility**

P. Kathirgamanathan, M. Kumaraverl, N. Bramananthan, S. Ravichandran

Brunel Univ. London, UK

We report here red quantum dot based electroluminescent devices (QLEDs) that meet the colour co-ordinates requirement set by REC2020. We also report the world first dark red CFQD (heavy metal free) ((x,y), (0.690, 0.309)) devices. The electroluminescent characteristics of devices of both CdSe/ZnS and cadmium free quantum dots are compared.

MEET4 - 5: ***Invited*** **Stability of Quantum Dot Color Pixel**
15:10 **Converter Printed by Ink Jetting**

M. Hasegawa, Y. Hirayama

Merck PM, Japan

We evaluated a stability of ink jetting printed Cd-free quantum dots (QDs) color pixel converter by using quantum yield (QY) measurement system and also using optical in situ measurement setup. We examined effects of coating materials to a stability of printed QDs, and found effects of solvent to QY of QDs.

15:30 - 17:10 **Main Hall**

MEET5: Emerging Quantum Dots and Nanotechnologies

Special Topics of Interest on Lighting and Quantum Dot Technologies

Chair: J. Jang, Kyung Hee Univ., Korea
Co-Chair: M. DeMiguel-Ramos, Univ. of Cambridge, UK

MEET5 - 1: ***Invited*** **Luminescent Perovskite-Polymer Composite**
15:30 **Films for Display**

J. He, H. Chen, Y. Wang[*]*, C. Zhang, H. Chen, S.-T. Wu, Y. Dong*

Univ. of Central Florida, USA
[*]*Chinese Ac. of Sci., China*

Ultrastable, highly luminescent green perovskites – polymer composite films have been achieved with a swelling-deswelling microencapsulation approach. A hybrid downconverter system comprising such films and state-of-the art red emitters are proposed for low cost, yet high efficiency wide color gamut liquid crystal displays (LCD).

Also presented in Innovative Demonstration Session (see p. 227)

MEET5 - 2: 15:50 ***Invited*** **Halide Perovskite Quantum Dots: New Generation Materials for Display Applications**

H. Zhong

Beijing Inst. of Tech., China

Halide perovskite quantum dots exhibit high photoluminescence quantum yields (60 - 90%), wide wavelength tenability (400 - 800 nm), ultra-narrow band emissions (20 - 50 nm) as well as additional polarization. The combination of these superior optical properties and low cost fabrication makes them to be potential candidates for display technology.

MEET5 - 3: 16:10 ***Invited*** **Innovative Display Technology for Low Vision Aid and Medical Application**

M. Sugawara, M. Suzuki, N. Miyauchi, M. Ishimoto

QD Laser, Japan

Retinal Imaging Laser Eyewear has a miniature laser projector inside the frame which provides the wearer with digital image information through the pupil using the retina as a screen. This paper describes its principle of focus-free imaging, prototype, laser safety, and application as low vision aid and ophthalmic testing equipment.

MEET5 - 4 **Withdrawn**

MEET5 - 5 16:50 **Interfacial Improvement Using Solution Processed Interlayer on Inverted Perovskite Quantum-Dot Light Emitting Diodes**

H. Jun, E. Moyen, H.-M. Kim, J. Jang

Kyung Hee Univ., Korea

We report a solution processed interlayer for the inverted perovskite quantum-dot (QD) light emitting diodes (PeQLEDs). The insertion of interlayer under the QDs increases the photoluminescence (PL) intensity of QDs by 10 times. Moreover, device performances of PeQLED with the interlayer were improved compared with those without it.

Author Interviews
17:10 – 17:40

Workshop on Display Electronic Systems

Wednesday, December 6

13:10 - 13:15 **Meeting Room 4**

Opening

Opening Remarks
13:10

H. Okumura, Toshiba, Japan

13:15 - 14:15 **Meeting Room 4**

DES1: Various Visualization Technologies

Chair: R. Oke, Panasonic Liquid Crystal Display, Japan
Co-Chair: T. Fujine, Sharp, Japan

DES1 - 1
13:15

12.3-in. High Resolution (1920xRGBx720) a-Si TFT LCD with Direct-Lit Local-Dimming Backlight System for Automotive Display

C.-Y. Du, C.-H. Kuan, C.-C. Chang, H.-H. Chen, H.-M. Su, W.-Z. Zeng

Chunghwa Picture Tubes, Taiwan

In this work, we developed of 12.3-in. (1920xRGBx720) automotive display with direct-lit local dimming backlight control technique which divided into 24 blocks by the ratio of 8 (H): 3 (V). In this case, we achieved high dynamic contrast ratio (>2000), high brightness 1500 nits and low power consumption properties.

DES1 - 2
13:35

Research on Color & Brightness Correction Method and Its Hardware Design for Video Wall Display

T. Wang[*], Y. Tang[,**], Y. Cui[*], Y. Zheng[*]*

[*]Southeast Univ., China
[**]Xizang Minzu Univ., China

A video wall processing platform based on FPGA has been developed. An algorithm is designed to calculate the RGB gray value based on the original panel performance. The experimental results show that the luminance deviation is within ±2 cd/m^2 while the chromaticity coordinate deviation below ±0.02 for different panels.

DES1 - 3
13:55 **Design of Novel IPLD System for Head Mounted Application with Embedded System**

Z. Gong[*], Y. Tang[,**], T. Wang[*], Y. Zheng[*]*

[*]Southeast Univ., China
[**]Xizang Minzu Univ., China

A novel Immersive Panoramic Live Display (IPLD) System has been recently developed, which can capture panoramic videos from the fisheye camera, and turn into a real-time perspective image suitable. The results show that when the perspective window size is 150x150, the display frame rate can reach 30 fps.

----- Break -----

14:50 - 16:10 **Tachibana Conference Hall**

3D1/DES2: 3D Display in AR/VR and Hyper Reality

Special Topics of Interest on AR/VR and Hyper Reality

Chair: T. Koike, Hosei Univ., Japan
Co-Chair: H. Okumura, Toshiba, Japan

3D1/ DES2 - 1: 14:50 ***Invited*** **Development of 55-in. 8K-3D IPS LCD with 3D Polarization Filter**

J. Maruyama, R. Oke, T. Murakoso, I. Hiyama, Y. Kato, Y. Umezawa[*], T. Sato[*], T. Takahashi[*], H. Yamashita[**], K. Tanioka[**], T. Chiba[**]

Panasonic Liquid Crystal Display, Japan
[*]Arisawa Manufacturing, Japan
[**]Kairos, Japan

We have developed the world's first (*) 8K-3D IPS -LCDs with a 3D polarization filter. In addition to super-high resolution of 8K, it provides a sense of depth by stereo-vision. It enables 8K-3D surgical systems for endoscopic and microscopic surgeries. (* As of March 2017, our study)
Also presented in Innovative Demonstration Session (see p. 227)

3D1/ DES2 - 2: 15:10 ***Invited*** **A Virtual Reality Display Based on Cluster-Eye Image Stitching**

H. Yen, C. Lin, G.-D. J. Su

Nat. Taiwan Univ., Taiwan

In this paper, we present a virtual-reality display which combines the principles of optical cluster eyes and insects' compound eyes. The system consists of two curved lens arrays to focus the image on the retina. The thickness of our optical system is less than 30 mm and it provides a field of view of up to 150° per eye. Using a 3D printer, the design is demonstrated experimentally.

3D1/ DES2 - 3 15:30 **Holographic Augmented Reality Head-Mounted Display with RGB Full HD Microdisplay**

Y.-T. Kim, J. Seo, W. Seo, G. Sung, J.-S. Chung, B. Shin, C.-K. Lee, J. An, S. Kim, H. Song, Y. Kim, H. Kim, C.-S. Choi, Y. Kim, K. Won, S.-H. Lee, C. Yoo, H.-S. Lee, S. Hwang

Samsung Elect., Korea

We realized a holographic AR head-mounted display with RGB full HD microdisplay. We confirmed the real augmented reality which perfectly matches virtual images to the real world. Further, the pixel mapping algorithm based on multi-layer in computer generated holography processing is proposed for the holographic image enhancement.

3D1/ DES2 - 4 15:50 **An Augmented Reality Display System**

X. Ma, N. Wu, X. Liu, Q. Zeng, X. Zhang

BOE Tech. Group, China

Augmented Reality (AR) is a technique that add additional information to real world. We are concerned with the implementation of the drive scheme and the signal processing section. In the paper we will describe optical design, drive scheme, pixel distortion correction and compensation in three aspects.

Author Interviews
16:20 – 17:00

Thursday, December 7

10:40 -12:20 **Shirakashi Conference Room**

LCT3/DES3: HMD Applications

Special Topics of Interest on AR/VR and Hyper Reality

Chair: H. Okada, Univ. of Toyama, Japan
Co-Chair: R. Oke, Panasonic Liquid Crystal Display, Japan

LCT3/ DES3 - 1: 10:40 ***Invited*** **The Optimal Fast Response LCD for VR-HMD**

T. Matsushima, K. Seki, S. Kimura, Y. Iwakabe, T. Yata, Y. Watanabe, S. Komura

Japan Display, Japan

We explain the moving picture characteristics of the display device required for virtual reality head-mounted displays (VR-HMD) and describe the optimum liquid crystal display mode. A short pitch lurch control (SLC)-IPS with a high-speed response and a simple structure is suitable for this purpose.

Also presented in Innovative Demonstration Session (see p. 227)

LCT3/ DES3 - 2: 11:05 ***Invited*** **Evaluation of Moving Picture Quality on LCD Device for Head-Mounted Display**

M. Kobayashi, T. Miura, N. Yamaguchi, M. Yashiki, T. Masuda, T. Katayama, S. Higashida, K. Hanaoka, H. Yoshida, S. Shimada

Sharp, Japan

We developed a LCD having EBET values of less than 1 ms with flashing backlight, and less than about 4 ms with scan backlight for our proposed measurement positions. This paper provides simple evaluation method using EBET measurements and simulations for moving picture quality of the HMD.

LCT3/ DES3 - 3: 11:30 ***Invited*** **Near Eye Application Based on Digital Electro-Optics Platform (X-on-Silicon)**

C.-W. Tsai, F. Lin, C. Wang

Jasper Display, Taiwan

Digital Electro-optics Platform is the main concept of Jasper Display Corp. (JDC) to develop various applications. These applications are based on our X-on-Silicon technologies, for example, Liquid Crystal on Silicon (LCoS), μLEDoS, OLEDoS, and CELLoS. LCoS technology is applied to Microdisplay, Spatial Light Modulator (SLM), Dynamic Optics, and Holographic Display.

Also presented in Innovative Demonstration Session (see p. 227)

LCT3/ DES3 - 4: 11:55 ***Invited*** **Head Mounted Display Implementations for Use in Industrial Augmented and Virtual Reality Applications**

T. Fukuda[*], J. Orlosky[,**], T. Kinoshita[*]*

[*]Westunitis, Japan
[**]Osaka Univ., Japan

This paper gives an overview of hardware designed for augmented and virtual reality systems designed, tested, and customized for industrial use. We will review existing technologies and their use cases and discuss a number of software implementations currently being deployed in research and industry.

----- Lunch -----

Author Interviews
14:40 – 15:20

15:00 -18:00 **Exhibition Hall**

Poster **DESp1: Display Electronic Systems**

DESp1 - 1 **Design of a-Si:H Gate Driver Circuit with Fast Charging and Discharging Capability for High-Resolution Liquid Crystal Displays**

P.-T. Lee, C.-E. Lee, M.-X. Wang, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This work proposes a gate driver circuit using a-Si:H technology for high-resolution TFT-LCDs. According to the simulation results, the gate-node voltage of the driving TFT can be raised to 40.6 V when discharging the output node to shorten the falling time of the output waveform to 1.38 μs.

DESp1 - 2 **Withdrawn**

DESp1 - 3 **Optimization of Flashing Period for Line Display Using Saccade Eyeball Movement**

K. Kanazawa, S. Kazuno, M. Okumura

Kanagawa Inst. of Tech., Japan

In this paper, a novel short flashing period controller for saccade-type line display was developed to optimize the flashing period. Experimental results indicated that the optimum flashing period was 0.78 ms and independent of the number of pixels.

DESp1 - 4 **Image Correction in 8K Displays Using AI**

M. Hiyama, M. Shiokawa, K. Kusunoki, K. Takahashi, Y. Yanagisawa, M. Katayama, S. Yamazaki

Semiconductor Energy Lab., Japan

When a large-size 8K display is fabricated with an a-Si:H TFT backplane, the display panel needs to be divided into segments that are driven separately, which results in mura. We reduced the mura through image processing using AI technology. This can also potentially be effective for OLED displays.

DESp1 - 5 **Withdrawn**

DESp1 - 6L **A 10-Bit Two-Stage DAC with an RDAC-Embedded Op-Amp for TFT-LCD Column Driver IC**

C.-W. Lu, Y.-C. Huang[*]

Nat. Tsing Hua Univ., Taiwan
[*]*ITRI, Taiwan*

This study proposes a 10-bit two-stage DAC with an RDAC-embedded op-amp for TFT-LCD Column Driver IC. The 10-bit column driver prototype was realized in 0.18-μm CMOS technology with the worst DNL/INL being 0.29/0.72 LSB. The silicon area is only 11 × 373 μm^2 for each output channel.

Thursday, December 7

15:00 -18:00 **Exhibition Hall**

***Poster* DESp2: Display Electronic Systems for Wide Color Gamut**

Special Topics of Interest on Wide Color Gamut and Color Reproduction

DESp2 - 1 **Withdrawn**

15:00 -18:00 **Exhibition Hall**

***Poster* DESp3: Display Electronic Systems for AR/VR**

Special Topics of Interest on AR/VR and Hyper Reality

DESp3 - 1 **A Hardware Solution of High Resolution and High Frame for Module in VR**

J. B. He, C. Deng, J. B. Zhou, L. L. Zhang, L. Wang, J. E. Liu, D. W. Shen

Tianma Micro-elect., China

This paper firstly analyzes the situation of VR and the technical key points of hardware. The method in this paper is designed for LCM/OLED manufacture or solution provider, it was verified in many modules, and also is suitable for VR test and exhibition.

Friday, December 8

10:40 - 11:55 **Meeting Room 4**

DES4: Various Augmented Reality Systems

Special Topics of Interest on AR/VR and Hyper Reality

Chair: H. Okumura, Toshiba., Japan
Co-Chair: T. Kishigami, Mitsubishi Elec., Japan

DES4 - 1: 10:40 ***Invited* Novel MRI Hyper-Realistic Head-Up Display System for Patient Comfort**

T. Sasaki, A. Hotta, T. Murata, Y. Ueda[*]*, H. Okumura*

Toshiba, Japan
[*]*Toshiba Medical Sys., Japan*

VR technologies are significant for medical applications. New MRI system “Vantage Galan 3T” focused on patient comfort. MRI-HUD was also provided. Images of wide field of view created with dome screen and reflection mirror eliminate feeling of limited space of MRI gantry from the beginning to end of the examination.

DES4 - 2: 11:05 ***Invited*** **Virtual Experiments of Augmentation of a Transparent Cockpit**

Y. Ueno, T. Hoshi, A. Hiyama, M. Inami

Univ. of Tokyo, Japan

The disadvantage of the conventional transparent cockpit is that drivers cannot know the positional relationship between the transparent vehicle body and objects near the body. First, we create a transparent cockpit simulator. Next, we implement a method to solve the problem on the simulator and evaluate its usefulness by experiments.

DES4 - 3: 11:30 ***Invited*** **Augmented and Diminished Reality: Computational Imaging of Existence and Non-Existence**

S. Mori

Keio Univ., Japan

This article presents a technical summary of a research area called diminished reality (DR). DR is described from its principle to open problems, with a comparison with its opposite concept known as augmented reality to highlight their differences.

Author Interviews
12:00 – 12:40

----- Lunch -----

15:30 - 16:35 **Meeting Room 4**

DES5: Novel Displays for Transportation

Special Topics of Interest on Automotive Displays

Chair: K. Morita, Chuo Univ., Japan
Co-Chair: H. Okumura, Toshiba, Japan

DES5 - 1: 15:30 ***Invited*** **Review of Flight Deck Display Development**

K. Funabiki, H. Tsuda

Japan Aerospace Exploration Agency, Japan

Since 1980's, mechanical flight instruments have been replaced by electronic displays. Despite of the nature of the display, safety requirement for the flight display would not allow flexible design of contents. Electronic Flight Bag is now considered to be a promising solution to provide various data to the pilot.

DES5 - 2 15:55 **Efficient Modeling of LED Crosstalk of a Matrix Backlight Unit**

M. Schmidt, M. Grüning, D. Schäfer, C. Xu

Saarland Univ., Germany

An approach for calculating the image dependent backlight for Direct-Lit LCDs with a high number of LEDs is presented. It shall lift up the trade-off between local dimming results and the complexity of the algorithm. Moreover, an optimal ratio between the LED-pitch and the light spread function is proposed.

DES5 - 3
16:15

Design and Fabrication of a High-Bright Sunlight Readable Transparent Head-Up Display for Automotive Application

C.-C. Liao[,**], J.-T. Lian[*], C.-W. Su[***]*

[*]Chunghwa Picture Tubes, Taiwan
[**]Nat. Tsing Hua Univ., Taiwan
[***]Nat. Taiwan Normal Univ., Taiwan

This paper proposes a high-bright sunlight readable transparent head-up-display (HUD) using the polymer dispersed liquid crystal technology. Unlike traditional methods, the proposed HUD provides good display legibility even under bright sunlight. Experimental results indicate that the proposed transparent-HUD with good visibility, high-transparency (transmittance close to 50%), and high clarity.

Author Interviews
17:00 – 17:40

Supporting Organizations:
Sendai Section, IEEE
The Society of Automotive Engineers of Japan
Special Interest Group on Mixed Reality (SIG-MR), The Virtual Reality Society of Japan
Technical Committee on Electronic Information Displays, Electronics Society, IEICE
Technical Committee on Image Engineering (IE), Information and Systems Society, IEICE
Technical Group on Information Display, ITE

I-DEMO
(Innovative Demonstration Session)

Live demonstrations
of emerging information display technologies
by oral and poster presenters
Thursday, Dec. 7, 2017
15:00 – 18:00
Exhibition Hall
(Exhibition Bldg.)
Sendai International Center
See page 227 for details

Workshop on Flexible Electronics

Wednesday, December 6

13:10 - 13:20 **Hagi Conference Hall**

Opening

Opening Remarks
13:10

T. Kamata, AIST, Japan

13:20 - 14:25 **Hagi Conference Hall**

FLX1: Flexible Sensors and Devices

Chair: T. Kamata, AIST, Japan
Co-Chair: H. Maeda, Dai Nippon Printing, Japan

FLX1 - 1: 13:20 ***Invited*** **Atmospheric Spatial-ALD of High Mobility Amorphous Metal Oxide Thin Film Transistors**

G. Gelinck[,**], A. Illiberi[*], I. Katsouras[*], W. V. Boekel[*], C. Frijters[*], J. Maas[*], F. Roozeboom[*,**], Y. Creyghton[*], P. Poodt[*]*

[*]Holst Ctr., The Netherlands
[**]Eindhoven Univ. of Tech., The Netherlands

Indium Zinc Oxide (IZO) films were grown at atmospheric pressure and high deposition rate using spatial atomic layer deposition (s-ALD). TFTs show high field-effect mobility -exceeding 30 cm^2/Vs- and excellent stability, demonstrating the potential of s-ALD for future display production.

FLX1 - 2: 13:45 ***Invited*** **Multifunctional Flexible Sheet Sensor Using Printing Technologies**

H. Kondoh[*], T. Miyoshi[*], S. Nishi[*], T. Kamata[,**]*

[*]JAPERA, Japan
[**]AIST, Japan

We have constructed an all printed electronics device manufacturing line and fabricated a TFT array on a flexible film substrate. We have newly developed the simultaneous, multiple-point pressure and temperature detection flexible sheet sensor by printing pressure sensitive and temperature sensitive layers onto the TFT array.

FLX1 - 3L: 14:10 ***Invited*** **Wearable Sensor Technologies for Daily Health Care Monitoring**

S. Nebuya[*,**]

[*]*Kitasato Univ., Japan*
[**]*Posh Wellness Lab., Japan*

Although electrical impedance measurement and tomography have been studied and applied for many research fields for several decades, only few applications had only been used with commercially successful as a body fat analyzer for the last decade. Therefore, some of novel wearable electronics technologies would be introduced in this paper.

----- Break -----

14:50 - 16:25 **Hagi Conference Hall**

FLX2/LCT1: Advanced LC Technologies for Flexible Devices

Chair: K. Akamatsu, Fujifilm, Japan
Co-Chair: H. Okada, Univ. of Toyama, Japan

FLX2/ LCT1 - 1: 14:50 ***Invited*** **Curved LCD and Future Application**

W. M. Huang, C.-T. Chen

AU Optronics, Taiwan

Curved LCDs and their applications are introduced. The substrates of curved LCDs and new process for PI base LCDs are discussed. We also focus on the high curvature display for CID. The 13.2-in. curved LCDs with R50 mm curvature and 181 ppi was developed.

FLX2/ LCT1 - 2: 15:15 ***Invited*** **Organic LCD: Large Area, Low Cost, High Performance LCDs on Plastic**

P. A. Cain, J. Harding, M. Banach

FlexEnable, UK

Organic LCDs (OLCDs) bring a unique set of attributes not possible with other flexible display technologies, including large area scalability, low cost, and high brightness with long lifetime. We report on the breakthrough performance of OTFT that today takes it beyond a:Si and can be manufactured on existing lines.

Also presented in Innovative Demonstration Session (see p. 227)

FLX2/ LCT1 - 3: 15:40 ***Invited*** **High Quality Organic Thin Film Transistors Fabricated with LC Organic-Semiconductors**

H. Iino, J. Hanna

Tokyo Tech, Japan

We researched the potentials of liquid crystalline organic-semiconductor materials for organic thin film transistor applications. Liquid crystalline materials have good solution processability and high thermal durability for uniform polycrystalline films regardless of small crystalline materials. Furthermore, liquid crystalline organic-semiconductor, Ph-BTBT-10 shows high mobility over 10 cm^2/Vs even though polycrystalline films.

FLX2/ LCT1 - 4 16:05 **Anisotropic Electrical Conductivity of Nanosegregated LC Thin Films of Polymerizable Perylene Bisimide Bearing a Triethylene Oxide Chain and Cyclotetrasiloxane Rings**

M. Funahashi, A. Seki

Kagawa Univ., Japan

A polymerizable liquid-crystalline perylene tetracarboxylic bisimide derivative bearing a triethylene oxide chain and cyclotetrasiloxane rings was synthesized. The compound exhibited a lamella-columnar phase in which the electron transport channels and ion-conductive sublayers were nanosegregated. The spin-coated films were polymerized via exposure to the vapors of trifluoromethanesulfonic acid.

Author Interviews
16:25 – 17:00

Thursday, December 7

9:00 - 10:00 **Hagi Conference Hall**

FLX3: Flexible TFT Technologies

Chair: M. Ito, Toppan Printing, Japan
Co-Chair: M. Nakata, NHK, Japan

FLX3 - 1 9:00 **Abnormal V_{th} Degradation Behavior of the Polycrystalline Silicon Thin-Film Transistors on the Polyimide Substrate**

Y.-D. Ho, C.-J. Liu, H.-W. Li, C.-H. Tsai, H.-H. Lu, Y.-H. Lin

AU Optronics, Taiwan

The abnormal V_{th} degradation behavior of the poly-Si TFTs on the PI substrates was introduced. By the experiment results, the abnormal effect was highly related to the mechanical strain, electrical stress and temperature.

FLX3 - 2 **Withdrawn**

FLX3 - 4L 9:20 **High Mobility InSb Film with Poly-Si TFTs Formed by Laser Annealing for Flexible Advanced System on Polymer**

C. J. Koswaththage, T. Harada, F. Gakiya, T. Higashizako, Y. Ishiki, T. Okada, T. Noguchi

Univ. of the Ryukyus, Japan

InSb film with high hall mobility of 1,050 cm^2/Vs was fabricated for mounting with poly-Si TFTs on flexible Polyimide (PI) for System on Panel applications. New device applications such as magnetic or infrared sensors with poly Si TFT system on panel are expected.

FLX3 - 3 9:40 **Excellent Electrical Performance and Reliability Improvement on a-IGZO-Driven Flexible LCD**

W.-C. Lu, C.-C. Kuo, Y.-Y. Huang

Chunghwa Picture Tubes, Taiwan

We successfully developed the 5.5-in. narrow bezel FFS-mode Flexible LCD with IGZO TFT. The Mobility of the TFTs is more than 10 $cm^2/V{\cdot}s$, and the Ion/Ioff is more than 10^9. The Flexible LCD panel combined with the flexible backlight can reach the radius of curvature to 41 mm.

----- Break -----

10:40 - 12:10 **Hagi Conference Hall**

FLX4: Flexible and Stretchable Displays

Chair: T. Furukawa, Yamagata Univ., Japan
Co-Chair: K. Uemura, Nippon Steel & Sumitomo Metal, Japan

FLX4 - 1: 10:40 ***Invited*** **Stretchable RGB LED Display with Spiral-Shaped Wiring Technology**

H. Ohmae, S. Sawada, K. Matsukawa, Y. Tomita

Panasonic, Japan

We developed a stretchable and foldable passive matrix driven display using 45 by 80 RGB LED's mounted on a novel spiral-shaped wiring. It successfully provided 3 mm pitch displays to achieve the stretchability over 50%, and 1 mm pitch displays to improve the resolution and the brightness over 1200 cd/m^2.

FLX4 - 2 **Withdrawn**

FLX4 - 5L 11:05 **Single Crystalline Silicon CMOS Circuit Fabrication on Plastic Substrate by Meniscus Force Mediated Layer Transfer Technique**

R. Mizukami, T. Yamashita, S. Higashi

Hiroshima Univ., Japan

SiO_2 pillar shaping implantation enabled fabrication of single-crystalline Si thin-film transistors (TFTs) on a plastic substrate by meniscus force mediated layer transfer. TFTs showed high field effect mobilities of 603 cm^2/Vs (n) and 197 cm^2/Vs (p), respectively, and CMOS inverters showed clear input/output characteristics under supply voltage of 2.0 V.

FLX4 - 3: 11:30 ***Invited*** **Foldable Touch AMOLED Integrated with Plastic Window Technologies**

S.-T. Yeh, J.-C. Ho, G. Chen, Y.-H. Yeh, K.-M. Chang, C.-C. Lee, J. Chen

ITRI, Taiwan

The foldable AMOLED was successfully debonded by low stress debonding technology. A 3 mm bending radius foldable touch AMOLED with plastic window was demonstrated. Also demonstrated is a novel Solution-coated Gas Barrier technology. It provides high level of gas barrier performance and optical transparency, and excellent coverage over uneven substrate surface.

FLX4 - 4 **Withdrawn**

FLX4 - 6L 11:55 **Room-Temperature Deposition of a Crystallized Dielectric YSZ Film on Glass Substrate Covered with Cellulose Nanopaper**

S. Horita, J. Patidar[*], H. Yagyu[**], M. Nogi[**]

JAIST, Japan
[*]Indian Inst. of Sci., India
[**]Osaka Univ., Japan

To get a crystallized YSZ film on CNP layer without sputtering damage, it was found that thermal resistance between the sample and holder should be much reduced, and that a thin Zr+Y metal film should be deposited at the initial deposition for crystallization of YSZ film by reactive sputtering.

----- Lunch -----

13:10 - 14:25 **Sakura Hall 1**

FMC4/FLX5: Roll-to-Roll Manufacturing Technologies

Chair: A. Fujita, JNC, Japan
Co-Chair: Y. Mishima, JAPERA, Japan

FMC4/ FLX5 - 1: 13:10 ***Invited*** **Development of Printed Electronics Device by Nano-Scale Roll to Roll Patterning**

T. Tanaka, M. Abe, N. Ito, K. Okuno, T. Hitomi, K. Komatsu, M. Oshikata, M. Ataka[*], T. Kishiro[*], S. Matsui[**], M. Okada[**]

Asahi Kasei, Japan
[*]Holon, Japan
[**]Univ. of Hyogo, Japan

Asahi-Kasei has been developing Seamless Roller Mold as a printing stamp, then demonstrated Transparent Conductive Film (TCF) by using high resolution printing technology for large area touch sensors. We will show the fabrication process of SRM and show printed samples on flexible substrate.

FMC4/ FLX5 - 2 13:30 **Flexible Transparent Electrodes for Large-Area Printed Electronics**

T. Muto, T. Hara, W. Morita, T. Izumi, K. Nagamoto

Lintec, Japan

Fabrication of transparent electrodes consisted of a stack of ITO, metal grid, and gas barrier films is described. The film electrodes have smooth surface morphology and low surface resistivity. Performance of the thin film devices formed on the electrodes was enhanced from ITO films by its electrical properties.

FMC4/ FLX5 - 3 13:50 **Novel Direct Imaging Exposure System with High Productivity for Flexible Substrate in Roll-to-Roll Method**

Y. Kito, M. Hori, Y. Hayashida, T. Suzuki, H. Kajiyama, H. Komiyama, T. Watanabe, T. Shimoyama, T. Kurashige, Y. Ishigaki, S. Nakayama, M. Kato

Nikon, Japan

We developed a novel exposure system for mass production, advancing the main specifications of the proof-of-concept prototype that we reported at IDW ’16. New system achieved a resolution of 6 μm and an overlay accuracy of less than ± 3 μm under productivity comparable to that of a 1st-generation FPD lithography system.

FMC4/ FLX5 - 4L 14:10 **Microwave-Assisted Rapid Synthesis of Carbon Nanotubes Covalently Conjugated with Sulfonated Polyaniline for Enhancing Stable Dispersion of Aqueous Conductive Inks**

P.-C. Wang, T.-J. Tsai, H.-L. Liao

Nat. Tsing Hua Univ., Taiwan

Sulfonated polyaniline was covalently conjugated to carbon nanotubes by microwave-assisted polymerization. The aqueous dispersion based on CNTs covalently functionalized with sulfonated polyaniline was used as the medium for oxidative chemical polymerization of 3,4-ethylenedioxythiophene. The transparent electrodes fabricated by spray-coating using the resultant conductive ink gave ~90 s/cm conductivity.

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

***Poster* FLXp1: Flexible Electronics Technologies**

FLXp1 - 1 **Invalidation Mechanism of Flexible OLED/Thin Film Encapsulation Device under Cyclic Bending Test**

K. Hu, H. Feng, B. Yuan, X. Li, S. Liu, X. Gao, X. Huang[*]

Kunshan New Flat Panel Display Tech. Ctr., China
[*]Kunshan Govisionox Optoelect., China

The invalidation mechanism of Organic Light Emitting Diode (OLED)/ Thin Film Encapsulation (TFE) device is investigated by cyclic bending test. Reliability of OLED/TFE lost after being bent for 5000 cycles. Structural analysis shows open circuit of cathode induced by the crack propagation is the main reason for failure of OLED/TFE device.

FLXp1 - 2 **A Study on Mechanical Test Method Used for Flexible Display Device**

Y. Liu, K. Hu[*], P. Dang[*], X. Gao[*], X. Huang[,**]*

[*]Beijing Visionox Tech., China
[**]Kunshan New Flat Panel Display Tech. Ctr., China
[***]Kunshan Govisionox Optoelect., China

The development of international standards of flexible display device mechanical test method is introduced in the paper. Based on IEC 62715-6-1, the mechanical reliability of metal lines is investigated. According to the results, the simulation fitted well with the experimental results, which showed that the bending test method was reasonable.

FLXp1 - 3 **Analysis of Flexible LTPS TFT Stability under Continuous Outward Sliding Stress**

B. Yuan, K. Hu, G. Huang, H. Feng, X. Gao, X. Huang[*]

Kunshan New Flat Panel Display Tech. Ctr., China
[*]Kunshan Govisionox Optoelect., China

Flexible Low Temperature Poly Silicon (LTPS) thin film transistor (TFT) was fabricated and the electrical stability under continuous Outward Sliding Stress (OSS) was investigated. Hump phenomenon of TFT without and with 2 μm organic protective film appeared after 500 and 80,000 times' OSS under 10 mm and 5 mm bending radius, respectively.

FLXp1 - 4 **Investigation and Improvement of Cracking Mechanism in Transparent Insulating Film**

K. Umemoto, Y. Shirai, I. Shiono, Y. Toshimori, S. Zhang

Mitsubishi Materials, Japan

Crack resistance of various transparent insulating films was investigated by measuring the residual stress of the film using simple mechanical probe method. As a result, the cracking mechanisms of each materials were discussed, and we suggest a new material which has excellent in crack resistance.

FLXp1 - 5 **Roll-to-Roll Fabrication Process of Silver-Nanowire Embedded Transparent Electrode with Light Extraction Layer for OLEDs**

C. Kim, E. Jung, H. Choi, Y. E. Sul, S. M. Cho

Sungkyunkwan Univ., Korea

The silver-nanowire embedded transparent electrode was fabricated with light extraction layer via the roll-to-roll process. Scattering layer was inserted between silver-nanowire network and substrate to extract the light trapped in substrate and device. Fabricated OLED device with hybrid electrode showed higher efficiency.

FLXp1 - 6 **The Effect of Annealing Temperature on the Optical and Electrical Properties of Different Diameter AgNWs Films**

C. Wei, C.-T. Peng

Tatung Univ., Taiwan

Annealing in silver nanowire (AgNW) films will reduce the surface roughness and increase conductivity. Different size AgNW films were annealed with different temperature. The results show the electrical conductivity improves in all nanowire size with annealing. However, the optical transmittance seems to be irrelevant to annealing.

FLXp1 - 7 **Flexible White/Warm White Hybrid AC Powder Electroluminescent Devices Fabricated by Modified Wet-Stamping and Screen Printing**

S. Zhang, H. Su, R. J. W. Teo[*]*, T. K. S. Wong*

Nanyang Technological Univ., Singapore
[*]*Singapore Inst. of Manufacturing Tech., Singapore*

Hybrid AC powder electroluminescent devices have been fabricated using screen printing and wet-stamping on flexible conductive polymer substrates. By using two organic fluorescent dyes to downshift the emission from ZnS phosphors, broadband white emission with color coordinates (0.304, 0.294) and correlated color temperature as low as 2864 K was obtained.

FLXp1 - 8L **High Gas Barrier Film for OLED**

K. Taira, T. Furukawa, N. Kawamura, M. Koden, T. Takahashi

Yamagata Univ., Japan

The effect of the planarization of PEN film surface on the water vapor barrier property was investigated. The barrier property was drastically improved by the planarization, being evaluated by the Ca corrosion method. Furthermore, the relation between Ca defects and the dark spots of OLED was compared.

FLXp1 - 9L **Roll-to-Roll Patterning of Reflective Electrode on Planarized Stainless Steel Foil**

Y. Hagiwara, T. Furukawa[*], T. Yuki[*], S. Yamaguchi, N. Yamada, J. Nakatsuka[**], M. Koden[*], H. Nakada[*]

Nippon Steel & Sumitomo Metal, Japan
[*]Yamagata Univ., Japan
[**]Nippon Steel & Sumikin Materials, Japan

'Roll-to-Roll' patterning of reflective electrode on planarized stainless steel foil was carried out to develop 'Roll-to-Roll' printing technology. Furthermore, the OLED device was fabricated on the planarized stainless steel foil with reflective electrode. This OLED device kept on emitting overall during the folding test with inter-plate distance of 50 mm.

FLXp1 - 10L **Solution-Processed Nonvolatile Optical Transistor Memory for Multi-Level Data Storage Devices**

F. Shiono[*], T. Nagase[,**], T. Kobayashi[*,**], H. Naito[*,**]*

[*]Osaka Pref. Univ., Japan
[**]The Res. Inst. for Molecular Elect. Devices, Japan

We fabricated nonvolatile molecular floating-gate transistor memories by solution process and investigated their memory characteristics under light illumination. Solution-processed floating-gate transistors exhibit good memory operations and allow tuning threshold voltage shift by incident light. The results show potentials for applications to multi-level storage memories and image sensors with good solution-processability.

FLXp1 - 11L **Proposal of a-Si film Photo-Sensors Integrating with Poly-Si TFT System on Flexible Polymer**

T. Higashizako, C. J. Koswaththage, T. Okada, T. Noguchi, T. Morimura[*], O. Nishikata[*], A. Ota[*]

Univ. of the Ryukyus, Japan
[*]ULVAC, Japan

After forming buffer layer on PI or glass by sputtering, a-Si film was formed by PE-CVD at 300˚C. High photosensitivity was obtained on flexible and bendable PI. It is possible to realize multi-functional display panel by integrating high mobility poly-Si TFTs with high photo-sensitivity sensor films.

FLXp1 - 12L **Morphological Control of Monomer Aggregation Using Fluororesin Transfer Process for Flexible LC Displays**

S. Kawamorita, Y. Shibata, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

For high quality of flexible LCDs, we examined the fluororesin transfer using silicone elastomer molds as a fabrication process of polymer-wall structure. We clarified that optimization of the amount of resin adhesion onto mold surface is necessary for alignment of LC aggregation.

Friday, December 8

9:00 - 10:00 **Meeting Room 3**

FLX6: Advanced Process and Evaluation Technologies
Special Topics of Interest on Lighting and Quantum Dot Technologies

Chair: T. Shiro, Teijin, Japan
Co-Chair: T. Eguchi, Sumitomo Bakelite, Japan

FLX6 - 1
9:00

Roll-to-Roll Processing of Functional Films for Flexible Electronics

J. Fahlteich, M. Fahland, P. Kudlacek, W. Manders*, M. Junghähnel, S. Mogck, C. Keibler*

Fraunhofer Inst. for Organic Elect., Germany
**Holst Ctr., The Netherlands*

This paper discusses roll-to-roll processing of flexible substrates for OLED lighting application addressing transparent electrode deposition on both permeation barrier films and ultrathin glass. Functional polymer substrates with water vapor transmission rates of 10^{-6} g/m²d at 20°C / 50% r.h. and a surface sheet resistance below 25 Ohm are reported.
Also presented in Innovative Demonstration Session (see p. 227)

FLX6 - 2
9:20

Novel Roll-to-Roll Fabrication Processes of Transparent Electrodes on Ultra-Thin Glass

T. Furukawa, N. Kawamura, T. Noda, Y. Hasegawa*, D. Kobayashi**, M. Koden*

Yamagata Univ., Japan
**Nippon Elec. Glass, Japan*
***Seria, Japan*

We developed novel fabrication technologies of transparent electrodes on ultra-thin glass by roll-to-roll process. The transparent electrode consists of IZO and assistant electrodes with insulating patterns. The assisting electrodes and the insulating patterns were printed on the IZO by screen printing. OLED lightings were fabricated after cutting the roll substrate.

FLX6 - 3
9:40

Novel Evaluation Method for Flexible OLED Lighting Device

K. Hyodo, S. Maeda, A. Horiguchi**

Konica Minolta, Japan
**CEREBA, Japan*

Recently developed novel organic light emitting diodes (OLEDs) for lighting applications are flexible and deformable. Unlike the conventional lighting devices, such as fluorescent light tube and light bulb, the novel flexible and deformable devices require new evaluation methods. We have evaluated flexible and deformable OLEDs using new methods.

----- Break -----

Author Interviews
12:00 – 12:40

Workshop on Touch Panels and Input Technologies

Wednesday, December 6

13:10 - 13:15 **Sakura Hall 2**

Opening

Opening Remarks
13:10

N. Hashimoto, Citizen Watch, Japan

13:15 - 14:35 **Sakura Hall 2**

INP1: AR and Interactive Systems

Special Topics of Interest on AR/VR and Hyper Reality

Chair: H.Ando, Osaka Univ., Japan
Co-Chair: J.Akita, Kanazawa Univ., Japan

INP1 - 1: 13:15 ***Invited*** **Lensless Light-Field Imaging with LC Fresnel Zone Aperture**

K. Tajima, Y. Nakamura, M. Sao, T. Shimano, K. Matsumoto[*]*, A. Tanabe*[*]*, N. Hashimoto*[*]

Hitachi, Japan
[*]Citizen Watch, Japan

A lensless light-field imaging technology with a Fresnel zone aperture (FZA) has previously been developed. To obtain clear images, it is necessary to cancel several kinds of noise components. Accordingly, in the present study, a technique for noise cancellation using a liquid crystal FZA is proposed and experimentally evaluated.

INP1 - 2: 13:35 ***Invited*** **Yet Another Approach for Enhancing Image Quality: Pixel Placement**

J. Akita

Kanazawa Univ., Japan

Conventional approaches for enhancing image quality, such as increasing pixel count, reducing pixel size, would result in increased quantity of image information. In this paper, we propose and discuss the method of randomizing (effective) pixel placement as another approach for enhancing image quality.

INP1 - 3: 13:55 ***Invited*** **Low Resource Visual Display Method Based on Illusion of Eyeball Movement**

H. Ando

Osaka Univ., Japan

We are studying the display system using illusion. By using illusion and utilizing human resources, it is possible to minimize device resources. Here, we will explain the display using human eye movements (Smooth Pursuit: Slit-based light field 3D display, Saccade: Saccade based display).

INP1 - 4: 14:15 ***Invited*** **Media Technologies for Education Workshops**

J. Watanabe

NTT, Japan

This paper describes previous exhibition, workshop, and escape room game performed to attract attention to self-awareness and deeper understanding of science. They used media technologies to provide self-related experiences.

----- Break -----

14:50 - 16:10 **Sakura Hall 2**

HAP1/INP2: Haptic Technologies

Chair: M. Takasaki, Saitama Univ., Japan
Co-Chair: A. Yamamoto, Univ. of Tokyo, Japan

HAP1/ INP2 - 1: 14:50 ***Invited*** **Whole-Body Haptic Interface for Virtual Reality**

H. Kajimoto

Univ. of Electro-Commun., Japan

Virtual Reality becomes popular and the importance of tactile sense is widely acknowledged. I discuss important points in designing tactile device for VR. Three factors are discussed. One is whole-body that enables the sense of presence. Another is real-time response that enables cross-modal effects. The last one is low cost.

HAP1/ INP2 - 2: 15:10 ***Invited*** **Body Motion Estimation by Machine Learning**

Y. Makino, Y. Horiuchi, H. Shinoda

Univ. of Tokyo, Japan

In this paper, we propose a new system that predict human body motion 0.5 seconds before the actual motion. We utilized machine learning for forecasting human actions. This forecasting system can estimate human gestures in advance to the actual action. This is useful to reduce delays in interactive system.

Also presented in Innovative Demonstration Session (see p. 227)

HAP1/ INP2 - 3: 15:30 ***Invited*** **Tactility for Communication and Well-Being**

J. Watanabe
NTT, Japan

This paper describes previous researches and workshops performed to enhance communication and self-awareness using tactile science and technologies. In addition, I will describe current project about wellbeing and its relationship with tactile technologies.

HAP1/ INP2 - 4 15:50 **Research on a Haptic Device's Capability to Enhance the Degree of Kinesthetic Illusion Through Vibro-and-Visual Stimulation**

H. Komura, S. Yoshida, Y. Kato, T. Shimura, M. Honda[*]*, M. Ohka*
Nagoya Univ., Japan
[*]*Ind. Res. Inst. of Shizuoka Pref., Japan*

To develop new rehabilitation equipment, we combine the Kinesthetic Illusion (KI) and the Rubber Hand Illusion. Using a paired comparison method, since we observe a significant difference in the KI degree between the stationary and extended wrist cases, we conclude that visual stimulus can reinforce the kinematic illusion.

Author Interviews
16:20 – 17:00

Thursday, December 7

9:00 - 10:05 **Meeting Room 4**

UXC3/INP3: Interaction for Automotive

Special Topics of Interest on Automotive Displays

Chair: H. Shibata, Fuji Xerox, Japan
Co-Chair: F. Gotoh, Japan Display, Japan

UXC3/ INP3 - 1: 9:00 ***Invited*** **Lateral Force Produces Geometry and Texture Information on Touchscreen**

S. Saga
Univ. of Tsukuba, Japan

In this paper, we introduce a method that allows the user to simultaneously feel both large geometry and small textures on a touchscreen. Lateral force based haptic illusion enables geometry display, and direction-controlled mechanical vibration enables texture display. The method allows many kinds of geometry and texture information easily.
Also presented in Innovative Demonstration Session (see p. 227)

UXC3/ INP3 - 2 9:25 **Position Tracking Based on Reallocation Resampling Particle Filter Algorithm on Capacitive Touch Panels**

T.-C. Chu, C.-Y. Chuang, W.-C. Chiu, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This paper presents a method by using the reallocation resampling method to enhance the ability of tracking position and solve the problem of particle degradation in the Particle filter. Experimental results show that the proposed method has lower RMSE and trajectory delay than Kalman filter for capacitive touch panels system.

UXC3/ INP3 - 3 9:45 **Automotive Tablet Display with In-Cell Touch Panel for Auto after Market**

Y.-C. Li, D.-W. Ku, C.-Y. Hsu, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

We have developed a 8-in. HD FFS in-cell touch display for auto after market. The TIC panel have good quality display with high touch sensitivity. Our proposed prototype achieved high sensitivity to use a glove with 2 mm PMMA coverlens and finger with 3 mm PMMA coverlens.

----- Break -----

10:40 - 12:00 **Sakura Hall 2**

HAP2/INP4: Haptic Devices

Chair: H. Shinoda, Univ. of Tokyo, Japan
Co-Chair: M. Konyo, Tohoku Univ., Japan

HAP2/ INP4 - 1 10:40 **Electrostatic Tactile Display Integrated with a Projected Capacitive Touch Screen**

H. Haga, D. Sugimoto, Y. Yang, K. Shigemura

Tianma Japan, Japan

An electrostatic tactile display with a projected capacitive touch screen integrated into a single panel was demonstrated. Every electrode is driven for both tactile presentation and the touch sensor in a time-division manner. Electrodes for tactile presentation and for the touch sensor are driven concurrently for a localized tactile sensation.

HAP2/ INP4 - 2: 11:00 ***Invited*** **Physical Interactions on Flat Panel Displays Using Electrostatic Actuation Technologies**

A. Yamamoto

Univ. of Tokyo, Japan

This paper reviews physical interaction systems for flat panel displays, which have been realized using electrostatic actuation technologies. The systems include multi-touch surface haptic displays, on which users interact with computer graphics through contact pads, and active tabletop systems where physical objects move around on the display for interactions.

Also presented in Innovative Demonstration Session (see p. 227)

HAP2/ INP4 - 3: 11:20 ***Invited*** **Tactile Display with Friction Reduced by Ultrasonic Vibration**

M. Takasaki

Saitama Univ., Japan

This presentation deals with a tactile display with friction control. Display surface friction can be reduced by surface acoustic wave (SAW), which is a kind of ultrasonic vibration mode. Basic principle to indicate human tactile sensation is described. Prototypes of the display and their control are reported.

Also presented in Innovative Demonstration Session (see p. 227)

HAP2/ INP4 - 4: 11:40 ***Invited*** **Subjective Haptic Technology and Its Applications**

Y. Tanaka[,**]*

[*]Nagoya Inst. of Tech., Japan
[**]JST PRESTO, Japan

Tactile sense is subjective because it depends on our body and movements as well as contact objects. Focused on such inner characteristics, we have developed a wearable sensor for analyzing and/or communicating individual tactile sensations and a palpation system for laparoscopic surgery for augmenting surgeons' tactile sense.

Also presented in Innovative Demonstration Session (see p. 227)

----- Lunch -----

13:10 - 14:25 **Meeting Room 4**

INP5: Fingerprint Sensors and Secure Devices

Chair: K.Sumi, Aoyama Gakuin Univ., Japan
Co-Chair: K.Yamazaki, Corning Japan, Japan

INP5 - 2: 13:10 ***Invited*** **Fingerprint Authentication — Sensing Method**

E. Sano

Mitsubishi Elec., Japan

Fingerprint authentication is becoming a familiar technology. To further foster its use, it is not only important to make thinner sensors, adequate for embedding in various devices—including display devices—but also to improve the rate of users who can be successfully authenticated. Both issues are addressed here.

INP5 - 1: 13:35 ***Invited*** **Fingerprint Authentication — Systems and Algorithms**

K. Sumi

Aoyama Gakuin Univ., Japan

In this article, basic image algorithms on fingerprint authentication and advances are explained. Especially, fingerprint ridge restoration from a noisy input image and rotation invariant matching techniques are emphasized. Also, performance evaluation methodology for fingerprint authentication is explained.

INP5 - 3: 14:00 ***Invited*** **Integrated Transparent NFC Antenna on Touch Display**

Y. Sugita, J. Mugiraneza, S. Yamagishi

Sharp, Japan

We describe a novel user interface by using an integrated transparent NFC (Near Field Communication) antenna on a touch display. The proposed technology allows the user to interact directly and intuitively with digital information through the display. Moreover, transparent NFC antenna realized compact and advanced design.

Also presented in Innovative Demonstration Session (see p. 227)

Author Interviews
14:40 – 15:20

15:00 - 18:00 **Exhibition Hall**

Poster **INPp1: Touch Panel**

INPp1 - 1 **Study of Optimized Design for ESD Test at Touch In-Cell Panel**

T.-C. Huang, Y.-C. Lai, Y.-L. Cheng, H.-P. Chiu

Chunghwa Picture Tubes, Taiwan

We study the static electricity resistant liquid crystal display driven by in-cell touch structure, the proposed LCD utilizes a liquid crystal mixture with negative dielectric anisotropy and a polarizer with conductive particles PSA(resistance$\leqq 10^9\ \Omega/\square$), allowing the device to be in much stable state against external electrostatic discharge (ESD).

INPp1 - 2 **Novel In_2O_3 Based Transparent Conducting Oxide Material for Touch Screen**

R. Akiike, Y. Tsuchida, H. Hara, H. Kuramochi

Tosoh, Japan

We would like to introduce our novel indium oxide based transparent conducting oxide (TCO). Novel TCO film showed lower resistivity by lower process temperature, 197 μΩ·cm at 150°C, 217 μΩ·cm at 100°C respectively. It can be applied to flexible touch screen (TS) favorably.

INPp1 - 3L **Development of Moon Phase Teaching Materials Using VR**

S. Sekiya, A. Shiraki, T. Oshima[*]*, M. Sano, H. Nakayama*[**]*, T. Kakue, T. Shimobaba, T. Ito*

Chiba Univ., Japan
[*]*Gunma Pref. Maebashi Tech. High School, Japan*
[**]*Nat. Astronomical Observatory of Japan, Japan*

Japanese students have a problem of low motivation for science courses. In order to solve this problem, we developed a simulator about the planets that works on the 2D display in previous study. In this study, help the stereoscopic recognition of students by operating the simulator in VR.

Friday, December 8

10:40 - 12:00 **Meeting Room 3**

HAP3/INP6: Automotive and Mobile HMI

Special Topics of Interest on Automotive Displays

Chair: M. Sato, Tokyo Tech, Japan
Co-Chair: Y. Tanaka, Nagoya Inst. of Tech., Japan

HAP3/ INP6 - 1: 10:40 ***Invited*** **Use of Shape Memory Alloy as a Haptic Technology for Displays Panels**

M. Gondo, A. Hirano

Seidensha, Japan

Tactile technology using shape memory alloys has been developed. In this paper, we explain the principle of the actuator. In particular, how we overcame a fast response that is the basis of this tactile technology. We will describe actual prototypes for personal computers and tablets.
Also presented in Innovative Demonstration Session (see p. 227)

HAP3/ INP6 - 2 11:00 **An In-Vehicle Infotainment System with Automotive Grade Hover Gesture Touch Display**

W.-F. Chang, C.-L. Li, F.-H. Tsao, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

In this paper, we applied the different hover gestures to operate different functions. Through the 3D hover gestures, the user can easily operate the functions of in-vehicle infotainment system (IVI system) by simple hover gestures intuitively. Therefore, our system is not only operating easier but greatly improve the driving safety.

HAP3/ INP6 - 3: 11:20 ***Invited*** **Present and Future of Midair Haptics**

H. Shinoda

Univ. of Tokyo, Japan

Midair haptics based on non-contact tactile simulation using ultrasound radiation pressure has a great potential to renew user interfaces and VR, and broaden the use of human haptic sense. In this talk, I will summarize the present of midair haptics and discuss the future of the technology and application.

HAP3/ INP6 - 4: 11:40 ***Invited*** **Vibration Feedback for Representing Haptic Interaction**

M. Konyo

Tohoku Univ., Japan

This paper presents vibrotactile feedback methods to represent natural feelings and reactions in response to user movement. Pseudo-haptic representing methods for friction, inertia, and viscosity are briefly described. Several applications such as pointing-stick type and gesture interfaces and vibrotactile rendering method generated from first-person view videos are also reported.

Also presented in Innovative Demonstration Session (see p. 227)

Author Interviews
12:00 – 12:40

----- Lunch -----

13:50 - 15:10 **Meeting Room 4**

INP7/UXC6: Pen and Touch Input Technologies

Chair: N. Hashimoto, Citizen Watch, Japan
Co-Chair: H. Shibata, Fuji Xerox, Japan

INP7/ UXC6 - 1: 13:50 ***Invited*** **New In-Cell Capacitive Touch Panel with Fine Pitch Sensor for Narrow Passive Stylus and New User Interface**

F. Gotoh, H. Mizuhashi, H. Kurasawa, Y. Kida, Y. Nakajima

Japan Display, Japan

An 8-in. 4K UHD in-cell touch IPS-LCD with 1.2 mm fine pitch sensor has been developed. By applying Code Division Multiplex (CDM) technology, the SNR is improved dramatically, resulting in the successful use of 1 mm tip stylus. Also high resolution touch image has been obtained, leading to new applications.

Also presented in Innovative Demonstration Session (see p. 227)

INP7/ UXC6 - 2 14:10 **Drawing in Talking: Using Pen and Voice for Drawing System Configuration Figures in Talking**

X. Xu, J. Liao, H. Shibata

Fuji Xerox, Japan

This paper proposes a multimodal user interface system using pen and voice to draw system configuration figures. We aim to support real time drawing in talking and explore effective mode switching technique that does not interfere speaker's natural talk. We experimentally confirmed that our proposed technique was the most efficient. We also discuss how to improve the mode switching technique.

Also presented in Innovative Demonstration Session (see p. 227)

INP7/ UXC6 - 3: 14:30 ***Invited*** **The Effect of Edge Targets on Crossing-Based Selection with Direct Touch Input**

K. Go, Y. Kagawa, Y. Kinoshita
Univ. of Yamanashi, Japan

This paper presents experimental results on evaluating the effect of edge targets on crossing-based selection in the touch screen environment. The results indicated that the edge targets had a negative effect on selection time while they had a positive effect on accuracy when compared with the center targets on screen.

Also presented in Innovative Demonstration Session (see p. 227)

INP7/ UXC6 - 4 14:50 **Multi-Mouse Puzzle, an SDG-Based Puzzle Application for Collaborative Learning**

L. Luo, S. Orio[*], M. Mori[**], H. Kita
Kyoto Univ., Japan
[*]Infourt, Japan
[**]Hosei Univ., Japan

Single Display Groupware (SDG) is an environment where multiple users collaborate by sharing information on a display and each having some control. This paper discusses design and preliminary review an SDG application 'Multi-Mouse Puzzle' for elementary education based on the authors' experience of using SDG in schools.

----- Break -----

Author Interviews
17:00 – 17:40

Supporting Organizations:
The Forum for Advancement of Stereoscopic Three Dimensional Image Technology and Arts
Holographic Display Artists and Engineers Club (HODIC), The Optical Society of Japan
Human Interface Society
Technical Group on Information Sensing Technologies, ITE

Innovative Demonstration Session

Thursday, December 7

15:00 - 18:00 **Exhibition Hall**

Innovative Demonstration Session

LCT3/ DES3 - 1 **The Optimal Fast Response LCD for VR-HMD**

T. Matsushima, K. Seki, S. Kimura, Y. Iwakabe, T. Yata, Y. Watanabe, S. Komura

Japan Display, Japan

LCT3/ DES3 - 3 **Near Eye Application Based on Digital Electro-Optics Platform (X-on-Silicon)**

C.-W. Tsai, F. Lin, C. Wang

Jasper Display, Taiwan

LCT4 - 3 **Advance FSA(UV Curing Like) Process Technology to Improve Broken Spot for G8.6 TFT-LCDs**

Y. Yao, J. Chou, J. Hsu, W. York

Chongqing HKC Optoelect. Tech., China

LCT7 - 1 **Highly Transparent Color LCD by Using Scattering LCD Mode, Direct Edge Light and Field Sequential Color Driving Method**

K. Okuyama, T. Nakahara, Y. Numata, T. Nakamura

Japan Display, Japan

LCTp3 - 8L **An ECB Mode LC Device Suitable for Low Power Consumption Smart Windows**

S.-J. Lee[*], D.-S. Yoon[,**], H.-S. Yang[*], E.-J. Kim[*], S.-B. Kwon[*,**]*

[*]Hoseo Univ., Korea
[**]NDIS, Korea

AMDp2 - 8 **Study the Characteristics of a-Si:H Thin Film Transistors by Covering with Different Materials**

W.-Y. Li, Y.-F. Chou, P.-J. Chiang, C.-W. Liao, X.-D. Liu, L.-Q. Shi, R.-L. Chen, S.-J. Chen, L.-M. Zeng, T.-H. Wang, X.-W. LV, C.-Y. Lee

Shenzhen China Star OptoElect. Tech., China

FMC4/ FLX5 - 1 **Development of Printed Electronics Device by Nano-Scale Roll to Roll Patterning**

T. Tanaka, M. Abe, N. Ito, K. Okuno, T. Hitomi, K. Komatsu, M. Oshikata, M. Ataka[*], T. Kishiro[*], S. Matsui[**], M. Okada[**]

Asahi Kasei, Japan

[*]Holon, Japan

[**]Univ. of Hyogo, Japan

OLED4 - 4 **High Efficiency Large Area White Organic Light-Emitting Diodes Using Phosphorescent Materials — Degradation and Stability Improvement**

M. Seetharaman, A. Mohan, A. Awasthi, S. Bindu, G. Garg, J. Meenakshinathan, K. Manohara, M. Balakrishnan, M. Katiyar

Indian Inst. of Tech., India

OLEDp1 - 9L **Large-Area Flexible OLED Fabricated by Full Roll-to-Roll Processes from Transparent Electrode to Encapsulation**

S. M. Cho, C. Kim, E. Jung, G. Y. Han

Sungkyunkwan Univ., Korea

3D1/ DES2 - 1 **Development of 55-in. 8K-3D IPS LCD with 3D Polarization Filter**

J. Maruyama, R. Oke, T. Murakoso, I. Hiyama, Y. Kato, Y. Umezawa[*], T. Sato[*], T. Takahashi[*], H. Yamashita[**], K. Tanioka[**], T. Chiba[**]

Panasonic Liquid Crystal Display, Japan

[*]Arisawa Manufacturing, Japan

[**]Kairos, Japan

3D4 - 4 **HOE-Based Screen for Virtual-Image Projection and Scene Capture**

T. Nakamura[,**], S. Kimura[***], K. Takahashi[***], Y. Aburakawa[***], S. Takahashi[*], S. Igarashi[*], M. Yamaguchi[*]*

[*]Tokyo Tech, Japan

[**]JST PRESTO, Japan

[***]NTT DoCoMo, Japan

3D5 - 2 **Full HD Autostereoscopic Display Based on Time-Multiplexed Parallax Barrier with Adaptive Time-Division**

H. Kakeya, A. Hayashishita, M. Ominami

Univ. of Tsukuba, Japan

3Dp1 - 4 **A Flexible Pipeline from a Multi-View Camera to an Integral 3D Display**

T. Oooka, K. Takahashi, K. Hara[*], M. Katayama[*], M. Kawakita[*], T. Fujii

Nagoya Univ., Japan

[*]NHK, Japan

3Dp1 - 6 **A 2x2 Waveguide Holograms Attached on LCD Panel for a Multi-Function Display**

W.-T. Liu[*], W.-K. Lin[,**], B.-S. Lin[**], W.-C. Su[*]*

[*]Nat. Changhua Univ. of Education, Taiwan

[**]Nat. Chiao Tung Univ., Taiwan

3Dp1 - 7 **Color Compact Head-Mounted Holographic Display Using Laser Diodes**

H. Kubo, Y. Oguro, Y. Sakamoto

Hokkaido Univ., Japan

3Dp1 - 9 **An Efficient Backlight Design for Directional Backlight Autostereoscopic Display**

K. Li, X. Chen, Y. Zhou, H. Zhang, C. Chen[*], H. Fan[*], J. Wang, J. Zhou

Sun Yat-Sen Univ., China

[*]Guangzhou Midstereo Tech., China

VHF4 - 3 **Numerical Rating of Motion Image Quality on Latest 4K TVs Using Viewing-Distance-Free Robust Approach**

I. Kawahara

FairSpec, Japan

VHF5 - 3 **Simplified Method to Quantify Sparkling of Antiglare Display without Image Processing and Its Application**

M. Hayashi

Daicel, Japan

VHF5 - 4 **Reduction of Visual Fatigue in Displays by Surface Treatments**

Y. Yang, H. Cui, Y. Yang, P.-H. Lung, Y. Zhang[*]

Wuhan China Star Optoelect. Tech., China

[*]China Nat. Inst. of Standardization, China

VHFp3 - 9L **New Metric for Display Resolution Evaluation Based on Human Visual Perception**

K. Choi, B. Min, J. Kim, S. Choi

Samsung Elect., Korea

EP1 - 3 **Highly Reflective Electrostatic Shutter Display**

E. Schlam, J. Finch, J. Koskulics

New Visual Media Group, USA

MEET5 - 1 **Luminescent Perovskite-Polymer Composite Films for Display**

J. He, H. Chen, Y. Wang[*], C. Zhang, H. Chen, S.-T. Wu, Y. Dong

Univ. of Central Florida, USA
[*]Chinese Ac. of Sci. China

MEETp2 - 11 **Design and Research of a Vehicle Mounted Curved Surface Screen**

R. Chen, H. Zhou, Z. Zhang, L. Fang, J. Chen, S. Wu, J. Kang, X. Zhou, P. Shen, J. Li

Xiamen Tianma MicroElect., China

FLX2/ LCT1 - 2 **Organic LCD: Large Area, Low Cost, High Performance LCDs on Plastic**

P. A. Cain, J. Harding, M. Banach

FlexEnable, UK

FLX6 - 1 **Roll-to-Roll Processing of Functional Films for Flexible Electronics**

J. Fahlteich, M. Fahland, P. Kudlacek[*], W. Manders[*], M. Junghähnel, S. Mogck, C. Keibler

Fraunhofer Inst. for Organic Elect., Germany
[*]Holst Ctr., The Netherlands

INP5 - 3 **Integrated Transparent NFC Antenna on Touch Display**

Y. Sugita, J. Mugiraneza, S. Yamagishi

Sharp, Japan

INP7/ UXC6 - 1 **New In-Cell Capacitive Touch Panel with Fine Pitch Sensor for Narrow Passive Stylus and New User Interface**

F. Gotoh, H. Mizuhashi, H. Kurasawa, Y. Kida, Y. Nakajima

Japan Display, Japan

INP7/ UXC6 - 2 **Drawing in Talking: Using Pen and Voice for Drawing System Configuration Figures in Talking**

X. Xu, J. Liao, H. Shibata

Fuji Xerox, Japan

INP7/ UXC6 - 3 **The Effect of Edge Targets on Crossing-Based Selection with Direct Touch Input**

K. Go, Y. Kagawa, Y. Kinoshita
Univ. of Yamanashi, Japan

UXC2/ VHF2 - 3 **Relationships Between Reading Speed and Eye Movement Parameters**

J. Kobayashi[,**], T. Kawashima[**]*
[*]Dai Nippon Printing, Japan
[**]Future Univ. Hakodate, Japan

UXC3/ INP3 - 1 **Lateral Force Produces Geometry and Texture Information on Touchscreen**

S. Saga
Univ. of Tsukuba, Japan

HAP1/ INP2 - 2 **Body Motion Estimation by Machine Learning**

Y. Makino, Y. Horiuchi, H. Shinoda
Univ. of Tokyo, Japan

HAP2/ INP4 - 2 **Physical Interactions on Flat Panel Displays Using Electrostatic Actuation Technologies**

A. Yamamoto
Univ. of Tokyo, Japan

HAP2/ INP4 - 3 **Tactile Display with Friction Reduced by Ultrasonic Vibration**

M. Takasaki
Saitama Univ., Japan

HAP2/ INP4 - 4 **Subjective Haptic Technology and Its Applications**

Y. Tanaka[,**]*
[*]Nagoya Inst. of Tech., Japan
[**]JST PRESTO, Japan

HAP3/ INP6 - 1 **Use of Shape Memory Alloy as a Haptic Technology for Displays Panels**

M. Gondo, A. Hirano
Seidensha, Japan

HAP3/ INP6 - 4 **Vibration Feedback for Representing Haptic Interaction**

M. Konyo
Tohoku Univ., Japan

HAPp1 - 2 **Vibrotactile Representation of Camera Motion with Two Vibrators**

D. Gongora, H. Nagano, M. Konyo, S. Tadokoro

Tohoku Univ., Japan

HAPp1 - 5L **Development of Vibration Cube to Convey Information by Haptic Stimuli**

M. Azuma, T. Handa, T. Shimizu, S. Kondo

NHK, Japan

JOINT EXHIBITION

"Amazing Art Holograms and Digital-Processed Holograms"
co-sponsored by Holographic Display Artists and Engineers Club (HODIC)

Wednesday, Dec. 6 – Friday, Dec. 8, 2017
Exhibition Hall (Exhibition Bldg.)
Sendai International Center

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Outgoing Unique Technologies from Tohoku-Region

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	M. Kimura	Ryukoku Univ.
	T. Noguchi	Univ. of the Ryukyus
	K. Nomoto	Sony
	K. Omoto	Apple
	T. Ozawa	AU Optronics, Japan
	T. Sasaki	Japan Display
	M. Shibazaki	Innolux
	K. Suga	Sharp
	K. Takatori	Tianma Japan
	Y.-H. Yeh	ITRI

Workshop on FPD Manufacturing, Materials and Components

Workshop Chair:	K. Käläntär	Global Optical Solutions
Program Chair:	T. Tomono	Toppan Printing
Program Vice-Chair:	K. Tamai	Asahi Glass
General Secretary:	R. Yamaguchi	Akita Univ.
Vice Secretary:	S. Namekawa	Nippon Steel & Sumikin Chem.
Program Committee:	I. Amimori	A51Tech
	S. Asari	ULVAC
	A. Fujita	JNC

	Y. Iimura	Tokyo Univ. of A&T
	Y. Inoue	Corning Japan
	H. Kato	Sharp
	D. Matsuura	Dai Nippon Printing
	T. Mori	Nitto Denko
	T. Nonaka	Merck PM
	Y. Saitoh	Fujifilm
	T. Sato	ZEON
	M. Shinohara	Omron
	T. Tsuzuki	NHK
	H. Wakemoto	Japan Display
	H. Yamamoto	Utsunomiya Univ.
	Y. Yang	CSOT

Workshop on Inorganic Emissive Display and Phosphors

Workshop Chair:	Y. Nakanishi	Shizuoka Univ.
Program Chair:	N. Miura	Meiji Univ.
General Secretary:	N. Matsuda	Toshiba Materials
Program Committee:	K. Hara	Shizuoka Univ.
	T. Hisamune	Mitsubishi Chem.
	S. Itoh	Futaba
	D. Jeon	KAIST
	H. Kobayashi	Tottori Univ.
	T. Kunimoto	Tokushima Bunri Univ.
	T. Kusunoki	Dexerials
	T. Miyata	Kanazawa Inst. of Tech.
	T. Mukai	Nichia Chem. Ind.
	K. Ohmi	Tottori Univ.
	D. Poelman	Gent Univ.
	T. Shiga	Univ. of Electro-Commun.
	M. Shiiki	Hitachi
	K. Wani	TAZMO
	R. Xie	NIMS

Workshop on OLED Displays and Related Technologies

Workshop Chair:	H. Kuma	Idemitsu Kosan
Program Chair:	T. Komatsu	JOLED
Program Vice-Chair:	T. Shimizu	NHK
General Secretary:	T. Uchida	Tokyo Polytechnic Univ.
Program Committee:	C. Adachi	Kyushu Univ.
	M. Adachi	Japan Display
	S. Aratani	Samsung Electronics
	S. Enomoto	Toshiba
	T. Fukuda	Saitama Univ.
	T. Ikuta	JNC
	T. Inoue	TDK
	Y. Kijima	Huawei Techs. Japan
	K. Kishino	Sony
	A. Mikami	Kanazawa Inst.of Tech.
	K. Monzen	Nissan Chem. Inds.
	H. Murata	JAIST
	S. Naka	Univ. of Toyama
	K. Nakayama	Osaka Univ.
	Y. Sakai	Mitsubishi Chem.
	S. Tokito	Yamagata Univ.
	T. Tsuji	Pioneer
	T. Wakimoto	Merck PM

Workshop on 3D/Hyper-Realistic Display and Systems

Workshop Chair:	M. Tsuchida	NTT
Program Chair:	K. Yamamoto	NICT
General Secretary:	M. Katayama	NHK
Program Committee:	M. Date	NTT
	T. Fujii	Nagoya Univ.
	Y. Ichihashi	NICT
	T. Koike	Hosei Univ.
	T. Nishitsuji	Mitsubishi Elec.
	J.-Y. Son	Konyang Univ.
	C.-H. Tsai	ITRI
	M. Tsuboi	NTT DOCOMO
	H. Yamamoto	Utsunomiya Univ.
	S. Yano	Shimane Univ.

Workshop on Applied Vision and Human Factors

Workshop Chair:	S. Uehara	Asahi Glass
Program Chair:	Y. Hisatake	Japan Display
General Secretary:	Y. Imai	Mitsubishi Elec.
Program Committee:	J. Bergquist	Semiconductor Energy Lab.
	Y. Endo	Asahi Glass
	K. Hirai	Chiba Univ.
	N. Hiruma	NHK-ES
	T. Kurita	NHK-Media Tech.
	K. Masaoka	NHK
	Y. Nakamura	Mitsubishi Elec.
	G. Ohashi	Shizuoka Univ.
	T. Shibata	Tokyo Univ. of Social Welfare
	T. Shiga	Univ. of Electro-Commun.
	Y. Shimodaira	Shizuoka Univ.
	H. Ujike	AIST
	Y. Yang	Wuhan China Star Optoelect. Tech.

Workshop on Projection and Large-Area Display and Their Components

Workshop Chair:	S. Ouchi	Hitachi
Program Chair:	K. Ohara	Texas Instr. Japan
Program Vice-Chair:	S. Shikama	Setsunan Univ.
General Secretary:	T. Suzuki	JVCKENWOOD
Vice-Secretary:	O. Akimoto	Sony Semiconductor Solutions
	M. Takaso	Telepathy Japan
Program Committee:	Y. Asakura	Nittoh Kogaku
	D. Cuypers	CMST
	T. Fujiwara	Hitachi
	T. Hashizume	Seiko Epson
	H. Hatanaka	Ushio
	T. Hayashi	Okamoto Glass
	K. Ichihashi	Panasonic
	D. Iwai	Osaka Univ.
	T. Kawazoe	Univ. of Tokyo
	H. Kikuchi	NHK
	M. Kurashige	Dai Nippon Printing
	M. Kuwata	Mitsubishi Elec.
	T. Nakaguchi	Chiba Univ.
	J. Pan	Chiao Tung Univ.
	H. Sugiura	Mitsubishi Elec.
	M. Takayama	Honda
	N. Tate	Kyushu Univ.
	S. Yamaya	Nippon Seiki

Workshop on Electronic Paper

Workshop Chair:	K. Hashimoto	E Ink Japan
Program Chair:	T. Fujisawa	DIC
Program Vice-Chair:	N. Kobayashi	Chiba Univ.
General Secretary:	Y. Toko	Stanley Elec.
Program Committee:	M. Higuchi	NIMS
	Y. Hotta	Ricoh
	S. Maeda	Tokai Univ.
	M. Omodani	Tokai Univ.
	N.-S. Roh	Samsung Display
	A. Suzuki	Chiba Univ.
	G. Zhou	South China Normal Univ.

Workshop on MEMS and Emerging Technologies for Future Displays and Devices

Workshop Chair:	M. Nakamoto	Shizuoka Univ.
Program Chair:	J. Moon	Shizuoka Univ.
Program Vice-Chair:	Y. Nakai	Toshiba
General Secretary:	T. Ichihara	Panasonic
Vice-Secretary:	T. Komoda	Yamagata Univ.
Program Committee:	T. Akinwande	MIT
	Z. Alpaslan	Ostendo Techs.
	G. Barbastathis	MIT
	Y. Bonnassieux	Ecole Polytechnique
	V. Bulovic	MIT
	S. Coe-Sullivan	QD Vision
	M. Esashi	Tohoku Univ.
	G. Fern	Brunel Univ.
	A. Flewitt	Univ. of Cambridge
	H. Fujita	Univ. of Tokyo
	P. H. Holloway	Univ. of Florida
	J. Jang	Kyung Hee Univ.
	P. Kathirgamanathan	Brunel Univ.
	H. Kikuchi	NHK
	J.-M. Kim	Univ. of Oxford
	I. Kymissis	Columbia Univ.
	V. Lee	Lumiode
	J. Manders	NanoPhotonica
	W. Milne	Univ. of Cambridge
	K. C. Park	Kyung Hee Univ.
	D. Pribat	Ecole Polytechnique
	J. Silver	Brunel Univ.
	S. Tanaka	Tohoku Univ.
	F. Templier	CEA-LETI
	H. Tuller	MIT
	S. Uchikoga	Toshiba
	J. Van Derlofske	3M
	Q. Yan	Sichuan COC Display Devices

Workshop on Display Electronic System

Workshop Chair:	H. Okumura	Toshiba
Workshop Vice-Chair:	T. Yamamoto	NHK
Program Chair:	Y. Oyamada	Tottori Univ.
General Secretary:	T. Mitasaki	NTT
Program Committee:	T. Fujine	Sharp
	R. Hattori	Kyushu Univ.
	K. Käläntär	Global Optical Solutions
	L. Kerofsky	InterDigital Communs.
	T. Kishigami	Mitsubishi Elec.
	H.-S. Koo	Minghsin Univ. of S&T

	O.-K. Kwon	Hanyang Univ.
	K. Makita	Canon
	K. Morita	Chuo Univ.
	H. Nam	Kyung Hee Univ.
	H. Nitta	Japan Display
	R. Oke	Panasonic Liquid Crystal Display
	S. Ono	Apple
	A. Sakaigawa	Huawei Techs. Japan
	K. Sekiya	Kanagawa Inst. of Tech.
	S. Takamura	NTT

Workshop on Flexible Electronics

Workshop Chair:	T. Kamata	AIST
Program Chair:	T. Eguchi	Sumitomo Bakelite
General Secretary:	Y. Mishima	JAPERA
Program Committee:	K. Akamatsu	Fujifilm
	H. Endo	NEC
	H. Fujikake	Tohoku Univ.
	M. Funahashi	Kagawa Univ.
	T. Furukawa	Yamagata Univ.
	H. Hirata	Toray Eng.
	M. Ito	Toppan Printing
	M. Kimura	Nagaoka Univ. of Tech.
	H. Maeda	Dai Nippon Printing
	A. Miyamoto	Univ. of Tokyo
	T. Nagase	Osaka Pref. Univ.
	M. Nakata	NHK
	A. Nakazawa	Asahi Glass
	T. Sekitani	Osaka Univ.
	T. Shiro	Teijin
	T. Tomono	Toppan Printing
	K. Uemura	Nippon Steel & Sumitomo Metal
	Y. Uraoka	NAIST

Workshop on Touch Panels and Input Technologies

Workshop Chair:	N. Hashimoto	Citizen Watch
Program Chair:	M. Sato	Tokyo Tech
Program Vice-Chair:	Y. Sugita	Sharp
General Secretary:	H. Haga	Tianma Japan
Program Committee:	J. Akita	Kanazawa Univ.
	K. Imoto	Toshiba
	M. Inoue	Huawei Techs. Japan
	H.-S. Koo	Minghsin Univ. of S&T
	H. Mizuhashi	Japan Display
	K. Nakatani	Touchpanel Labs.
	H. Okumura	Toshiba
	T. Ono	Mitsubishi Elec.
	Y. Sasaki	Mitsubishi Elec.
	J. Watanabe	NTT
	K. Yamazaki	Corning Japan

Topical Session on User Experience and Cognitive Engineering

General Chair:	H. Shibata	Fuji Xerox
Program Chair:	T. Matsui	Osaka Univ.
General Secretary:	Y. Andoh	Fuji Xerox
Program Committee:	T. Hashiyama	Univ. of Electro-Commun.
	J. Ichino	Kagawa Univ.
	J. Kobayashi	Dai Nippon Printing
	M. Mori	Kyoto Univ.

	S. Ono	Kagoshima Univ.

Topical Session on Haptics Technologies

General Chair:	M. Konyo	Tohoku Univ.
Program Chair:	A. Yamamoto	Univ. of Tokyo
General Secretary:	H. Okumura	Toshiba
Program Committee:	H. Haga	Tianma Japan
	N. Hashimoto	Citizen Watch
	H. Kajimoto	Univ. of Electro-Commun.
	Y. Makino	Univ. of Tokyo
	M. Sato	Tokyo Tech
	H. Shinoda	Univ. of Tokyo
	Y. Sugita	Sharp
	M. Takasaki	Saitama Univ.
	Y. Tanaka	Nagoya Inst. of Tech.

Special Topics of Interest on Oxide-Semiconductor TFT

Facilitator:	M. Kimura	Ryukoku Univ.
Program Committee:		
AMD	H. Kumomi	Tokyo Tech
FMC	T. Tomono	Toppan Printing
FLX	M. Nakata	NHK

Special Topics of Interest on Lighting and Quantum Dot Technologies

Facilitator:	T. Ikuta	JNC
Program Committee:		
FMC	R. Yamaguchi	Akita Univ.
PH	K. Hara	Shizuoka Univ.
OLED	T. Shimizu	NHK
VHF	Y. Imai	Mitsubishi Elec.
MEET	J. Moon	Shizuoka Univ.
FLX	A. Miyamoto	Univ. of Tokyo

Special Topics of Interest on AR/VR and Hyper Reality

Facilitator:	Y. Oyamada	Tottori Univ.
Program Committee:		
LCT	S. Oka	Japan Display
FMC	K. Käläntär	Global Optical Solutions
3D	M. Tsuchida	NTT
VHF	S. Uehara	Asahi Glass
PRJ	S. Ouchi	Hitachi
DES	Y. Oyamada	Tottori Univ.
INP	N. Hashimoto	Citizen Watch
HAP	H. Okumura	Toshiba

Special Topics of Interest on Automotive Displays

Facilitator:	K. Morita	Chuo Univ.
Program Committee:		
LCT	S. Ishihara	Osaka Inst. of Tech.
FMC	K. Käläntär	Global Optical Solutions
OLED	T. Komatsu	JOLED
3D	M. Tsuchida	NTT
VHF	Y. Imai	Mitsubishi Elec.
PRJ	S. Ouchi	Hitachi
DES	K. Morita	Chuo Univ.
FLX	Y. Uraoka	NAIST
INP	N. Hashimoto	Citizen Watch

Special Topics of Interest on Wide Color Gamut and Color Reproduction

Facilitator:	K. Takatori	Tianma Japan
Program Committee:		
FMC	K. Käläntär	Global Optical Solutions

3D	M. Katayama	NHK
VHF	Y. Imai	Mitsubishi Elec.
MEET	J. Moon	Shizuoka Univ.
DES	T. Fujine	Sharp

FINANCIAL SUPPORTING ORGANIZATIONS (as of November 8, 2017)

Applied Materials, Inc.
Japan Display Inc.
NICHIA CORPORATION
Sharp Corporation
Sony Corporation

SUPPORTING MEMBERS (as of November 8, 2017)

EIZO Corporation
JAPAN BROADCASTING CORPORATION
JNC Corporation
Merck Performance Materials Ltd.
Tianma Japan, Ltd.
TOKYO ELECTRON LIMITED
ULVAC, Inc.
Zeon Corporation

EXHIBITORS: COMPANIES (as of November 8, 2017)

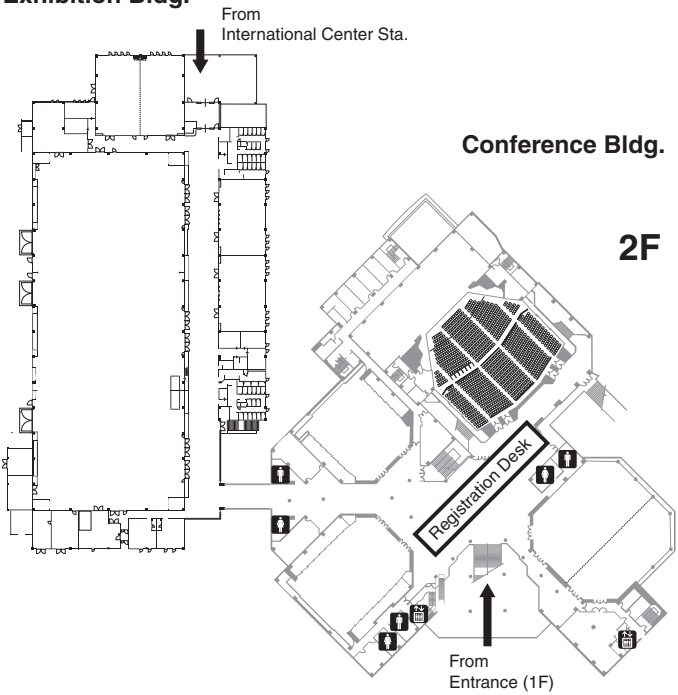
ALTECH CO., LTD.
Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP
HIOKI E.E. CORPORATION
HOWA Sangyo Co., LTD.
IDTechEx
KONICA MINOLTA JAPAN, INC.
MATSUBO Corporation
NAGASE & CO., LTD.
Opto Design Inc.
OXIDE Corporation
SHINTECH, INC.
Silvaco Japan Co., Ltd.
Solas OLED LTD.
Synchrotron Light in Tohoku, Japan / SLiT-J (Tohoku Univ. SLiT-J Project Promotion Council Working Committee)
TOPCON TECHNOHOUSE CORPORATION
Toray Research Center, Inc.
Tosoh Corporation
TOYO Corporation
VITEC GLOBAL ELECTRONICS CO., LTD.
Wexx Co., Ltd.
YUASA SYSTEM Co., Ltd.

EXHIBITORS: UNIVERSITIES (as of November 8, 2017)

Electron Device Engineering Labs., Univ. of Toyama
Fujieda Lab., Ritsumeikan Univ.
Fujikake / Ishinabe Lab., Tohoku Univ.
Iimura Lab., Tokyo Univ. of A&T
Maeda Lab., Tokai Univ.
Mutsu Lab./Ryukoku Extension Center, Ryukoku Univ.
Noguchi Lab., Univ. of the Ryukyus
Suyama Lab., Tokushima Univ.
Yamamoto Lab., Utsunomiya Univ.

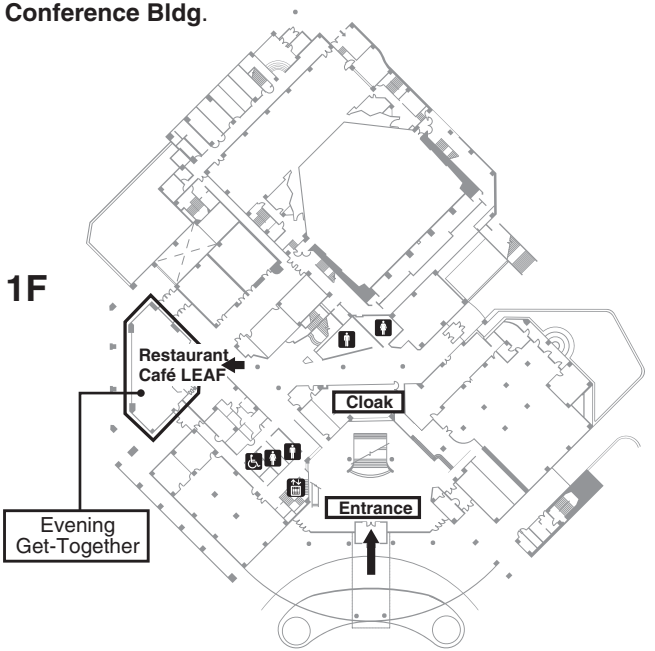
CONFERENCE SITE OVERVIEW

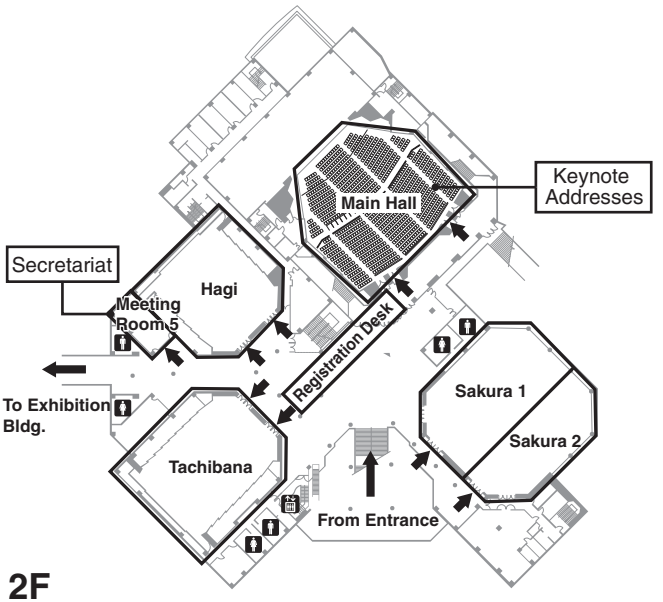
Exhibition Bldg.



FLOOR PLAN

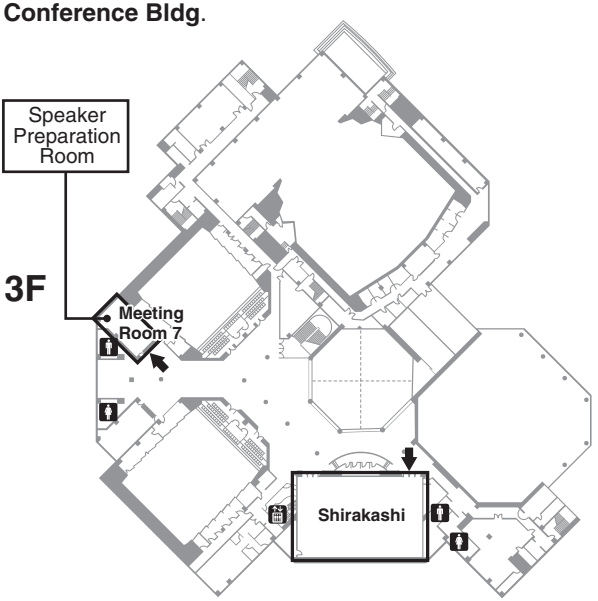
Conference Bldg.



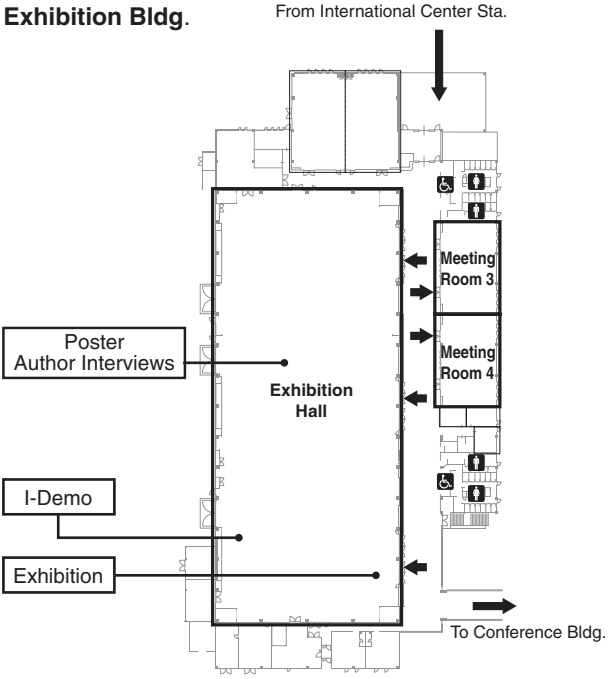


FLOOR PLAN

Conference Bldg.



Exhibition Bldg.



IDW '17 Workshop Timetable

		Conference building 2F					Conference building 3F	Exhibition building			
Date	2F Lobby	Main Hall	Tachibana	Hagi	Sakura 1	Sakura 2	Shirakashi	Meeting Room 3	Meeting Room 4	Exhibition Hall	
Tue., Dec. 5	Registration 17:00 - 20:00	Evening Get-Together at Café Leaf (1F) 18:00 - 20:00									
Wednesday, December 6	Registration 8:00 - 18:00	Opening & Keynote Addresses 9:30 - 11:50									
		Lunch									
		OLED1 13:10 - 14:40	AMD1 13:10 - 14:15	FLX1 13:10 - 14:25	FMC1 13:10 - 14:30	INP1 13:10 - 14:35	VHF1/UXC1 13:10 - 14:45	EP1 13:10 - 14:25	DES1 13:10 - 14:15		Exhibition 12:40- 18:00
		Break									
		OLED2 14:50 - 16:20	3D1/DES2 14:50 - 16:10	FLX2/LCT1 14:50 - 16:25	FMC2 14:50 - 16:05	HAP1/INP2 14:50 - 16:10	UXC2/VHF2 14:50 - 16:20	EP2 14:50 - 16:00	PH1 14:50 - 16:00		
										Author Interviews 16:20 - 17:00	
		Reception at Zuiun (2F) in Sendai Shozankan									
Thursday, December 7	Registration 8:00 - 18:00	OLED3 9:00 - 10:20	AMD2 9:00 - 10:00	FLX3 9:00 - 10:00	FMC3 9:00 - 10:20	VHF3 9:00 - 10:20	LCT2 9:00 - 10:25	PH2 9:00 - 9:50	UXC3/INP3 9:00 - 10:05		Exhibition 10:00 - 18:00
		Break									
		OLED4 10:40 - 12:00	AMD3 10:40 - 12:05	FLX4 10:40 - 12:10	PRJ1† 10:40 - 12:21	HAP2/INP4† 10:40 - 12:05	LCT3/DES3 10:40 - 12:20	EP3† 10:40 - 11:45	UXC4† 10:40 - 11:48		
		Lunch									
		OLED5 13:10 - 14:25	AMD4 13:10 - 14:45	MEET1 13:10 - 14:55	FMC4/FLX5 13:10 - 14:25	VHF4 13:10 - 14:30	LCT4 13:10 - 14:10	EP4 13:10 - 14:30	INP5 13:10 - 14:25		
										Author Interviews 14:40 - 15:20	
										Posters & Innovative Demonstration Session 15:00 - 18:00	
Friday, December 8	Registration 8:00 - 13:00	MEET2 9:00 - 10:20	AMD5 9:00 - 10:20	3D2 9:00 - 10:20	PRJ2 9:00 - 10:20	VHF5 9:00 - 10:20	LCT5 9:00 - 10:20	FLX6 9:00 - 10:00	UXC5/EP5 9:00 - 10:05		Exhibition 10:00 - 14:00
		Break									
		MEET3 10:40 - 12:20	AMD6 10:40 - 11:50	3D3 10:40 - 11:55	PRJ3 11:00 - 12:00	VHF6 10:40 - 12:00	LCT6 10:40 - 12:00	HAP3/INP6 10:40 - 12:00	DES4 10:40 - 11:55		
										Author Interviews 12:00 - 12:40	
		Lunch									
		MEET4 13:50 - 15:30	AMD7 13:50 - 15:20	3D4 13:50 - 15:10	PRJ4 13:50 - 15:10	VHF7 13:50 - 15:10	LCT7 13:50 - 15:10	FMC5 13:50 - 15:10	INP7/UXC6 13:50 - 15:10		
		Break									
		MEET5 15:30 - 17:10	AMD8 15:30 - 16:40	3D5 15:30 - 16:25	PRJ5 15:30 - 16:45	VHF8 15:30 - 16:55	LCT8 15:30 - 16:50	FMC6 15:30 - 16:30	DES5 15:30 - 16:35		
										Author Interviews 17:00 - 17:40	

† Including Short Presentations

IDW ’17 Special Topics of Interest Navigator

		Oxide-Semiconductor TFT		Lighting and Quantum Dot Technologies			AR/VR and Hyper Reality						Automotive Displays					Wide Color Gamut and Color Reproduction	
		Tachibana	Exhibition Hall	Main Hall	Meeting Room 3	Exhibition Hall	Tachibana	Sakura 1	Sakura 2	Shirakashi	Meeting Room 4	Exhibition Hall	Sakura 1	Sakura 2	Meeting Room 3	Meeting Room 4	Exhibition Hall	Sakura 2	Exhibition Hall
Wed., Dec. 6	PM	AMD1: Oxide TFT: Advanced Devices 13:10 - 14:15							INP1: AR & Interactive Systems 13:10 - 14:35										
							3D1/DES2: 3D Display in AR/VR & Hyper Reality 14:50 - 16:10												
Thu., Dec. 7	AM	AMD2: Oxide TFT: Stability 9:00 - 10:00			PH2: Phosphors for Lighting Application 9:00 - 9:50			FMC3: Display Optics for AR/VR 9:00 - 10:00								UXC3/INP3: Interaction for Automotive 9:00 - 10:05		VHF3: Special Session on Color Vision 9:00 - 10:20	
		AMD3: Oxide TFT: Fabrication 10:40 - 12:05		OLED4: OLED for Lighting Applications 10:40 - 12:00						LCT3/DES3: HMD Applications 10:40 - 12:20			PRJ1: Automotive / Display Application 10:40 - 12:00						
	PM	AMD4: Oxide TFT: Application 13:10 - 14:45																	
			AMDp1,MEETp3: Poster 15:00 - 18:00			PHp2,OLEDp2, MEETp1: Poster 15:00 - 18:00						FMCp2, 3Dp2, VHFp2,DESp3: Poster 15:00 - 18:00					FMCp3,VHFp1: Poster 15:00 - 18:00		VHFp4: Poster 15:00 - 18:00
Fri, Dec. 8	AM				FLX6: Advanced Process & Evaluation Technologies 9:00 - 10:00														
											DES4: Various Augmented Reality Systems 10:40 - 11:55				HAP3/INP6: Automotive & Mobile HMI 10:40 - 12:00				
	PM			MEET4: EL Quantum Dots Technologies 13:50 - 15:30				PRJ4: Wearable Technology 13:50 - 15:10						VHF7: Ergonomics for Automotive Applications 13:50 - 15:10					
				MEET5: Emerging Quantum Dots & Nanotechnologies 15:30 - 17:10					VHF8: Virtual Reality 15:30 - 16:55							DES5: Novel Displays for Transportation 15:30 - 16:35			

IDW '17 Session Navigator

	Wednesday, December 6			Thursday, December 7					Friday, December 8					
	PM			AM			PM		AM		PM			
User Experience & Cognitive Engineering	Shirakashi		Exhibition Hall	Meeting Room 4			Exhibition Hall		Meeting Room 4		Exhibition Hall	Meeting Room 4		
	Human Factors*	Education & Reading*	A.I.	Interaction for Automotive*	Eye Movement & Advertisement		A.I.	Posters	E-book & Education*		A.I.	Pen & Touch Input Techs.*		
Haptics Technologies		Sakura 2	Exhibition Hall		Sakura 2		Exhibition Hall			Meeting Room 3				
		Haptic Techs.*	A.I.		Haptic Devices*		A.I.	Posters		Automotive & Mobile HMI*				
3D/Hyper-Realistic Displays		Tachibana	Exhibition Hall					Exhibition Hall	Hagi		Exhibition Hall	Hagi		Exhibition Hall
		3D Display in AR/ VR & Hyper Reality*	A.I.					Posters	Light Field & Multiview	Emerging Techs.	A.I.	Holography	Autostereoscopic Display	A.I.
Active-Matrix Displays	Tachibana		Exhibition Hall	Tachibana			Exhibition Hall		Tachibana		Exhibition Hall	Tachibana		Exhibition Hall
	Oxide TFT: Advanced Devices		A.I.	Oxide TFT: Stability	Oxide TFT: Fabrication	Oxide TFT: Application	A.I.	Posters	Organic / Carbon TFT (1)	Organic / Carbon TFT (2)	A.I.	Novel Display Devices	High Resolution	A.I.
Display Electronic Systems	Meeting Room 4	Tachibana	Exhibition Hall		Shirakashi			Exhibition Hall		Meeting Room 4	Exhibition Hall		Meeting Room 4	Exhibition Hall
	Various Visualization Techs.	3D Display in AR/ VR & Hyper Reality*	A.I.		HMD Appls.*			Posters		Various Augmented Reality Systems	A.I.		Novel Displays for Transportation	A.I.
Emissive Technologies		Meeting Room 4	Exhibition Hall	Meeting Room 3			Exhibition Hall							
		Phosphors for General	A.I.	Phosphors for Lighting Appl.			A.I.	Posters						
Emerging Technologies & Novel Applications						Hagi	Exhibition Hall		Main Hall		Exhibition Hall	Main Hall		Exhibition Hall
						Micro/NanoDisplays & Nanotech. Appl.	A.I.	Posters	Novel Materials & Comps.	Fundamental Comps. & Process Techs.	A.I.	EL Quantum Dots Techs.	Emerging Quantum Dots & Nanotechs.	A.I.
e-Paper	Meeting Room 3		Exhibition Hall		Meeting Room 3		Exhibition Hall		Meeting Room 4					
	New Appls. for e-Paper	Various Techs. for e-Paper	A.I.		Novel Color e-Paper Techs.	Advanced Electrochromic Displays	A.I.	Posters	E-book & Education*					
Flexible Electronics	Hagi		Exhibition Hall	Hagi		Sakura 1	Exhibition Hall		Meeting Room 3		Exhibition Hall			
	Flexible Sensors & Devices	Advanced LC Techs. for Flexible Devices*	A.I.	Flexible TFT Techs.	Flexible & Stretchable Displays	Roll-to-Roll Manufacturing Techs.*	A.I.	Posters	Advanced Process & Evaluation Techs.		A.I.			
Interactive Technologies	Sakura 2		Exhibition Hall	Meeting Room 4	Sakura 2	Meeting Room 4	Exhibition Hall			Meeting Room 3		Meeting Room 4		Exhibition Hall
	AR & Interactive Systems	Haptic Techs.*	A.I.	Interaction for Automotive*	Haptic Devices*	Fingerprint Sensors & Secure Devices	A.I.	Posters		Automotive & Mobile HMI*		Pen & Touch Input Techs.*		A.I.
Human Factor	Shirakashi		Exhibition Hall	Sakura 2		Sakura 2	Exhibition Hall		Sakura 2		Exhibition Hall	Sakura 2		Exhibition Hall
	Human Factors*	Education & Reading*	A.I.	Special Session on Color Vision		Motion Image Quality & Sickness	A.I.	Posters	Display Measurement & Evaluation	High Dynamic Range & Image Quality	A.I.	Ergonomics for Automotive Appls.	Virtual Reality	A.I.
Liquid-Crystal Technologies		Hagi		Shirakashi			Exhibition Hall		Shirakashi		Exhibition Hall	Shirakashi		Exhibition Hall
		Advanced LC Techs. for Flexible Devices*		High Image Quality LCDs	HMD Appls.*	High Reliability	A.I.	Posters	LC Alignment Tech. (1)	LC Alignment Tech. (2)	A.I.	Transparent LCDs	Emerging Techs.	A.I.
Manufacturing, Process & Equipment	Sakura 1		Exhibition Hall			Sakura 1	Exhibition Hall							
	Manufacturing & Measurement Techs.		A.I.			Roll-to-Roll Manufacturing Techs.*	A.I.							
Materials & Components		Sakura 1	Exhibition Hall	Sakura 1			Exhibition Hall					Meeting Room 3		Exhibition Hall
		Display Film Techs.	A.I.	Display Optics for AR/VR			A.I.	Posters				Electrode Material & Photoresist Techs.	Glass Material Techs.	A.I.
MEMS						Hagi	Exhibition Hall		Main Hall		Exhibition Hall	Main Hall		Exhibition Hall
						Micro/NanoDisplays & Nanotech. Appl.	A.I.	Posters	Novel Materials & Comps.	Fundamental Comps. & Process Techs.	A.I.	EL Quantum Dots Techs.	Emerging Quantum Dots & Nanotechs.	A.I.
Organic Light-Emitting Diode Displays & Organic Devices	Main Hall		Exhibition Hall	Main Hall			Exhibition Hall							
	OLED Displays & Devices	OLED Materials	A.I.	OLED Advanced Tech. (1)	OLED for Lighting Appls.	OLED Advanced Tech. (2)	A.I.	Posters						
Projection & Large Area Displays					Sakura 1		Exhibition Hall		Sakura 1		Exhibition Hall	Sakura 1		Exhibition Hall
					Automotive / Display Appl.		A.I.	Posters	Standardization	Digital Cinema & Projection Mapping	A.I.	Wearable Tech.	Holographic Device	A.I.

A.I.: Author Interviews
* Joint Session

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