ITE

SID
SOCIETY FOR INFORMATION DISPLAY

IDW '15

THE 22ND INTERNATIONAL DISPLAY WORKSHOPS

Special Topics of Interest on

- Oxide-Semiconductor TFT
- Augmented Reality and Virtual Reality
- Lighting Technologies
- Printed Electronics

Workshops on

- LC Science and Technologies (LCT)
- Active Matrix Displays (AMD)
- FPD Manufacturing, Materials and Components (FMC)
- EL Displays and Phosphors (PH)
- Field Emission Displays, CRTs and Plasma Displays (FED)
- 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

Otsu Prince Hotel
Otsu, Japan
December 9 – 11, 2015

CONTENTS

Program Highlights 7
General Information 12
Travel Information 15

Plenary Sessions

Wednesday, December 9
IDW '15 Opening 21
IDW '15 Keynote Addresses 21
IDW '15 Invited Address 22
IDW '15 Special Address 22

Special Topics of Interest on Oxide-Semiconductor TFT

Thursday, December 10
AMDp1 *Poster*: Oxide TFT 23
FLXp2 *Poster*: Flexible Electronics 2 29
AMD1 Oxide TFT: Crystalline Oxide 30
AMD2 High Resolution Displays Using LTPS and Oxide TFTs 32

Friday, December 11
AMD3 Oxide TFT: Reliability 33
AMD4 Oxide TFT: TFT Fabrication Technologies 34
AMD5 Oxide TFT: Applications 36
AMD6 Oxide TFT: Solution Processes 37

Special Topics of Interest on Augmented Reality and Virtual Reality

Wednesday, December 9
DES1 Various Visualization Technologies 39

Thursday, December 10
INP3 AR and Interactive Systems 40
DESp2 *Poster* : Image Processing for Augmented Reality 41

Friday, December 11
3D4/VHF6 Autostereoscopic and Head-Mounted Displays 42
3D5 3D/Hyper-Realistic Display Systems 43
FMC5 Augmented Reality and Virtual Reality 44
PRJ6 Wearable Applications 45

Special Topics of Interest on Lighting Technologies

Wednesday, December 9
OLED2 OLED for Lighting Applications 47

Thursday, December 10
PH1 Phosphors for Lighting Application **48**
PHp2 *Poster*: Phosphors for Lighting Application **50**

Special Topics of Interest on Printed Electronics

Thursday, December 10
FLXp3 *Poster*: Flexible Electronics 3 ..... **52**

Friday, December 11
OLED4 Advanced OLED Technologies II **53**
FLX4 Flexible Printed Electronics **54**

Workshop on LC Science and Technologies

Wednesday, December 9
LCT1 Fascinating High Resolution Panel Technologies **55**
LCT2 Advanced LC Materials **56**

Thursday, December 10
LCTp1 *Poster*: Display Evaluations **57**
LCTp2 *Poster*: Innovative Technology for Surface/Interface Control **58**
LCTp3 *Poster*: Optical Elements for Phase Control **60**
LCTp4 *Poster*: IPS/FFS Display Modes **61**
LCTp5 *Poster*: Emerging LCD Technologies **63**
LCTp6 *Poster*: Liquid Crystal Lens **65**
3D2/LCT3 Autostereoscopic 3D Displays **67**
LCT4 New Fast Response LCDs **68**

Friday, December 11
FLX2/LCT5 Flexible LCDs **69**
LCT6 IPS/FFS Display Modes **70**
LCT7 Innovative Technology for Surface/Interface Control **71**

Workshop on Active Matrix Displays

Thursday, December 10
AMDp1 *Poster*: Oxide TFT **73**
AMDp2 *Poster*: Active-Matrix Devices **79**
AMD1 Oxide TFT: Crystalline Oxide **82**
AMD2 High Resolution Displays Using LTPS and Oxide TFTs **84**

Friday, December 11
AMD3 Oxide TFT: Reliability **85**
AMD4 TFT Fabrication Technologies **86**
AMD5 Oxide TFT: Applications **88**
AMD6 Oxide TFT: Solution Processes **89**
AMD7 Advanced Si Technologies **90**

Workshop on FPD Manufacturing, Materials and Components

Thursday, December 10
FMCp1 *Poster*: Materials and Components **92**
FMCp2 *Poster*: Display Optics and Information Technologies **94**
FMCp3 *Poster*: Manufacturing Technologies **95**
FMCp4 *Poster*: Film Technologies **96**
FMC1 Materials and Components **97**
FMC2 Display Optics and Information Technologies **98**

Friday, December 11
FMC3 Manufacturing Technologies **100**
FMC4 Film Technologies **101**
FMC5 Augmented Reality and Virtual Reality **102**

Workshop on EL Displays and Phosphors

Thursday, December 10
PH1 Phosphors for Lighting Application **104**
PHp1 *Poster*: Phosphors **105**
PHp2 *Poster*: Phosphors for Lighting Application **109**
PH2 Phosphor for General **110**

Friday, December 11
PH3 Phosphor Application **111**

Workshop on Field Emission Displays, CRTs and Plasma Displays

Friday, December 11
Opening **112**
FED1 Advanced Technologies and FE Mechanism **112**
FED2 FEA Fabrication Process and Novel Materials **113**
FED3 Flexible Light Source Using Plasma Technologies **115**

Workshop on OLED Displays and Related Technologies

Wednesday, December 9
OLED1 Advanced OLED Technologies I **117**
OLED2 OLED for Lighting Applications **118**

Thursday, December 10
OLED3 OLED Materials **120**
OLEDp1 *Poster*: OLED Poster **121**

Friday, December 11
OLED4 Advanced OLED Technologies II **127**
OLED5/FLX3 Flexible OLED and OTFT **128**

Workshop on 3D/Hyper-Realistic Displays and Systems

Thursday, December 10
3D1 Holography **130**
3Dp1 *Poster*: 3D/Hyper-Realistic Displays **131**
3D2/LCT3 Autostereoscopic 3D Displays **139**
3D3 Wavefront/Light Field Recording and Rendering **141**

Friday, December 11
3D4/VHF6 Autostereoscopic and Head-Mounted Displays **142**
3D5 3D/Hyper-Realistic Display Systems **143**
3D6 Floating and Omnidirectional Display Systems **144**

Workshop on Applied Vision and Human Factors

Wednesday, December 9
VHF1 Display Metrology **146**
VHF2 Display Image Quality **147**

Thursday, December 10
VHF3 Human Factors **148**
VHFp1 *Poster*: Applied Vision and Human Factors **149**
VHF4 Color and Vision **152**
VHF5 Color Rendering **153**

Friday, December 11
3D4/VHF6 Autostereoscopic and Head-Mounted Displays **154**

Workshop on Projection and Large-Area Displays and Their Components

Thursday, December 10
Opening **156**
PRJ1 Projection Applications **156**
PRJp Short Presentation: Projection **157**
PRJp1 *Poster*: Projection **157**

Friday, December 11
PRJ2 Projection Components and Materials **159**
PRJ3 Solid State Light Source **161**
PRJ4 Automotive Display and Lighting **162**
PRJ5 Projection Optics **163**
PRJ6 Wearable Applications **165**

Workshop on Electronic Paper

Wednesday, December 9
EP1 Emerging Technologies for e-Paper **167**

EP2 Electrochromic Displays....168

Thursday, December 10
EP3 Electrophoretic Displays and Applications....169
EPp Short Presentation: Electronic Paper....170
EPp1 *Poster*: Electronic Paper....170

Workshop on MEMS and Emerging Technologies for Future Displays and Devices

Thursday, December 10
MEETp1 *Poster*: Emerging Technologies....173
Opening....174
MEET1 Quantum Dots Applications....174

Friday, December 11
MEET2 Novel Materials and Components....175
MEET3 MEMS and Related Technologies....177
MEET4 Nanotechnologies for Display Applications....178
MEET5 Emerging Quantum Dots and Nanotechnologies....179

Workshop on Display Electronic Systems

Wednesday, December 9
DES1 Various Visualization Technologies....182
DES2 Transparent Display Systems....183

Thursday, December 10
DESp1 *Poster*: Display Electronic Systems....184
DESp2 *Poster* : Image Processing for Augmented Reality....186
DES3 Application for Automobiles....186
DES4 Image Processing....187

Workshop on Flexible Displays

Thursday, December 10
FLXp1 *Poster*: Flexible Electronics 1....189
FLXp2 *Poster*: Flexible Electronics 2....191
FLXp3 *Poster*: Flexible Electronics 3....192
Opening....193
FLX1/INP4 Flexible Input Devices....193

Friday, December 11
FLX2/LCT5 Flexible LCDs....194
OLED5/FLX3 Flexible OLED and OTFT....195
FLX4 Flexible Printed Electronics....196
FLX5 Flexible Displays and Devices....197

Workshop on Touch Panels and Input Technologies

Wednesday, December 9
Opening....199
INP1 Interactive Technologies....199

INP2 Touch Panel **200**

Thursday, December 10
INP3 AR and Interactive Systems **201**
INPp1 *Poster*: Touch Panel **203**
FLX1/INP4 Flexible Input Devices **203**

Innovative Demonstration Session

Thursday, December 10
Innovative Demonstration Session **205**

IDW '15 Committees **210**

Floor Map **220**

IDW '15 Workshop Timetable ..... **Pullout**
IDW '15 Special Topics of Interest Navigator ..... **Pullout**
IDW '15 Session Navigator ..... **Pullout**

PROGRAM HIGHLIGHTS

The 22nd International Display Workshops will be held as IDW '15 for encouraging aggressive research and development of display technologies throughout the world and especially in the Asian region. IDW '15 focuses on the following four special topics, which are extremely timely, as well as fourteen active workshops.

Special Topics of Interest on
- Oxide-Semiconductor TFT
- Augmented Reality and Virtual Reality
- Lighting Technologies
- Printed Electronics

Workshops on
- LC Science and Technologies
- Active Matrix Displays
- FPD Manufacturing, Materials and Components
- EL Displays and Phosphors
- Field Emission Displays, CRTs and Plasma Displays
- OLED Displays and Related Technologies
- 3D/Hyper-Realistic Displays and Systems
- Applied Vision and Human Factors
- Projection and Large-Area Displays and Their Components
- Electronic Paper
- MEMS and Emerging Technologies for Future Displays and Devices
- Display Electronic Systems
- Flexible Electronics
- Touch Panels and Input Technologies

The three-day conference will feature 471 papers, including 2 Keynote addresses, an Invited address, a Special address, 102 invited presentations, 145 oral presentations, and 220 poster presentations. Following plenary session of Keynote and Invited addresses in the Wednesday morning, presentations will begin and continue in 7 parallel oral sessions through Friday. Poster sessions and author interviews and demonstrations will enable participants to discuss topics in detail. This year, special address will be given by Nobel Laureate, Prof. Hiroshi Amano of Nagoya University, in the Wednesday evening. Exhibits by universities and display industry-related businesses will also be featured from Wednesday to Friday in parallel with workshops. IDW '15 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 TFTs are not only one of the most promising technologies in electronic displays but also could become key devices in all general electronics. In this IDW, you can hear many presentations on brand-new technologies, such as material, device structure, fabrication processes, transistor performance, reliability, and applications, from domestic and international university, institute, and companies. No OXT, no success! However, you will be lucky because you will get all the useful information you need once you attend IDW.

Special Topics of Interest on Augmented Reality and Virtual Reality (AR&VR)
In recent years, Augmented Reality and Virtual Reality applications have made substantial progress, benefitting from high-performance display devices, sensors, cameras with tracking capabilities, and computer graphics technologies. The FMC-WS session will present recent trends in 3D display, e.g., holographic display and retro-reflective imaging. The INP-WS session will cover new topics such as Real-world oriented UI (for

making everything interactive) and interactive technologies (for designing everything in the world). The DES-WS session will introduce display techniques for the visualization of Augmented Reality and Virtual Reality. The talks cover various fields and thus can provide you different perspectives on display techniques. The PRJ-WS session focuses on wearable applications in Augmented Reality and Virtual Reality, typified by head-mounted displays. The two-session 3D-WS will highlight 3D and hyper-realistic display systems and floating and omnidirectional display systems. The 3D-WS and VHF-WS have co-organized the session, *Autostereoscopic and Head-Mounted Displays*, that focuses on 3D display-related topics as well as vision and human factors.

Special Topics of Interest on Lighting Technologies (LIT)

The Lighting Technologies of 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 ’15 will be the presentations on innovative high directional LED lighting devices combined with the holographic technology, development of a red phosphor with a narrow line spectra for general lighting and LCD backlights with high brightness and color quality (PH-WS), and OLED lighting technologies with high color rendering, light-outcoupling and color conversion methods (OLED-WS).

Special Topics of Interest on Printed Electronics (PE)

Printing technologies are opening up a new era of electronic devices with their high productivity, low cost, large scale and low environmental-burden fabrication advantages. Printed Electronics, a Special Topics of Interest from the last year, will cover all aspects concerning printed electronics from scientific and technological viewpoints. This year, two Work Shops (OLED, FLX) will hold oral sessions including the printed layer structure with white emission using an all phosphorescent system, soluble emitting material and film formation technologies(OLED), solution-processed superlattice transistors and fluorinated polymer for printed electronics (FLX).

Workshop on LC Science and Technologies (LCT)

The LCT workshop covers topics from fundamental studies to recent developments in LCD technologies and LC materials. The special notes of this year are the five invited presentations related to high resolution LCD technologies, photo alignment technologies, new LC materials for FFS-mode LCDs and new autostereoscopic 3D displays. Moreover, new LC technologies, such as LC lenses, and flexible displays will be presented.

Workshop on Active Matrix Displays (AMD)

The AMD workshop covers Si-TFT, oxide TFT, organic TFT, OLED, and sensors. Recent paper presentations tend to focus on oxide TFT, which may be expected to play a role in applications for higher definition LC and OLED displays than 8k4k or 800 ppi. We highlight the oxide TFT as a special topic of interest (STI) with six dedicated sessions covering a wide area from materials, physics, devices, and processes to applications. We look forward to your participation!

Workshop on FPD Manufacturing, Materials and Components (FMC)

The FMC workshop covers recent developments and achievements in the fields of flat panel display technologies that include materials, components, display panel manufacturing and measurement. The oral presentations contain 17 papers of which 8 are invited papers. In addition, 21 posters will be presented. Since display optics is a field with large number of innovations, a session is devoted to the issues and the developments in this field. Furthermore papers related to visible light communication, materials for visible light sources, materials for 3D

holograms, medical display issues and innovations, optical film innovations, liquid crystal for high performance organic field effect transistors, and viewing angle control film will be presented. The FMC WS is supporting the AR/VR session devoted to special topics of interests, in which the recent trends in 3D will be presented.

Workshop on EL Displays and Phosphors (PH)

This workshop presents the latest achievements in devices and phosphors for emissive displays, general lighting and liquid-crystal backlighting. Invited talks will present emerging technologies such as high-efficiency phosphors, quantum dots, lighting source and backlights.

Workshop on Field Emission Displays, CRTs and Plasma Displays (FED)

This workshop thoroughly covers the fields of FED, CRT and PDP technologies. Recent progress in imaging devices and displays with field emitter arrays will be discussed. The invited talk will present a new promising electron source, a single-atom electron emission source for applications to electron microscopes. Additionally, fabrication processes, field emission characteristics and mechanisms, and applications to imaging devices under extreme conditions will be discussed. Since the invention of plasma displays in 1964, there has been much progress. Now, the PDP display technologies have stepped up to explore medical and biological applications. The characteristics of a flexible light source using PDP technologies will be presented.

Workshop on OLED Displays and Related Technologies (OLED)

The OLED workshop covers all aspects of the science and technologies of OLED and other organic devices, ranging from material research, basic device physics to display including backplane technologies and other applications. The oral and poster sessions will cover OLED device technologies including Printed Electronics (PE) as STI, OLED lighting technologies (LIT), OLED evaluation technologies and materials. Recent progress such as R to R process technology, high performance OLED lighting, molecular orientation and thermally activated delayed fluorescent (TADF), and materials etc. will be reported.

Workshop on 3D/Hyper-Realistic Displays and Systems (3D)

This workshop focuses on recent progress in image capturing, processing and display technologies, high-quality image coding and transmission technologies, AR/VR technologies, and visual evaluation for 3D and hyper-realistic display systems. It covers dual-/multiview stereoscopic image, autostereoscopic display, 2D/3D image conversion, holography and holographic elements, integral photography, light field processing and analysis, volumetric image, floating images, omnidirectional images, immersive visualization systems, depth and shape estimation, 3D scanners and printers, multi-/hyperspectral imaging, multiprimary and hyperspectral displays, crosstalk evaluation, visual depth and material perception, image coding and transmission, standardization, new optical components, and more for 3D/hyper-reality technologies. This year, some novel technologies will be presented as invited papers, such as 240 fps videos, super-multiview displays, floating displays and holograms. This workshop is intended to provide the audience with a good opportunity to understand the latest trends in these fields. We will also highlight AR/VR technology as a special topic of interest.

Workshop on Applied Vision and Human Factors (VHF)

The VHF workshop covers all topics on vision, human factors, and image quality relating to information displays. The oral and poster sessions include lively discussions on the latest topics ranging from fundamental theories to applications. We have five VHF oral sessions on Display Metrology, Display Image Quality, Human Factors, Color and Vision, and Color Rendering, in addition to a VHF poster session. We also have a

joint session with a 3D workshop on the theme of AR (Augmented Reality), and promising groundbreaking interdisciplinary discussions. Four invited talks will be given in the oral sessions, concerning metric for relative display gamut size, aging of eye and display design, observer metamerism in displays, and the color rendering index required for UHDTV production.

Workshop on Projection and Large-Area Displays and Their Components (PRJ)

The PRJ workshop covers the latest wearable applications, vehicle display technologies, head light, solid-state light sources, holograms, short throw optics etc., projection mapping, Augmented Reality (virtual reality), 3D measurement (Sensing and ADAS: Advanced Driving Assistant Systems) and all the projection technologies. This year, our session will focus on head mounted displays, wearable-related technologies, laser light sources, projection devices, speckle reduction, and dressed photon technology. Recent studies of advanced technologies such as automotive solid state light, lighting (ADB: Adaptive Driving Beam), virtual imaging for wearable, medical applications and the latest coherent LIDAR systems will be featured. There will be 33 presentations, 17-oral and 8-poster, including 8 invited presentations in total.

Workshop on Electronic Paper (EP)

This workshop focuses on current topics in electronic paper including rewritable paper and flexible displays. Newly developed e-Paper technologies are now eagerly sought for emerging applications such as e-Books, e-Notes, electronic shelf labels, signage, and smart window. Various novel technologies such as electrophoretic, electro/thermo/photo/gaso chromics will be presented. There will also be reports on promising applications for e-Paper in offices. Systems, devices, materials, applications, and usability of e-Paper are expected to be enthusiastically discussed.

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 MIT (QD Vision), Ecole Polytechnique, CEA-LETI, Brunel University, Kyung Hee University, 3M, Nano Photonica, Merck, Ritsumeikan University, Tohoku University and Keio 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)

This workshop covers all aspects of display electronics and 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 22 papers including 9 invited talks, 5 oral presentations and 8 poster presentations. Sessions related to the transparent display technologies, vehicle display technologies, and the driving/low-power technologies for LCD/OLED are planned. We will also highlight various visualization technologies related to AR/VR as a STI.

Workshop on Flexible Electronics (FLX)
FLX-WS is focusing on advanced technologies for flexible electronics including displays, wearable sensors, and IoT technologies, which are composed of a wide range of fields from materials science to practical applications. The sessions cover all aspects of the hottest flexible devices and material technologies including TFT fabrication, substrates, encapsulation, printing processes and evaluation techniques.

Workshop on Touch Panels and Input Technologies (INP)
Interface technologies such as touch panels and interactive technologies are the stars of the session. AR/Interactive systems such as haptics and AR are special topics of INP. Computer vision and natural interface technologies are still important research topics of INP. This year, new topics will be presented: Real-world oriented UI which makes everything interactive and interactive technologies to design everything in the real world are special topics. 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 ’15. The award winners will be announced on the IDW website and given a plaque after the conference.

Innovative Demonstration Session
Innovative Demonstration Session will be held on December 10 at Ohmi 5 and Shakunage 2. IDW provides the opportunity for an interdisciplinary technical demonstration/ discussion in a larger space, more preparation and demonstration time than in the “Author Interviews and Demonstrations”. Demonstration Award will be awarded to the demonstration that has the biggest impact on the audience.

Special Address
Nobel laureate, Prof. Hiroshi Amano of Nagoya University, will give a special address at IDW ’15 on the theme, "Lighting the Earth by LEDs".
Prof. Amano was awarded the 2014 Nobel Prize in Physics for the invention of blue light-emitting diodes. He will present his address at 17:20 on Wednesday, December 9 in Ohmi 1.

Exhibition
The IDW ’15 Exhibition, which will be held from December 9 through December 11, 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 (Lobby, 2F).

December 9 (Wed.) 12:00 – 17:00
December 10 (Thu.) 10:00 – 18:00
December 11 (Fri.) 10:00 – 14:00

GENERAL INFORMATION

SPONSORSHIP
IDW '15 is sponsored by the Institute of Image Information and Television Engineers (ITE) and the Society for Information Display (SID).

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ON-SITE SECRETARIAT
Telephone and fax machines for IDW '15 use will be temporarily set up in the secretariat room (Room Eizansumire 1) at Otsu Prince Hotel (December 9-11). Phone/Fax: +81-77-521-1380

RECEPTION
A buffet style reception will be held on December 9 from 18:50 to 20:50 at the Prince Hall (3F) in Otsu Prince Hotel. 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 8 from 18:00 to 20:00 at Hiei (2F) in Otsu Prince Hotel. Wine (sponsored by Merck Ltd., Japan) 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 '15 includes admission to the conference and a USB Flash Drive of the proceedings. Detailed information will be announced on the website.

	Until Oct. 30	On and After Oct. 31
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.14 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 '15 committee.
***Photocopy of student ID is required.

Please note that the payment of reduced registration fee is accepted until October 30. The full fee will be charged for payments made on and after October 31. Also note that the number of reception tickets to register on site is limited.

Proceedings Data at the Conference Site
Proceeding data can be accessed from the web-server via the wireless network only in the Free Wi-Fi Area at the conference site.
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
Three ways are provided for registration.

(1) e-Registration
Access the following URL.
http://www.idw.or.jp/regist.html
e-Registration will be accepted until November 27, 2015.

(2) Mail or Fax Registration
Complete the registration form (download from the website) and send it to the secretariat shown below together with the proof of payment no later than November 27, 2015.

IDW '15 Secretariat
c/o Bilingual Group Ltd.
3-3-6 Kudan Minami, Chiyoda-ku, Tokyo 102-0074, Japan
Phone: +81-3-3263-1345 Fax: +81-3-3263-1264
E-mail: idw@idw.or.jp

The registration fee should be paid by one of the following methods.

1. Credit Card (VISA, MasterCard, JCB, AMEX or Diners)
2. Bank Transfer to:

Bank:	Bank of Tokyo-Mitsubishi UFJ (Swift Code: BOTKJPJT)
Branch:	Ichigaya Branch (Branch No. 14)
Account No.:	0167640 (Ordinary Account)
Account:	IDW

Please attach a copy of the bank receipt to the registration form to avoid any confusion. Please note that **the remittance charges, including that of Bank of Tokyo Mitsubishi UFJ, should be paid by the payer**.

All above payments should be made in **JAPANESE YEN**.
Also, please note that personal and traveler's checks are not accepted.

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

December	8 (Tue.)	17:00 – 20:00
December	9 (Wed.)	8:00 – 18:00
December	10 (Thu.)	8:00 – 18:00
December	11 (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, China Union Pay)

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

Cancellation Policy
Until **October 30**, cancellation is accepted by writing to IDW '15 Secretariat to get refunds for registration and reception. For cancellations received **on and after October 31 or no-shows, refunds will not be made**. However, after IDW '15 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 '15 due to the outbreak of infectious diseases and other unavoidable factors, we will substitute the IDW with the mail delivery of the IDW '15 proceedings at a later date to all those who have registered and completed payment.

INQUIRIES
IDW '15 Secretariat
c/o Bilingual Group Ltd.
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E-mail: idw@idw.or.jp

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
- 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 Optical Society of Japan
- The Society of Automotive Engineers of Japan
- The Society of Polymer Science, Japan
- The Virtual Reality Society of Japan

FUNDS

- Shiga Prefecture
- JSPS KAKENHI Grant Number 15HP0304

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

IDW/AD ’16

The 23rd International Display Workshops
in conjunction with Asia Display 2016

Dec. 7 – 9, 2016

Fukuoka Convention Center
Fukuoka, Japan

http://www.idw.or.jp

TRAVEL INFORMATION

ACCOMMODATIONS
JTB Western Japan, Corp. will handle arrangements for your hotel reservations.

It will be very hard to book a hotel in Otsu and Kyoto in December due to the peak tourist season. So we recommend you make reservations in advance at the hotels recommended by IDW.

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

Hotel list and the rates are available on the Pullout of this Advance Program.

JTB Western Japan, Corp.
Communication Division, MICE Center, IDW '15 Desk

Phone: +81-6-6252-2861 Fax: +81-6-6252-2862
Office Hours: 9:30-17:30 (Weekdays only)
E-mail: westec_op6@west.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 countries. 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 access the IDW website for applications.
http://www.idw.or.jp/visa.html

JAPAN RAIL PASS AND JR WEST 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 WEST PASS is an economical and flexible rail pass to travel around Western Japan.
Japan Rail Pass: http://www.japanrailpass.net/en/index.html
JR West Pass: http://www.westjr.co.jp/global/en/travel-information/pass/shop/

CLIMATE
The average temperature in Otsu during the conference should be around 10°C (50°F) in the daytime and 3°C (37°F) at night.

OTSU CITY

Otsu City is easily accessible from Kyoto Station, only 9 minutes away by train. It is located on the southern edge of Biwako, which with a surface area of 672 km^2 is the largest lake in Japan. It is the capital of Shiga Prefecture and is rich in history and natural beauty. About 1,300 years ago, it was the capital of Japan for a brief period of time. At the end of the 8th century, Kyoto became the heart of Japan, and Otsu prospered as a gateway to Kyoto for both land and water transportation systems, while also becoming a center for Buddhism.

Now it is a tourist center and a port for excursion boats on Biwako. The views from Otsu Prince Hotel are magnificent. Around twilight, Biwako gradually changes its colors and the city starts to light up along the shore. The city's industrial products include electrical appliances, textiles, precision instruments, computer components, and machinery.

PLACES OF INTEREST

Biwako (Lake Biwa)

Biwako occupies 1/6 of Shiga Prefecture. More than 450 rivers flow into the lake and there is only one natural outlet, the Seta River.

The lake supplies water to some 14 million residents around and downstream of the lake including Osaka, Kyoto and Kobe Cities.

There are a number of historic sites, hot springs, and other attractive tourist spots around the lake. Several types of boat cruises start from Nagisa-Koen Park as well as from Otsu Prince Hotel.

Enryakuji Temple

The temple was founded in 788 AD by the Buddhist Priest Saicho (767–822) to protect the former capital of Kyoto from evil spirits from the northeast. It was (and still is) the headquarters of the Tendai sect, the Buddhist sect that was popular among the aristocracy of the time and served as the foundation for a number of later sects. At the peak of its power, Enryakuji Temple was a huge complex of 3,000 subtemples.

A powerful army of warrior monks occasionally engaged in power struggles with other monasteries and political leaders. In 1571, warlord Oda Nobunaga ended this Buddhist militancy by attacking and razing the huge temple complex on Mt. Hiei. Currently, there are 200 temple buildings and its forest environment has great scenic charm. The temple itself is in an excellent state of preservation and the main buildings are National Treasures. Enryakuji Temple was registered as a UNESCO World Cultural Heritage site in 1994. It is located 10 minutes on foot from Enryakuji Station on the Hieizan-Sakamoto Cablecar Line. It takes about 25 minutes to get to JR Hieizan Sakamoto station from JR Otsu station.

Miidera (Onjoji) Temple

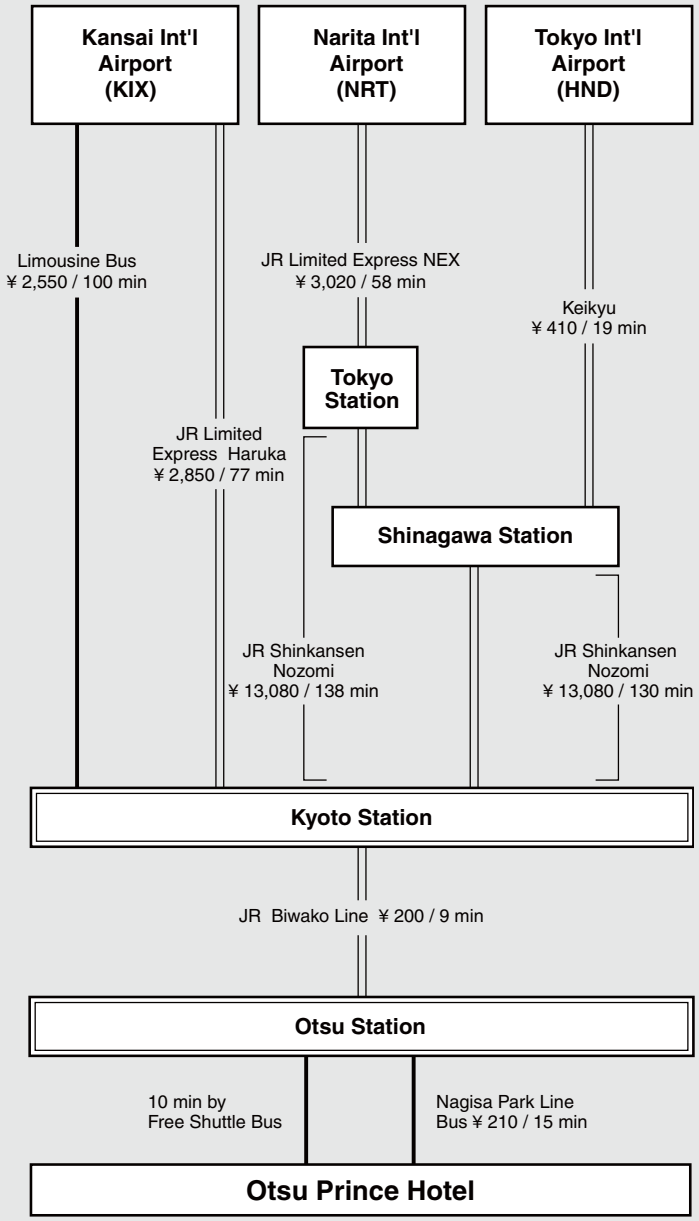
Located at the foot of Mt. Hiei, this temple was founded in 686 AD by Emperor Tenmu in honor and memory of his brother. The name "Miidera", literally means "Temple of Three Wells". The name derives from the springs at the temple which were used for the ritual bathing of newborns.

The Evening Bell of Miidera is one of the well-known Omi Hakkei (Best Eight Views of Omi). Miidera is also famous for the color of its autumn leaves and is an excellent place to enjoy beautiful Japanese autumn scenery until early December.

Take the Keihan Bus from JR Otsu Station to Miidera bus-stop, or take the Keihan Ishiyama Sakamoto Line to Miidera. The temple is 10 minutes on foot from Miidera station.

More information is available on
http://www.pref.shiga.lg.jp/multilingual/english/index.html
http://www.jnto.go.jp/eng/location/regional/shiga

Access to Conference Site



(as of Nov. 2015)

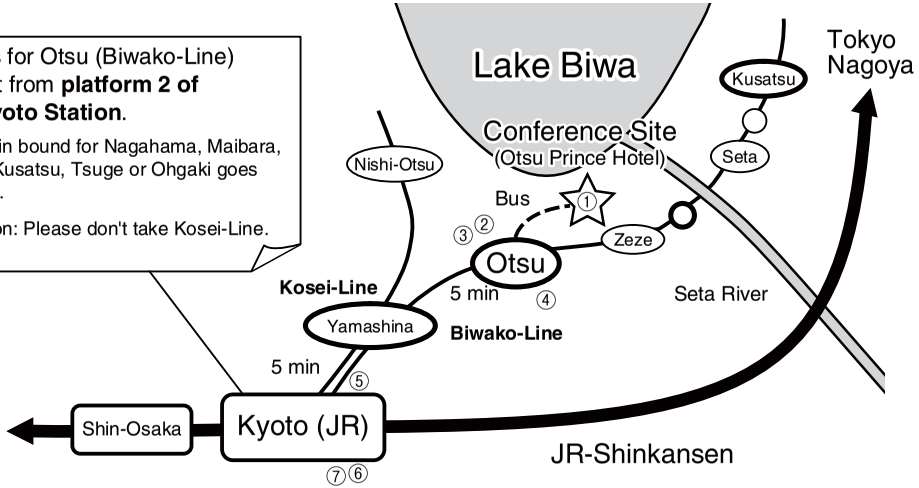
*Information of this page may be changed. Please confirm the details in each company.

Access from Kyoto and Hotel Location

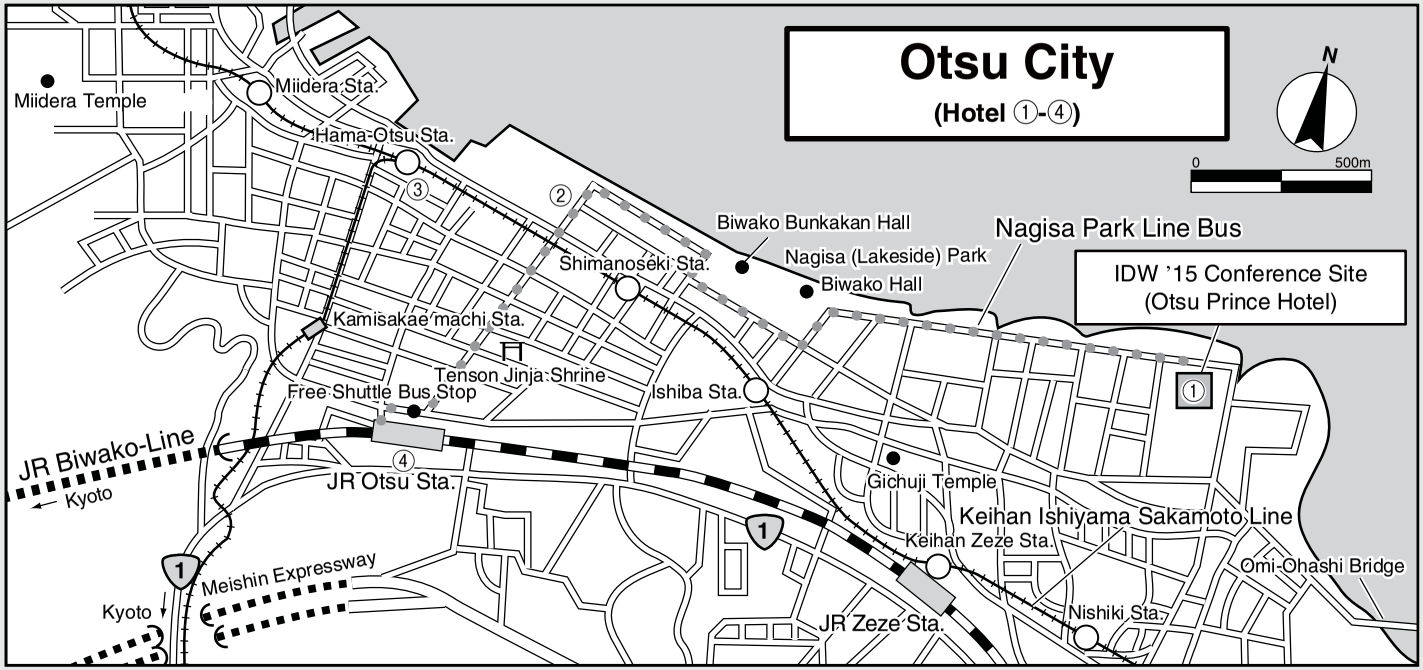
Trains for Otsu (Biwako-Line) depart from **platform 2 of JR Kyoto Station**.

Any train bound for Nagahama, Maibara, Yasu, Kusatsu, Tsuge or Ohgaki goes to Otsu.

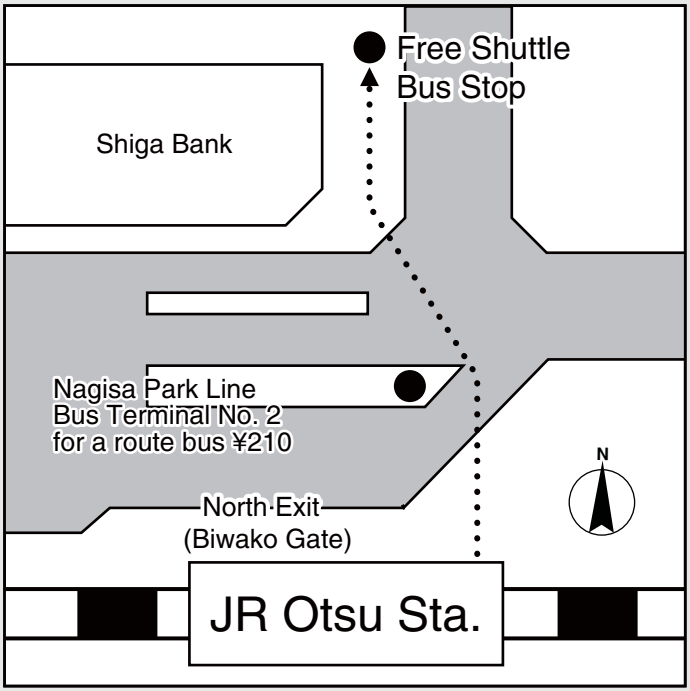
Attention: Please don't take Kosei-Line.



① Otsu Prince Hotel
Phone: +81-77-521-1111
② BIWAKO HOTEL
Phone: +81-77-524-7111
③ Hotel Blue Lake Ohtsu
Phone: +81-77-524-0200
④ Hotel Tetora Otsu. Kyoto
Phone: +81-77-527-6711
⑤ HOTEL HOKKE CLUB KYOTO
Phone: +81-75-361-1251
⑥ HOTEL KEIHAN KYOTO
Phone: +81-75-661-0321
⑦ Ibis Styles Kyoto Station
Phone: +81-75-693-8444


Otsu City
(Hotel ①-④)
N
0
500m
Miidera Temple
Miidera Sta.
Hama-Otsu Sta.
③
②
Biwako Bunkakan Hall
Nagisa Park Line Bus
Shimanoseki Sta.
Nagisa (Lakeside) Park
Biwako Hall
IDW '15 Conference Site
(Otsu Prince Hotel)
Kamisakae-machi Sta.
Tenson Jinja Shrine
Free Shuttle Bus Stop
Ishiba Sta.
①
JR Biwako-Line
Kyoto
④
JR Otsu Sta.
Gichuji Temple
Keihan Ishiyama Sakamoto Line
Keihan Zeze Sta.
1
Meishin Expressway
Omi-Ohashi Bridge
Kyoto
JR Zeze Sta.
Nishiki Sta.

Otsu Station



SID Display Week 2016

May 22 – 27, 2016

Moscone Convention Center

San Francisco, CA, USA

Plenary Sessions

Wednesday, December 9

9:30 - 9:50 **Ohmi 1**

Opening

Master of Ceremony: K. Ishii, Executive Chair, IDW

Opening Remarks
9:30

H. Okumura, General Chair, IDW
A. Ghosh, President, SID
M. Doi, President, ITE
M. Kimura, Program Chair, IDW

9:50 - 11:10 **Ohmi 1**

Keynote Addresses

Chair: M. Kimura, Program Chair, IDW
Co-Chair: H. Okumura, General Chair, IDW

Keynote Address - 1 **Dynamic Aware Interiors - Rethinking Interactive Displays**
9:50

Y. Kitamura

Tohoku Univ., Japan

Imagine reactive interior spaces which are aware of our actions and transform according to changing needs. Imagine furniture and walls that act as interactive displays and shapeshift to the correct physical form, and the appropriate interactive visual content and modality. I will present our recent efforts on realizing this vision.

Keynote Address - 2 **Global Business for Mobile Device**
10:30

J. Chu

Huawei Device, China

As the leading smartphone innovator in China, we would like to share the achievement of Huawei global business in mobile devices of years 2014 and 2015, and to foresee the future by market trends.

11:10 - 11:50 **Ohmi 1**

Invited Address

Chair: M. Kimura, Program Chair, IDW
Co-Chair: H. Okumura, General Chair, IDW

Invited Address - 1 **Information Flow of Things: Sensing, Networking, and Processing Technologies for Real-time Utilization of IoT Data**
11:10

K. Yasumoto

NAIST, Japan

Nowadays, a huge number of IoT devices including sensors, cameras, and various kinds of machines continuously produce data streams. It is expected to recognize the real world situation by analyzing these streams. For example, analysis of video streams captured by in-vehicle cameras may enable automatic detection and real-time sharing of scenic spots in wide geographical area. However, the real-time data analysis/processing will require a lot of computation and network resources depending on type and/or amount of data streams. This talk addresses existing technologies for handling IoT data streams in real-time and reveals technical challenges that must be solved in the future.

----- Lunch -----

17:20 - 18:20 **Ohmi 1**

Special Address

Chair: M. Kimura, Program Chair, IDW
Co-Chair: Y. Nakanishi, Shizuoka Univ., Japan

Special Address - 1 **Lighting the Earth by LEDs**
17:20

H. Amano

Nagoya Univ., Japan

The success of blue/white LEDs has motivated the nitride researchers to attempt to realize longer-wavelength LEDs. Improvement of the crystalline quality of high-In-content InGaN is essential for the fabrication of high-performance yellow-to-red LEDs and LDs. We will review the growth of high-In-content InGaN by MOVPE and the present status of long-wavelength LEDs.

Special Topics of Interest on Oxide-Semiconductor TFT

Thursday, December 10

13:40 - 15:40 **Ohmi 6**

***Poster* AMDp1: Oxide TFT**

AMDp1 - 1 **Stress Durability of CAAC-IGZO TFTs**

R. Honda[*], H. Baba[*], A. Suzuki[*], M. Hayakawa[**], N. Ishihara[*], H. Kanemura[**], Y. Shima[**], S. Saito[**], S. Matsuda[*], K. Dairiki[*], J. Koezuka[**], S. Yamazaki[,**]*

[*]Semiconductor Energy Lab., Japan
[**]Advanced Film Device, Japan

C-axis-aligned ab-plane-anchored crystalline In-Ga-Zn oxide (CAAC-IGZO) is a semiconductor material that has attracted attention in recent years. In this study, drain current stress tests for CAAC-IGZO TFTs were performed, and the TFTs under the stress were observed using emission microscopes to indicate hot-carrier effects.

AMDp1 - 2 **Correlation Among Crystal Morphology, Surface Shape, and Oxygen Vacancy Formations in In-Ga-Zn Oxide**

M. Nakashima, T. Hiramatsu, E. Kikuchi, Y. Yamada, M. Oota, K. Dairiki, S. Yamazaki

Semiconductor Energy Lab., Japan

The crystal orientations and surface shapes of In-Ga-Zn oxide (IGZO) thin films were examined by cross-sectional TEM. Furthermore, the correlation between crystallinity and oxygen vacancy was investigated by first-principles calculations. The results reveal that oxygen vacancies are less likely to be formed in crystalline than in amorphous IGZO.

AMDp1 - 3 **Behavior of a-IGZTO TFTs with BCE Structures Containing Floating Metal Electrodes**

M. Ochi, S. Morita, H. Goto, T. Kugimiya, M. Kanamaru[*], M. N. Fujii[**], Y. Uraoka[**]

Kobe Steel, Japan
[*]Kobelco Res. Inst., Japan
[**]NAIST, Japan

We report fabrication of back channel etch type oxide semiconductor TFTs equipped with floating metal electrodes on their channel region. The on-current was greatly enhanced by arranging of the additional electrodes. It is found that formation of parasitic TFTs also had a similar effect.

AMDp1 - 4 **Suppression of Photo-Bias Instability of Transparent Amorphous Indium Oxide Thin Film Transistors by in situ Nitrogen Doping**

C.-H. Chang, C.-C. Chang, P.-T. Liu, Y.-C. Tsai[*]

Nat. Chiao Tung Univ., Taiwan
[*]Appl. Materials, Taiwan

In this study, we analyzed the In_2O_3 thin films with different nitrogen flow rate during sputtering as the transistor's channel layer. The electrical analysis including device's reliability and material analysis were both examined.

AMDp1 - 5 **Related a-IGZO Oxide Structure Analysis for Reliability Improvement**

W.-T. Chen, K.-J. Chang, W.-P. Chen, C.-C. Nien, K.-K. Chen, H.-H. Lu, Y.-H. Lin

AU Optronics, Taiwan

Different device structures stress were studied in this study. Top gate TFT device showed good PBS/NBS results due to top gate metal shielding and thinner SiO_x to avoid gas/moisture permeation into the IGZO. The dual gate TFT device showed better PBIS/NBIS due to its nice electric field distribution.

AMDp1 - 6 **Simple Current-Biased Voltage-Programmed a-IGZO Pixel Circuit for High-Resolution AMOLED Displays**

F.-H. Chen, Y.-T. Liu, C.-M. Lu, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

A current-biased voltage-programmed amorphous indium-gallium-zinc-oxide pixel circuit which consists of three transistors and one capacitor is proposed for the use in high-resolution active-matrix organic light-emitting diode (AMOLED) displays. The simulation results confirm that the OLED current has immunity to the degradation of driving TFT, OLED, and carrier mobility.

AMDp1 - 7 **Development of High Performance AM-OLED Display Using IGZO TFT**

X.-W. Lv, Y.-H. Meng, C.-Y. Su, W.-H. Li, L.-Q. Shi, H.-J. Zhang, W. Shi, S.-M. Ge, T. Sun, C.-Y. Lee, A. Lien[*]

Shenzhen China Star Optoelect. Tech., China
[*]TCL Corporate Res., China

An optimized process of manufacturing IGZO TFT was developed. According to adjusting pattern sequence of GI, IGZO and ES, transfer characteristics and uniformity of TFTs were improved. Moreover, mura of panel is reduced greatly. Finally, a high performance 31-in. 4K2K AM-OLED display was fabricated.

AMDp1 - 8 **Investigation of Stacking Multi-Layers Oxide Thin Film Transistors Fabricated by Sol-Gel Process**

C. Y. Huang, C. E. Tsay, Y. W. Wang

Nat. Changhua Univ. of Education, Taiwan

The effects of multi-stack oxide semiconductor layers on TFT. ZnO based semiconductors are processed sequentially as active multi-layer through sol-gel process. Tin/zinc oxide is as the donor provider and gallium/zinc oxide is as the resist layer. The result highest mobility reaches 6.4 cm^2/Vs and on/off current ratio over 10^5.

AMDp1 - 9 **High Reliable Indium Gallium Zinc Oxide Thin Film Transistor under Negative Bias Illumination Stress**

J. Liu, J. Li, S. Qin, J. Lee, C. Lee

Shenzhen China Star Optoelect. Tech., China

We studied the influence of nitrogen plasma treatment on the indium gallium zinc oxide thin film transistor. Then we improved the performance of indium gallium zinc oxide through adding nitrogen into the deposition of silicon oxide insulator. Finally, we fabricated high reliable oxide thin film transistor under negative bias illumination stress.

AMDp1 - 10 **Characteristics Improvements by Adopting Multi-Active Layer Structure in a-IGZO Thin Film Transistors**

D. Xu, X. Duan, M. K. Baek, Y. Youn, C. Che, S. Lee

Hefei BOE Optoelect. Tech., China

This paper demonstrates a characteristics improvement method using multi-active layer structure in a-IGZO TFTs. The multi-active layer comprises bottom oxygen-rich (OR), middle oxygen-deficient (OD), and top OR a-IGZO layers, forming carrier-confinement structure. By using above-mentioned multi-layered IGZO active layer, TFT devices exhibited relatively better and more stable characteristics was gained.

AMDp1 - 11 **Electrical Properties of a-IGZO TFT with Various Annealing Temperature**

Y.-H. Hsieh, M.-C. Chen, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this paper, we use rf magnetron sputtering method to fabricate InGaZnO thin-film transistors. We use surface energy to identify the relationship between InGaZnO thin-film transistors with various annealing temperature. We also examine the InGaZnO TFT devices characteristic and hysteresis.

AMDp1 - 12 Comparison of Electrical Performance for a-IGZO Based Single Gate and Dual Gate Driving TFT Using TCAD

M. M. Billah, M. D. H. Chowdhury, J. Jang

Kyung Hee Univ., Korea

We compared electrical performances between single(SG) and dual(DG) driving a-IGZO TFTs using TCAD. DG-driving shows higher electric-field 2.59 (2.53) MV/cm and electron concentration 1.04×10^{19} (1×10^{19}) cm^{-3} at back (front) channel and thus bulk-accumulation TFT is possible. Using I-V & C-V measurements DG-driving shows higher carrier-concentration and lower E_C-E_F, leads to increase the drain current and mobility.

AMDp1 - 13 Withdrawn

AMDp1 - 14 Withdrawn

AMDp1 - 15 Investigation on Ambient Degradation of Amorphous InGaZnO Thin Film Transistors in an Unsealed Chamber

J. Xu, Q. Wu, L. Xu, H. Xie, S. Li, C.-Y. Lee*, A. Lien**, C. Dong*

Shanghai Jiao Tong Univ., China
**Shenzhen China Star Optoelect. Tech., China*
***TCL Corporate Res., China*

The device transfer characteristics of the unpassivated amorphous InGaZnO thin film Transistors were separately measured under ambient N_2, Ar, O_2, and moisture in an unsealed chamber, proving that moisture instead of oxygen, nitrogen, and inert gases was dominant in the ambient degradation effects under atmospheric conditions.

AMDp1 - 16L Reliability Improvement of Amorphous InGaZnO Thin-Film Transistors by Less Hydroxyl-Groups Siloxane Passivation

C. Kulchaisit, Y. Ishikawa, M. N. Fujii, H. Yamazaki, J. P. S. Bermundo, S. Ishikawa, T. Miyasako*, H. Katsui*, K. Tanaka*, K. Hamada*, Y. Uraoka*

NAIST, Japan
**JSR, Japan*

We control the hydroxide content in amorphous InGaZnO surface by passivation to improve the thin-film transistor's (TFT) reliability. We achieved the stable device using an organic-inorganic hybrid material by controlling the OH bond, and found that the OH amount in the passivation is a key issue in oxide TFT reliability.

AMDp1 - 17L The Impact of Thermal-Assist UV/Ozone Treatment in Amorphous Zinc Oxynitride Thin Film Transistors

K.-C. Ok, H.-J. Jeong, H.-M. Lee, J.-S. Park

Hanyang Univ., Korea

We fabricated high mobility (μ_{sat} > 40 cm^2/Vs) and stable (ΔVth < ± 1 V @PBS and NBS for 1hr) amorphous zinc oxynitride thin film transistors (a-ZnON TFTs) using thermal assist UV/ozone treatment. The electrical characteristics of a-ZnON TFTs were investigated by chemical bonding properties.

AMDp1 - 18L Influence of Copper Source/Drain Metal on BCE Amorphous IGZO TFTs

C.-Y. Hou, L.-Y. Chiu, J.-J. Zeng, S.-F. Wu, S.-C. Lee, W.-C. Tsai

AU Optronics, Taiwan

BCE_structure IGZO TFT using copper as the source/drain metal, we have developed a copper-blocked process to prevent Cu from diffusing into the IGZO active layer. The device characteristics and reliability of Cu BCE_structure IGZO TFT can be improved by copper-blocked process.

AMDp1 - 19L Improvement of High Mobility Al-Doped InSnZnO Back Channel Etch Thin Film Transistor with Double-Layered Passivation of SiO_2/Al_2O_3

G.-J. Jeon, K.-H. Lee, H. Yeom, Y. Nam, G. B. Mun, I.-S. Kang[*]*, S.-H. K. Park*

KAIST, Korea
[*]*Nat. Nano-Fab Ctr., Korea*

N_2O plasma treatment was performed to back channel of Al-doped InSnZnO. TFTs were passivated with SiO_2 or SiO_2/Al_2O_3. While subthreshold swing and hysteresis of TFTs with SiO_2 single layer were degraded after post-annealing, TFTs with SiO_2/Al_2O_3 showed much better performance with 0.09 V/decade and 30.55 cm^2/Vs.

AMDp1 - 20L Reliability and Performance Study of ZnO Co-Sputtered InGaZnO Thin Film Transistors Under Various Ambient Conditions

N. Tiwari, R. N. Chauhan, P.-T. Liu, H.-P. D. Shieh

Nat. Chiao Tung Univ., Taiwan

ZnO co-sputtered IGZO TFTs were fabricated and systematically investigated the impact of various annealing environments on their performance characteristics. The characteristics were improved in N_2 ambient-displaying field effect mobility ~ 16.10 cm^2/Vs, threshold voltage ~ 1.5 V, sub-threshold swing ~ 0.21 V/decade and NBIS shifting ~ –2.75 V.

AMDp1 - 21L InZnO Capped with InZnO:Si Bi-Stack Layers for Enhanced Photo-Bias Stability and Performance in Metal Oxide Thin Film Transistors

R. N. Chauhan, N. Tiwari, Y.-H. Tai, P.-T. Liu, H.-P. D. Shieh

Nat. Chiao Tung Univ., Taiwan

A thin film transistor with bi-stack layers of silicon incorporated InZnO(IZO:Si) on InZnO layer is proposed to enhance device performance and negative photo-biased stability. The resulting device realizes as enhancement mode (V_{th} ~ 1.30 V) with mobility of 15.3 cm^2/Vs, sub-threshold swing of 0.20 V/decade, better stability ~ –0.75 V.

AMDp1 - 22L Oxide TFT Shift Register Circuit with DC-type Output Driver

S.-J. Song, H. Nam

Kyung Hee Univ., Korea

This paper demonstrates a DC-type oxide TFT shift register that connects large size pull-up TFTs to positive supply instead of alternating clock signals to reduce the power consumption of clock drivers. The power consumption is simulated as 0.237 mW at a 16-stage gate driver for a 120 Hz full-HD display.

AMDp1 - 23L High Performance Solution Oxide TFTs for AMOLED Applications

L. Y. Lin, C. C. Cheng, C. Y. Liu, M. F. Chiang, P. H. Wu, M. T. Lee, C. K. Lo, L. F. Lin, S. H. Kuo

AU Optronics, Taiwan

Solution-processed metal oxide TFT arrays have been fabricated for AMOLED application in this work. Two different kinds of TFT configurations have been introduced; the highest mobility is 4.24 cm^2/Vs for coplanar and 11.37 cm^2/Vs for island stop TFT structure. Characteristics and reliability of solution-processed metal oxide TFTs have been also presented in this work.

AMDp1 - 24L Comparison of Performance and Stability of Tungsten-doped Indium Oxide Thin Film Transistor with SiO, SiN and SiO/SiN as Gate Insulators

P.-W. Chen, C.-H. Chang, P.-T. Liu

Nat. Chiao Tung Univ., Taiwan

In this study, we investigated the performance and stability of thin-film transistors with tungsten-doped indium oxide as channel layer, which were deposited on SiO, SiN and SiO/SiN. Positive/Negative bias stress were performed to explore the electrical reliability of IWO TFT with different gate insulators.

AMDp1 - 25L High-Mobility and High-Stability ZnON Thin-Film Transistors for Next-Generation Display Applications

Y. S. Kim, J. H. Kim, H. S. Kim
Chungnam Nat. Univ., Korea

In order to improve the performances of Zinc Oxynitride thin-film transistors, heat treatment conditions of ZnON semiconductors were studied here. Thin film properties and the resulting TFT performances including the device stability were evaluated. High-stability ZnON devices with ultra-high field-effect mobility (μ_{FE}) values exceeding 50 cm^2/Vs were achieved.

AMDp1 - 26L Withdrawn

13:40 - 15:40 **Ohmi 6**

***Poster* FLXp2: Flexible Electronics 2**

FLXp2 - 1 The Instability Change of Flexible a-IGZO TFTs under Different Mechanical Stress

H.-J. Jeong, K.-C. Ok, H.-M. Lee, J.-S. Park
Hanyang Univ., Korea

Amorphous InGaZnO (IGZO) thin film transistors (TFTs) were made on the polyimide (PI) substrate. We evaluated transistor performance and instability depends on mechanical stress, various bending radius (10 mm, 5 mm and 2 mm) were applied to flexible substrate. The variation in the threshold voltage under NBTS was –0.58 V (without bending)/ –6.48 V (2 mm).

FLXp2 - 2L Highly Robust Flexible Oxide TFTs Achieved by Plastic Substrate with Embedded CNT/GO Backbone

Y.-H. Kim, J. G. Um, M. Mativenga, J. Jang
Kyung Hee Univ., Korea

We demonstrate the highly robust flexible oxide TFT fabricated on 5 μm-thick PI. Particularly, by process employed of embedding the graphene oxide and carbon nanotubes mixture into the PI substrate, it makes excellent functionality as flexible substrate that self-standing without any supporting materials and prevent from the electrostatic discharge effect.

FLXp2 - 3L **Thermal Analysis of Oxide Thin Film Transistor with Fluorinated Silicon Nitride Gate Insulator**

H. Yamazaki, Y. Ishikawa, M. N. Fujii, J. P. S. Bermundo, E. Takahashi, Y. Andoh*, Y. Uraoka*

NAIST, Japan
**Nissin Elec., Japan*

We found that amorphous In-Ga-Zn-O thin-film transistors with W=5 μm showed higher mobility than TFTs with W=90 μm, and showed a sharp mobility curve. The results of thermal analysis show local heating at the edge of the drain. We conclude that these effects are caused by mobile minus ions.

----- Break -----

16:00 - 17:25 **Ohmi 1**

AMD1: Oxide TFT: Crystalline Oxide

Chair: H. Kumomi, Tokyo Inst. of Tech., Japan
Co-Chair: M. Hiramatsu, Japan Display, Japan

AMD1 - 1: 16:00 ***Invited*** **CAAC-Oxide Semiconductor Material and Its Applications**

M. Tsubuku, S. Yamazaki

Semiconductor Energy Lab., Japan

C-axis-aligned a-b-plane-anchored crystal indium- gallium-zinc-oxide (CAAC-IGZO) has unique characteristics with a layered crystal structure. We found that the IGZO with new atomic ratios of In:Ga:Zn = 4:2:3 to 4:2:4.1 and its neighborhood also has the layered CAAC structure and the electrical characteristics is improved in mobility and reliability.

AMD1 - 2: 16:25 ***Invited*** **Change in Structure and TFT Performances of IZO, IGO and IGZO Films by Crystallization**

A. Suko, J. Jia, S. Nakamura, Y. Shigesato

Aoyama Gakuin Univ., Japan

How the a-IGZO films crystallize and how the crystallinity affects the electrical properties, hence the TFT performances, have been investigated in detail. HREM analyses revealed the crystallization behavior in detail. For the comparative purpose the crystallization behaviors of a-IGO and a-IZO films are also investigated.

AMD1 - 3
16:50

Improvement in Characteristics, Reliability and Dispersion of CAAC-IGZO FETs with Surrounded Channel Structure

M. Hayakawa[*], S. Matsuda[**], S. Saito[*], Y. Shima[*], D. Matsubayashi[**], M. Dobashi[*], K. Tsutsui[**], R. Honda[**], J. Koezuka[*], K. Okazaki[*], S. Yamazaki[,**]*

[*]Advanced Film Device, Japan
[**]Semiconductor Energy Lab., Japan

Crystalline In-Ga-Zn-O (IGZO) field-effect transistors (FETs) with their channels electrically surrounded by two gate electrodes on the top side and the bottom side (we refer to such a structure as "surrounded-channel (S-ch) structure") were fabricated. Characteristics, reliability and dispersion of crystalline IGZO FETs were improved due to their S-ch structure.

AMD1 - 4L
17:10

Double-Channel InZnO/AlSnZnInO Thin-Film Transistors with Ultra High Mobility

J. H. Choi, J.-H. Yang, S. Nam, H.-O. Kim, O-S. Kwon, E.-S. Park, C.-S. Hwang, S. H. Cho

ETRI, Korea

We report high performance double-channel InZnO/AlSnZnInO (IZO/ATZIO) thin-film transistors (TFTs) with inverted staggered back channel etch (BCE) structure. The field-effect mobility (μ_{FE}), Subthreshold slope (SS), turn-on voltage (V_{on}), and on/off ratio were 51.2 cm^2/Vs, 0.15 V/decade, –1.6 V, and 3×10^9, respectively.

----- Break -----

"Innovative Demonstration Session" *by Oral and Poster Presenters*

Live demonstrations of emerging information display technologies

Thursday, Dec. 10, 2015
10:30 – 16:00
Ohmi 5 (2F)
Shakunage 2 (1F)
See page 205-209 for details

17:40 - 19:10 **Ohmi 1**

AMD2: High Resolution Displays Using LTPS and Oxide TFTs

Chair: P. Heremans, imec, Belgium
Co-Chair: H. Hamada, Kinki Univ., Japan

AMD2 - 1: 17:40 ***Invited*** **2K4K 550-ppi In-Cell Touch LTPS TFT-LCD**

M. Tada, T. Nakamura, H. Kimura

Japan Display, Japan

2K4K 550-ppi in-cell touch LTPS TFT-LCD has been developed in which low power consumption is realized using RGBW pixel, local dimming and low frame-rate driving. This LCD can be driven in 30 Hz frame-rate by the advanced TFT process with narrower channel width and thinner insulator storage capacitance.

AMD2 - 2 **Withdrawn**

AMD2 - 5L 18:05 **Scalability Characteristics of Self-Aligned Top-Gate IGZO TFTs**

J. S. Seo, J. Noh, P. S. Yun, J. U. Bae, K.-S. Park, I. B. Kang

LG Display, Korea

To achieve the short-channel scalability characteristics of self-aligned IGZO TFTs we perform to control the diffusion region (ΔL, LDD) inside channel and to reduce the total resistivity of S/D extension region. As a result of this work, we realize the below L<4 μm TFTs and improve its current driving ability.

AMD2 - 3 18:25 **Development of 32-in. 8K4K LCD with Oxide Semiconductor and GOA Technology**

M. Wang, Y. Zhao, Q.-M. Gan, F. Zhao, C.-K. Zhang, L.-Q. Shi, L.-M. Zeng, C. Dai, T. Lee, H-L. Hu, J. Wu, C.-Y. Chiu, C.-Y. Lee, A. Lien[*]

Shenzhen China Star Optoelect. Tech., China
[*]*TCL Corporate Res., China*

We have successfully developed a 32-in. 8K4K LCD prototype which has the highest pixel density (280PPI) in TV market. BCE type oxide semiconductor and photo- alignment FFS mode are used to gain enough aperture ratio. HSD method and GOA technology are also used to decrease COF quantity.

AMD2 - 4: 18:45 ***Invited*** **Over 800-ppi Liquid Crystal Display with High Aperture Ratio Using IGZO Platform**

S. Uchida, N. Ueda, K. Okada, A. Oda, K. Yamamoto, K. Yamamoto, N. Noguchi, T. Matsuo

Sharp, Japan

Using oxide semiconductor, we have developed a 806ppi (4K2K) LCD which pixel density reach 4K resolution smart-phone and Head-Mounted-Display(HMD). An excellent aperture ratio was achieved with patterning dimensions by a gh-line lithography manufacturing backplane. With i-line lithography, this technology can realize larger pixel density than 1000ppi which satisfy HMD demands.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:30 **Ohmi 1**

AMD3: Oxide TFT: Reliability

Chair: Y. Yamamoto, Japan
Co-Chair: K. Takatori, NLT Techs., Japan

AMD3 - 1: 9:00 ***Invited*** **Reliability of Oxide TFTs**

B. S. Bae, S. M. Shin, K. M. Yu, E.-J. Yun

Hoseo Univ., Korea

The negative shift of threshold voltage by light illumination was investigated for the oxide thin film transistor. By the light illumination, both the doubly ionized oxygen vacancy and charge trapping cause the negative shift of the threshold voltage.

AMD3 - 2: 9:25 ***Invited*** **Highly Reliable Oxide Thin Film Transistors for Flexible Devices**

Y. Uraoka, J. P. S. Bermundo, M. Fujii, Y. Ishikawa

NAIST, Japan

Oxide TFT were investigated for flexible display. Fluorinated SiN gate insulator greatly improved reliability of oxide TFT under bias stress. Excimer laser annealing was performed for the TFT with siloxane passivation for low temperature annealing. Amorphous InZnO was fabricated by spin-coating method and Ag paste was patterned by screen print.

AMD3 - 3 9:50 **Electrical Characteristics and Stability of Bottom Gate a-InGaZnO TFTs on Flexible Substrate**

H.-W. Li, C.-F. Yang, C.-P. Chang, C.-H. Tsai, H.-H. Lu
AU Optronics, Taiwan

The bottom gate a-IGZO TFTs with different buffer layers fabricated on PI substrate was investigated. The devices characteristics would not be affected by buffer layers, while applying the plasma treatment on PI substrate. Devices show a good performance, and the threshold voltage shift is less than 1 V under bias stress.

AMD3 - 4 10:10 **Novel BTS Model and Methodology for AC-Stress-Induced Long-Term Reliability in Thin-Film Transistors**

J. Jang, K. Jeon, J. Yang, J. Park, M. Seo, Y. Yoon, K. Kim, K. Jung, Y. Kim, M. Yoo
Samsung Display, Korea

A novel BTS(Bias-Temperature-Stress) model and methodology for predicting threshold voltage shifts(ΔV_{TH}) under AC stress is firstly proposed. In order to verify this model, TFTs of the amorphous silicon gate driver integrated in a LCD panel were measured, and the proposed model has ΔV_{TH} error rate of 11.7% on average.

----- Break -----

10:40 - 11:55 **Ohmi 1**

AMD4: TFT Fabrication Technologies

Chair: H. Minemawari, AIST, Japan
Co-Chair: Y. Fujisaki, NHK, Japan

AMD4 - 1: 10:40 ***Invited*** **Organic Blend Semiconductors for High Performance Thin-Film Transistor Applications**

T. D. Anthopoulos, J. Smith, S. Hunter
Imperial College London, UK

We report the development of p-channel organic small-molecule/polymer blend-based thin-film transistors with high hole mobility. Emphasis is placed on the use of molecular p-dopants as a mean to improve the transistors' operating characteristics as well as the operating frequency of integrated circuits such as multi-stage ring oscillators.

AMD4 - 2 11:05 **Development of All Solution Processed TFT in ESL Configuration**

M. Marinkovic, S. Bom[*], T. Balster[*], K. Su, A. Merkulov, V. Wagner[*], R. Anselmann

Evonik Inds., Germany
[*]Jacobs Univ. Bremen, Germany

Liquid-phase processed metal oxide and directly patternable etch-stop materials were successfully integrated in TFTs with ESL configuration. Fabricated devices exhibit the mobility of 14 cm²/Vs, the negligible contact resistance and good electrical stability. The up-scaling feasibility of process to large substrates and integration in high-end display devices will be presented.

AMD4 - 3L 11:25 **KrF Excimer Laser Annealing of a-InGaZnO Thin-Film Transistors with Solution Processed Hybrid Passivation Layers**

J. P. S. Bermundo, Y. Ishikawa, M. N. Fujii, T. Nonaka[*], H. Ikenoue[**], Y. Uraoka

NAIST, Japan
[*]Merck, Japan
[**]Kyushu Univ., Japan

We show how KrF excimer laser annealing (ELA) can be used as a low temperature annealing process to improve the properties of passivated amorphous InGaZnO thin-film transistors. We analyzed the effect of KrF ELA on the electrical properties, physical structure, chemical bonding and composition of a-InGaZnO.

AMD4 - 4L 11:40 **High Performance and Uniformity of Poly-Si Thin-Film Transistors using Solid-Phase Crystallization on YSZ Layers by Two-step PLA Method**

L. T. K. Mai, S. Horita

JAIST, Japan

Poly-Si TFTs were fabricated by two-step PLA method on two kinds of substrates, glass and YSZ/glass. TFTs on YSZ/glass show much better performance and uniformity of device-to-device, e.g., average mobility ~80 cm^2/Vs and its standard deviation ~18 cm^2/Vs, respectively, compared with ~40 cm^2/Vs and ~28 cm^2/Vs on glass, respectively.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 15:00 **Ohmi 1**

AMD5: Oxide TFT: Applications

Chair: Y. Uraoka, NAIST, Japan
Co-Chair: M. Inoue, Huawei Techs, Japan

AMD5 - 1: 13:30 ***Invited*** **Properties of Oxide-Semiconductor TFTs under Mechanical Strain for Flexible Electronics**

P. Heremans[,***], A. de Jamblinne de Meux[*,***], B. Hou[**], A. Tripathi[**]*

[*]imec, Belgium
[**]Holst Ctr., the Netherlands
[***]Univ. of Leuven, Belgium

We report on the mechanical properties of a-IGZO transistors. We find that the charge carrier mobility of a-IGZO transistors is remarkably independent of strain. We explain these experimental results by ab-initio modeling of amorphous IGZO semiconductor material. We compare a-IGZO to covalent semiconductors, a-Si and LTPS, and to organic transistors.

AMD5 - 2: 13:55 ***Invited*** **Novel Technologies for Source and Drain Resistance Reduction in Short-Channel Self-Aligned InGaZnO Thin-Film Transistors**

K. Sakuma, K. Ota, T. Irisawa, C. Tanaka, K. Ikeda, D. Matsushita, M. Saitoh

Toshiba, Japan

We have successfully demonstrated a low-resistance source and drain (S/D) region of InGaZnO-TFT using Ar ion implantation (Ar I/I) and self-aligned metallization processes. These silicon-compatible technologies are very promising for high performance and high density InGaZnO TFT as BEOL Tr. in 3D LSIs.

AMD5 - 3 14:20 **Advanced Compensation Technologies for Large-Size UHD OLED TVs**

S. Takasugi, H.-J. Shin, M.-K. Chang, S.-M. Ko, H.-J. Park, J.-P. Lee, H.-S. Kim, C.-H. Oh

LG Display, Korea

In this paper, we present novel OLED display panel compensation technologies for large-size UHD OLED TVs considering variations of threshold voltage, mobility, channel size, OLED efficiency, and OLED uniformity. Using these technologies, we have successfully launched 55-, 65- and 77-in. UHD OLED TVs.

AMD5 - 4 14:40 **Dual-Gate Self-Aligned a-IGZO TFTs Using 5-Mask Steps**

M. Nag[,**], F. De Roose[*,**], A. Bhoolokam[*,**], K. Myny[*], A. Kumar[***], S. Steudel[*], J. Genoe[*,**], W. Dehaene[**], G. Groeseneken[*,**], P. Heremans[*,**,***]*

[*]imec, Belgium
[**]Katholieke Univ. Leuven, Belgium
[***]Holst Ctr., the Netherlands

We report a dual-gate (DG) self-aligned (SA) a-IGZO TFT process that comprises only five mask steps. The top-gate (TG) is SA which enables high speed operation. The secondary bottom-gate (BG) enables to improve parameters such as on-current (I_{ON}) and the sub-threshold slope (SS^{-1}) substantially when both gates are connected together.

----- Break -----

15:10 - 16:35 **Ohmi 1**

AMD6: Oxide TFT: Solution Processes
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: T. D. Anthopoulos, Imperial College London, UK
Co-Chair: H. Kumomi, Tokyo Inst. of Tech., Japan

AMD6 - 1: 15:10 ***Invited*** **Oxide-Channel Ferroelectric-Gate Thin Film Transistors Prepared by Solution Process**

E. Tokumitsu, T. Shimoda

JAIST, Japan

Features of oxide-channel ferroelectric-gate thin film transistors (FGTs) are presented at first. Next, some recent topics, solution process and new printing process for TFT fabrications are presented. In particular, we demonstrate sub-micron channel FGTs fabricated by solution process with newly developed nano-rheology printing (n-RP) without using conventional lithography.

AMD6 - 2: 15:35 ***Invited*** **Stable Metal Semiconductor Field Effect Transistors on Oxide Semiconductor Channels Grown via Mist-CVD**

G. T. Dang, T. Kawaharamura[*], M. Furuta[*], S. Saxena, M. W. Allen

Univ. of Canterbury, New Zealand
[*]Kochi Univ. of Tech., Japan

We demonstrate the successful production of transparent metal-semiconductor field-effect-transistors (MESFETs), using reactively-sputtered silver oxide Schottky gates on In-Ga-Zn-O, Zn-Sn-O, SnO_2, and Ga_2O_3 channels, grown by non-vacuum, solution-processed Mist Chemical Vapor Deposition (Mist-CVD). We examine the performance and stability of these devices and discuss their suitability for display applications.

AMD6 - 3
16:00

Highly Reliable All-Printed Oxide TFT of High Work-Function Metal Electrodes with Low Contact Resistance by Doped Oxide Semiconductor

Y. Hirano, S. Matsumoto, R. Saotome, Y. Sone, S. Arae, M. Kusayanagi, Y. Nakamura, N. Ueda, K. Yamada

Ricoh, Japan

We have developed all-printed TFT with high work-function metal electrodes and novel oxide semiconductor in which carriers are generated by doping technique to make good contact with the electrodes. The TFT after forming planarization layer exhibited high mobility around 10 cm^2/Vs and high reliability against bias-temperature stress and illumination tests.

AMD6 - 4L
16:20

Self-Aligned Top-Gate InGaZnO Thin-Film Transistor Fabricated at 150°C Using Coatable Organic Insulator

T. Toda, Y. Magari, M. Furuta

Kochi Univ. of Tech., Japan

We fabricated self-aligned, top-gate InGaZnO thin-film transistors (IGZO TFTs) with a coatable organic insulator, Zeocoat, at a maximum process temperature of 150˚C. The IGZO TFT with a channel protection layer showed good switching properties; saturation mobility: 10.7 cm^2/Vs, subthreshold swing: 0.19 V/dec., and hysteresis: 0.2 V.

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Special Address

Lighting the Earth by LEDs

Hiroshi Amano
2014 Nobel Laureate
Nagoya Univ., Japan

17:20 – 18:20 Wednesday, Dec. 9
Ohmi 1 (2F)

Special Topics of Interest on Augmented Reality and Virtual Reality

Wednesday, December 9

13:30 - 15:10 **Ohmi 10**

DES1: Various Visualization Technologies

Chair: Y. Oyamada, Tottori Univ., Japan
Co-Chair: T. Mitasaki, NTT, Japan

DES1 - 1: 13:30 ***Invited*** **Near-Eye Display of Light Fields**

W. Wu, I. Tosic, N. Bedard, P. Llull, K. Berkner, N. Balram
Ricoh Innovations, USA

We address processing of light field data captured using a plenoptic camera for the purpose of display on a personal near-eye display. Our technique optimizes the focal plane configuration of a multi-focal display for the captured data and produces significantly better visual quality than the uniform focal plane configuration.

DES1 - 2: 13:55 ***Invited*** **Perceptual Illusions for Multisensory Displays**

T. Amemiya
NTT, Japan

Human perceptual properties have been applied for designing multisensory display technologies. This paper overviews the sensory-illusion-based approach we have used to create a force display that elicits illusory continuous force sensation by presenting asymmetric vibrations and a self-motion display based on a cross-modal effect between visual and tactile motion.

DES1 - 3: 14:20 ***Invited*** **Duality in Computational Photography and Display**

S. Hiura
Hiroshima City Univ., Japan

Computational Photography is a new concept of imaging to offer attractive functions such as blur reduction or posterior focus adjustment by assuming the optical devices as an encoder of the light to images. In this presentation, I will introduce several basic concepts and achievements in this field.

DES1 - 4: 14:45 ***Invited*** **Augmented Reality Visualization Fusion**

Y. Oyamada

Tottori Univ., Japan

In this presentation, we introduce a new interaction in Augmented Reality applications. The interaction is to overlap/overlay multiple markers that mimics physical action such as mixing and merging several objects.

----- Break -----

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

9:00 - 10:45 **Ohmi 8**

INP3: AR and Interactive Systems

Chair: M. Sato, MIT Media Lab, USA
Co-Chair: N. Hashimoto, Citizen Holdings, Japan

INP3 - 1: 9:00 ***Invited*** **Development of a TV System Augmented Outside the TV Screen**

H. Kawakita[,**], M. Uehara[*], T. Nakagawa[*], M. Sato[**]*

[*]NHK, Japan
[**]Tokyo Inst. of Tech., Japan

We advocated "Augmented TV" that gives an appearance of connecting the onscreen world, captured by the TV camera, to the real world in front of the TV screen. To realize the goal, we have developed AR system for TV video images, which is characterized by smoothness of the connecting representation.
Also presented in Innovative Demonstration Session (see p. 208)

INP3 - 2: 9:25 ***Invited*** **Disappearing Touchscreens: Making the World Interactive without Instrumenting It**

M. Sato[,**]*

[*]MIT Media Lab, USA
[**]Univ. of Tokyo, Japan

Interaction with physical objects and information in the real world is becoming increasingly important. However, conventional methods require adding physically complex touch sensors or tags. In this paper, we discuss several approaches to make the world more interactive without any need for these technical implementations.

INP3 - 3: 9:50 ***Invited*** **Haptic Technologies for Surface Interaction**

H. Kajimoto

Univ. of Electro-Commun., Japan

As the touch panel does not have physical cues such as bumps and edges of a keyboard, applying haptic (tactile) display technology to the touch panel was studied intensively. This talk introduce current trends of haptic interface for surface interaction, as well as our recent studies on electro-tactile displays.

INP3 - 4L 10:15 **Demonstration of Interactive 3D Display Using Holographic Screen and Consumer-Use 4K Projector**

T. Nakamura, S. Sakurai, S. Igarashi, M. Yamaguchi

Tokyo Inst. of Tech., Japan

We previously proposed an interactive 3D display, which is based on a transparent holographic screen and a projector-camera system. In this report, we demonstrate the interactive 3D display with improved 3D image quality using a holographic screen and a consumer-use 4K projector whose pixel count is 4096×2160.

INP3 - 5L 10:30 **Character Recognition System Using Cellular Neural Network Suitable for Integration on Electronic Displays –Development of Simulator and Evaluation of Operation–**

T. Kameda[*], M. Kimura[,**], Y. Nakashima[*]*

[*]NAIST, Japan

[**]Ryukoku Univ., Japan

We are developing cellular neural networks that might be suitable for integration on electronic displays. In order to decide best architecture of the neural networks, we developed a character recognition simulator. We confirmed that the neural networks can learn multiple characters.
Also presented in Innovative Demonstration Session (see p. 208)

----- Break -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

13:40 - 15:40 **Ohmi 6**

Poster **DESp2: Image Processing for Augmented Reality**

DESp2 - 1L **AR Marker Available on Foldable Surfaces**

H. Sasanuma, Y. Manabe, N. Yata

Chiba Univ., Japan

This paper is focused on marker-based AR technology. Existing AR markers are almost available on only flat surface. Therefore, this paper proposes an original AR marker design and processing method that can recognize the marker on the foldable and cylindrical surface.

----- Break -----

Friday, December 11

9:00 - 10:20 **Ohmi 9**

3D4/VHF6: Autostereoscopic and Head-Mounted Displays

Chair: Y. Takaki, Tokyo Univ. of A&T, Japan
Co-Chair: S. Uehara, Toshiba, Japan

3D4/ VHF6 - 1 9:00 **HaptoMIRAGE: An Active-Shuttered Real Imaged Auto-Stereoscopic Display**

Y. Ueda, H. Nii[*], K. Minamizawa, S. Tachi[**]

Keio Univ., Japan
[*]IIJ Innovation Inst., Japan
[**]Univ. of Tokyo, Japan

HaptoMIRAGE is an auto-stereoscopic display that does not require the viewer to wear devices like 3D glasses. it is convenient to produce content such that real objects and 3D virtual objects are combined. Furthermore, multiple users can share the 3D view from their respective viewpoints.

3D4/ VHF6 - 2 9:20 **Dual Orthogonal Flat Panel Autostereoscopic Display Using Visible Gap Contraction Prism**

H. Imai, N. Takanashi

NEC, Japan

We have developed a dual orthogonal flat panel autostereoscopic display using visible gap contraction prism. Since the prism contracts the visible gap region between two orthogonal panels optically, it is possible to diminish visual discomfort for viewer in observing stereoscopic images.

3D4/ VHF6 - 3 9:40 **Sense of Height and Virtual Body in Head-Mounted Display Environments**

T. Shibata, T. Inoue[*]

Tokyo Univ. of Social Welfare, Japan
[*]Kanagawa Inst. of Tech., Japan

When using a head-mounted display, we cannot see our own body. We conducted an experiment to evaluate effects of virtual body on the user's sense of height and fear of heights. The results showed that the virtual body increased the user sense of height slightly and fear of heights significantly.

3D4/ VHF6 - 4 10:00 **Development of Poor Man's 3D-AR Platform for Amateur Game Creators**

Y. Yoneda, E. Dong, T. Fujita, H. Kiriyama, K. Takemura, K. Iwasaki, R. Urushihara, T. Ichii*

Tokyo Inst. of Tech., Japan
**Ochanomizu Univ., Japan*

For 3D-AR by amateur creators, development of a low-cost and easy to use platform is necessary. The system should be composed of low-cost devices such as tablet-PCs and USB-cameras. However, the performance of each device is low. We'll show the way to cover the performance by combination of available sensors.
Also presented in Innovative Demonstration Session (see p. 206)

----- Break -----

10:40 - 12:00 **Ohmi 9**

3D5: 3D/Hyper-Realistic Display Systems

Chair: H. Sasaki, NICT, Japan
Co-Chair: M. Tsuchida, NTT, Japan

3D5 - 1: 10:40 ***Invited*** **2D/3D Compatible Microstereopsis Display Using Patterned Retarder 4KTV**

Y. Kuroki

Comfort Vision Res. Lab., Japan

The effectiveness of good depth perception with microstereopsis video images of a 4KTV with patterned retarders was confirmed. This enables group viewing by persons wearing and without 3D-glasses. This development will lead toward the wide use of 2D/3D compatible motion images with low cost at high resolutions such as 8K.

3D5 - 2: 11:00 ***Invited*** **See-Through Three-Dimensional Displays with Motion Parallax for Precise Image Superposition**

Y. Takaki

Tokyo Univ. of A&T, Japan

See-through displays can render digital information on real scenes. When see-through displays provide three-dimensional (3D) images having motion parallax, 3D images can be precisely superimposed on real objects. Two see-through displays with motion parallax are demonstrated: the super multi-view windshield display and the see-through integral imaging display.

3D5 - 3: 11:20 ***Invited*** **See-Through Projection System**

T. Higuchi, T. Yoshikawa, K. Hashikawa, M. Akagi, T. Yoshizawa, K. Iwawaki, Y. Ito, H. Kogoma, N. Saegusa

Pioneer, Japan

We developed a new display system, “See-through projection system”, consist of a projector and a transparent screen. Our system can be seen both bright images on the screen and the background images through the screen. We introduce applications of See-through projection system.

3D5 - 4: 11:40 ***Invited*** **Floating Image Display Based on a Dihedral Corner Reflector Array**

Y. Maeda

Parity Innovations, Japan

A floating image display using a dihedral corner reflector array, which forms distortion-free real image based on retro-reflection, and its applications are introduced as a future multimedia device. In one instance, an observer can see a floating image by the naked eye and manipulate it by touching the floating image.
Also presented in Innovative Demonstration Session (see p. 206)

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

15:10 - 16:10 **Ohmi 9**

FMC5: Augmented Reality and Virtual Reality

Chair: K. Käläntär, Global Optical Solutions, Japan
Co-Chair: I. Amimori, LLC SN Partners, Japan

FMC5 - 1: 15:10 ***Invited*** **Real-Time Dynamic Holographic 3D Display in Materials to Future Holographic 3D Televisions**

H. Gao, J. Liu, C. Zeng, Q. Yao, P. Liu, Y. Yu, H. Zheng, Z. Zeng

Shanghai Univ., China

We have realized real-time dynamic holographic 3D display in materials, which makes it possible to build large-size, high resolution, and video rate true 3D television or projector. In this talk, we will present property of our holographic display materials and their applications in future 3D displays.

FMC5 - 2: 15:30 ***Invited*** **Aerial Three-Dimensional Display Based on Retro-Reflective Optical Imaging**

D. Miyazaki, Y. Maeda[*], S. Onoda, Y. Tokubo, S. Murakami, R. Tamaki, T. Mukai

Osaka City Univ., Japan
[*]Parity Innovations, Japan

Imaging with a retro-reflective optical element can provide floating image formation with a wide view angle, because it has low-distortion in spite of high numerical aperture. Three-dimensional display technologies based on retro-reflection with mirror arrays, a dihedral corner reflector array and a roof mirror array are described.
Also presented in Innovative Demonstration Session (see p. 205)

FMC5 - 3 15:50 **Polarization State Analysis for Polarized Aerial Imaging by Retro-Reflection (PAIRR)**

M. Nakajima[*], K. Onuki[*], I. Amimori[**], Y. Hirotsugu[,***]*

[*]Utsunomiya Univ., Japan
[**]LLC SN Partners, Japan
[***]JST, CREST, Japan

This paper investigates polarization state of the reflected light from retro-reflector in order to improve the brightness of the polarized aerial imaging by retro-reflection (PAIRR). We have confirmed the importance of the effective reflectance. Then, we have found one of the suitable prism type reflector for the PAIRR.

----- Break -----

16:50 - 18:20 **Ohmi 10**

PRJ6: Wearable Applications

Chair: S. Shikama, Setsunan Univ., Japan
Co-Chair: S. Ouchi, Hitachi, Japan

PRJ6 - 1: 16:50 ***Invited*** **High-Luminance See-Through Eyewear Display with Novel Volume Hologram Waveguide Technology**

S. Nakano, T. Oku, K. Akutsu, M. Kuwahara, T. Yoshida, E. Kato, K. Aiki, I. Matsumura, A. Machida, H. Mukawa

Sony, Japan

We have developed a see-through eyewear display with novel volume hologram waveguide. The waveguide has two in-coupling and one out-coupling reflection holograms. This technology enables to achieve high-luminance (1000 cd/m^2) and high-uniformity (70%) characteristics, which is indispensable for augmented reality applications in various environments.

PRJ6 - 2: 17:15 ***Invited*** **Augmented Vision for Minimally Invasive Surgery**

T. Nakaguchi

Chiba Univ., Japan

Laparoscopic surgery is one of the most important trends in modern medicine. It, however, makes the surgical procedure much difficult and risky. Since augmented reality (AR) technologies have a potential to address these problems, we will present current situation and future problem of the projector-based AR system in Medicine.

PRJ6 - 3 17:40 **A Head Mounted Display Using the Original Flexible Arm and Headband**

M. Watanabe, Y. Fukuda, M. Yagi, H. Ishizaki, M. Nakanishi[*], N. Hanafusa[**], T. Katano

Brother Inds, Japan
[*]Keio Univ., Japan
[**]Univ. of Tokyo Hospital, Japan

We have developed a Head Mounted Display “HMD” using the original flexible arm and headband. Users of this HMD can place the display at the free position. The feasibility test of this HMD on ultrasound guided vascular access puncture confirmed good operability.
Also presented in Innovative Demonstration Session (see p. 207)

PRJ6 - 4L 18:00 **An Applied Method for Wearable Device with Assortment Work in Logistics**

T. Fujiwara, T. Kosaka, T. Matsuda, Y. Nakajima, T. Sakurada[*], T. Ozaki

Hitachi, Japan
[*]Hitachi Transport Sys., Japan

Wearable device attracts many companies. Logistics department especially expects it because getting advantage of hands-free. In this study, we adapted wearable device to assortment work in logistics and evaluated cost cut effect in comparison with current method. As the result of evaluation, cost cut effect is approximately 15%.

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Special Topics of Interest on Lighting Technologies

Wednesday, December 9

15:10 - 16:45 **Ohmi 1**

OLED2: OLED for Lighting Applications

Chair: Y. Kijima, JOLED, Japan
Co-Chair: H. Kuma, Idemitsu Kosan, Japan

OLED2 - 1: *Invited* Recent Advances in OLED Lighting
15:10

M. Boesing, F. Lindla, A. Koehnen, V. Gohri, M. Ruske*, S. Hartmann, E. Meulenkamp**

Philips Business Ctr. OLED Lighting, Germany
**OLEDWorks, USA*

In this work we present our most recent advances w.r.t. OLED lighting panel performance: By employing a new (improved) device structure in combination with an internal light extraction concept and a highly reflective top contact, we are able to drastically increase light extraction efficacy of the panel.

OLED2 - 2
15:30 **Blue Light Efficiency Enhancement of OLED by Thin Film Included Micro-Particles and Copper Sulfate Solution**

C.-H. Chiu, W.-C. Chien, C.-H. Chien*, Y.-H. Chen**

Chunghwa Picture Tubes, Taiwan
**Tatung Univ., Taiwan*

Copper sulfate solution and PDMS were used as the base material of optical film. Two kinds of micro metal oxide particles were chosen to be doped into the optical film. The optical thin film attached to the OLED can enhance 77% blue light intensity and increase color temperature of 550 K.

OLED2 - 3
15:50 **High Efficient and Stable Quantum Dots Film with Interdiffused Structure as Down-Conversion Material Utilized in Blue Organic Light Emitting Diode for Solid-State Lighting Application**

V. Arasu, D. Jo, B. Kim, H. Chung

Sungkywnkwan Univ., Korea

QDs Down-conversion film with thin, efficiently dispersed, non-agglomerated were fabricated by 'Polymer-free Nanoparticles Adhesion Technique'. The achieved down-conversion enhancement were 15% The major focuses were on development of high photoluminescence (91%), nearly zero interface and Interdiffused-core/alloy/shell structure QDs materials synthesized by simple and reproducible one-pot hydrothermal injection method.

OLED2 - 4
16:10 **Fabrication of High Efficiency Color-Conversion Layer for Hybrid OLED Lighting**

B. Kim, D. Jo, D. Yoon, H. Chung
Sungkyunkwan Univ., Korea

Hybrid OLED has been used with blue OLED and giving color changing layer to generate the white emission. In order to achieve high CRI and efficiency, we have developed facile and efficient fabrication method for color conversion layer, called as Adhesive Transfer, yielding the high packing density and out-coupling efficiency.

OLED2 - 5L
16:30 **Soluble Bipolar Red Host Material for Solution Processed Organic Light Emitting Diodes**

S.-R. Park, Y.-R. Cho, M. C. Suh
Kyung Hee Univ., Korea

We have fabricated highly efficient red phosphorescent organic light emitting diodes (OLEDs) by solution process combined with thermally evaporated blue common layer structure. To obtain high performances, we designed and synthesized a new bipolar host material with benzocarbazole and triphenyltriazine moieties (11-[3-(4,6-diphenyl-[1,3,5]triazin-2-yl)phenyl]-11H-benzo[a]carbazole, RH).

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

9:00 - 10:25 **Ohmi 2**

PH1: Phosphors for Lighting Application

Chair: A. Meijerink, Utrecht Univ., the Netherlands
Co-Chair: K. Wani, TAZMO, Japan

PH1 - 1:
9:00 ***Invited*** **High Directional LED Lighting for Forming Pattern, HOLOLIGHT: Its Business Developments and Prospects**

T. Ikeda
Pi Photonics, Japan

HOLOLIGHT is a unique patented LED lighting for forming pattern comprising square, round, line and arch. They have a lot of applications for inspection, stage, architecture, road, safety, art, sightseeing, laboratory, entertainment and so on.
Also presented in Innovative Demonstration Session (see p. 205)

PH1 - 2: 9:25 ***Invited*** **The GE TriGain Phosphor Based upon $K_2SiF_6:Mn^{4+}$ and Its Use in LED Lighting and LCD Backlights**

A. A. Setlur, F. Garcia, J. E. Murphy, S. P. Sista
GE Global Res., USA

Narrow-emitting downconverters, like GE's TriGain $K_2SiF_6:Mn^{4+}$ phosphor, improve both brightness and color quality for general lighting and LCD backlights. We discuss the performance of TriGain phosphors, focusing on how better phosphor chemistry gives higher efficiency, reliability, and lower phosphor usage. TriGain phosphors are commercially available from GE Lighting.

PH1 - 3 9:50 **The Synthesis, Characterisation and Potential of Eu^{3+} Doped Molybdate Phosphors for White Light Emitting Diodes**

A. Lipman, M. Fathullah, R. Stone, G. R. Fern, T. G. Ireland, C. Frampton, J. Silver
Brunel Univ. London, UK

A wide variety of Eu^{3+} doped molybdate phosphors were synthesised using the solid state reaction route and their photoluminescent properties were compared. Their crystal structures were investigated. A relationship between cell size and emission intensity was apparent. The implications of this for phosphor design are discussed.

LIT

PH1 - 4L 10:10 **White LEDs Using Sharp β-sialon:Eu Phosphor and $K_2SiF_6:Mn$ Phosphor for Wide-Color Gamut Display Application**

K. Yoshimura, H. Fukunaga, M. Izumi, M. Masuda, T. Uemura, K. Takahashi, R.-J. Xie*, N. Hirosaki**
Sharp, Japan
**NIMS, Japan*

Sharp β-sialon:Eu ($Si_{6-z}Al_zO_zN_{8-z}$:Eu $0<z<0.1$) green phosphor is suitable for wide-color gamut white LEDs backlighting system because of its sharp and asymmetric emission spectrum shape. In this work, red phosphors are investigated for the purpose for improvement of the display color gamut.

Also presented in Innovative Demonstration Session (see p. 206)

----- Break -----

10:30 - 12:30 **Ohmi 6**

Poster **PHp2: Phosphors for Lighting Application**

PHp2 - 1 **The Enhancement on Photoluminescence Characteristics of $Ba_{1-x}ZrSi_3O_9:xEu^{2+}$ Phosphors by Sr^{2+}Substituting**

K.-C. Cheng, C.-H. Chiang, T.-S. Zhan, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this article, single-phase $Ba_{(1-x)}ZrSi_3O_9:xEu^{2+}$, Sr^{2+} phosphors were synthesized via the solid-state reaction method. The crystal structure and luminescence properties were investigated using X-ray diffraction and photoluminescence measurements, respectively. An increase of the dopant Sr^{2+}, increased the emission intensity of the phosphors.

PHp2 - 2 **Effects of Fluxes on Luminescent Properties of YAG:Ce Phosphors and Their Application to White Light-Emitting Diodes**

C.-H. Chiang, T.-S. Zhan, K.-C. Cheng, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this work, the dependence of amount of the fluxes (H_3BO_3 and BaF_2) on the luminescence of $Y_{2.95}Al_5O_{12}:0.05Ce^{3+}$ phosphors and their application to white light-emitting diodes were investigated. The difference in luminescent properties of phosphor prepared with BaF_2 and H_3BO_3, was well explained by the powder morphology.

PHp2 - 3 **High Directivity Light Source Based on Photonic Crystal Structure**

C. C. Chiu, F.-L. Hsiao

Nat. Changhua Univ. of Education, Taiwan

The light-emitting diodes(LED) have been widely applied in projector displays and backlight. Especially, 3D display need highly directional and High brightness light source. Some research also proved to limit the light in specific area with the characteristics of photonic crystal band gap so as to enhance the light extraction rate.

PHp2 - 4 **Synthesis and Luminescent Properties of Novel Ce^{3+}- and Eu^{2+}-Doped $La_3Br(SiS_4)_2$ Bromothiosilicate Phosphors for White LEDs**

S.-P. Lee, T.-M. Chen

Nat. Chiao Tung Univ., Taiwan

Novel Ce^{3+}- and Eu^{2+}-doped $La_3Br(SiS_4)_2:Ce^{3+}/Eu^{2+}$ bromothiosilicate phosphors were prepared in a sealed ampule. The $La_3Br(SiS_4)_2:Ce^{3+}$ phosphor is excitable at 370 to 400 nm and generates a cyan emission, and the $La_3Br(SiS_4)_2:Eu^{2+}$ phosphor can be excited over a broad range from UV to blue and generates a red broadband emission.

----- Lunch -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

IDW Best Paper Award

IDW Outstanding Poster Paper Award

These awards will go to the most outstanding papers selected from those presented at IDW ’15.
The 2015 award winners will be announced on the IDW website: http://www.idw.or.jp/award.html

Quantum Dots Sessions

PHp	10:30 – 12:30	Thursday, Dec. 10
	Ohmi 6 (Poster)	
MEET1	16:05 – 17:25	Thursday, Dec. 10
PH3	9:00 – 10:00	Friday, Dec. 11
MEET5	16:50 – 18:20	Friday, Dec. 11
	Ohmi 8 (Oral)	

Special Topics of Interest on Printed Electronics

Thursday, December 10

13:40 - 15:40 **Ohmi 6**

Poster **FLXp3: Flexible Electronics 3**

FLXp3 - 1 **Development of Novel Primer Material Suitable for COP Film and Ag Nano-Ink**

T. Yamate[,**], E. Mieda[*], K. Kumazawa[*], H. Suzuki[*], M. Akazome[**]*

[*]Nippon Soda, Japan
[**]Chiba Univ., Japan

We have developed a unique organic-inorganic hybrid coating agent suitable for a primer which connects Ag nano-ink to COP film. This material forms the glass-like surface on the topmost surface of the hybrid layer after UV irradiation. Therefore, Ag nano-ink can adhere strongly with glass-like surface.

FLXp3 - 2L **Flexible Glass Substrate on Roll to Roll Gravure Off-Set Printing Process**

K.-T. Kuo, S. M. Garner, J.-C. Lin, P.-L. Tseng, S.-M. Lin, M.-H. Huang, R. L. Smith, T. H. Chou[*], C. W. Hsieh[*], Y. M. Wang[*], S. Yang[*], K. G. Wang[*], H. Y. Lin[*]

Corning, USA
[*]ITRI., Taiwan

Glass enables high-quality and long-life devices compared to plastic in electronics industry. The ultra-slim flexible glass also allows for new device designs and continuous manufacturing enabled by roll-to-roll (R2R) processes. This paper describes how gravure off-set printing applied to R2R process and made functional touch sensors on ultra-slim flexible glass.

FLXp3 - 3L **Control and Improvement of Electrical Performance of Solution-Processable Organic Transistors by Spin Coating from Mixed Organic Solvents**

R. Nakamichi[*], T. Nagase[,**], T. Kobayashi[*,**], Y. Sadamitsu[***], H. Naito[*,**]*

[*]Osaka Pref. Univ., Japan
[**]The Res. Inst. for Molecular Elect. Devices, Japan
[***]Nippon Kayaku, Japan

We have developed a simple method to control and improve the electrical characteristics of solution-processable OTFTs based on dialkylbenzothienobenzothiophenes by using mixed organic solvents. Top-gate OTFTs processed by spin coating from mixed non-halogen solvents exhibit high average field-effect mobility of 8.4 $cm^2V^{-1}s^{-1}$ and low threshold voltage of −0.18 V.

Friday, December 11

9:00 - 10:00 **Ohmi 2**

OLED4: Advanced OLED Technologies II

Chair: T. Komatsu, JOLED, Japan
Co-Chair: T. Fukuda, Saitama Univ., Japan

OLED4 - 1
9:00

Solution-Processed All Phosphorescent Small Molecule White Multi-OLED System

K. Oikawa, T. Iwasaki, T. Tsujimura, Y.-J. Pu[*], T. Chiba[*], S. Ohisa[*], J. Kido[*]

Konica Minolta, Japan
[*]Yamagata Univ., Japan

White light emitting multi-OLED with small-molecule all-phosphorescent system comprising two light emitting units and a charge generating layer (CGL) has been successfully developed for the first time in the world. In this paper, our proprietary solution-based process technologies, especially small-molecule phosphorescent materials and layer stack design technologies, will be discussed.

OLED4 - 2
9:20

Novel Materials for Highly Efficient Long-Lived Solution-Processed Phosphorescent Red OLED Devices

A. Hayer, P. Stoessel, N. Koenen, H. Heil, P. Levermore, B. Burkhart, K. Stegmaier, E. Böhm, H. Buchholz

Merck KGaA, Germany

We demonstrate highly efficient, long-lived ink-jet printable red phosphorescent materials. We show a series of new red emitters with high photoluminescence quantum efficiency, narrow spectra, excellent stability and very good printability. We further improve device performance by developing adapted hole transport layers.

OLED4 - 3
9:40

OLED Dry Film Uniformity Compensation by Inkjet Process

C.-Y. Lin, C.-Y. Lo

Nat. Tsing Hua Univ., Taiwan

Dry-film uniformity issue from wet-processed OLED because of the coffee-ring effect was improved by compensating the first inkjet-printed PEDOT:PSS with a second inkjet-printed one. Compensation volume, drop arrangement, and printing sequence were studied for optimized and improved film uniformity in this work.

----- Break -----

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 14:40 **Ohmi 2**

FLX4: Flexible Printed Electronics

Chair: T. Sekitani, Osaka Univ., Japan
Co-Chair: M. Ito, Toppan Printing, Japan

FLX4 - 1: 13:30 ***Invited*** **Exploring Low-Dimensional Charge Transport Phenomena in Solution-Processed Metal Oxide Superlattice Transistors**

Y. H. Lin, K. Zhao[*], R. Li[**], A. Amassian[*], T. D. Anthopoulos
Imperial College London, UK
[*]King Abdullah Univ. of S&T, Saudi Arabia
[**]Cornell Univ., USA

We report on metal oxide superlattice systems grown from solution and their use in high electron mobility transistors. On the basis of temperature-dependent electron transport measurements and carrier distribution evaluation, we argue that the enhanced performance arises from the presence of 2-dimensional electron gas-like systems formed at the oxide-oxide heterointerfaces.

FLX4 - 2: 13:55 ***Invited*** **Fluorophilicity as Selection Criterion of Solvents for Printed Organic Electronics**

Y. Kuwana, T. Abe, N. Shirota, T. Sakurada, M. Obi
Asahi Glass, Japan

We investigated the deterioration of carrier mobility of organic thin film transistors after immersing into various solvents containing fluorine. The deterioration was correlated with the fluorophilicity, the partition ratio between solvents containing fluorine and without fluorine. The fluorophilicity will be a useful parameter for screening the process solvent.

FLX4 - 3 14:20 **Highly Stable Transparent Conductive Coatings on Ultra-Thin Glass for Flexible Devices**

M. Junghaehnel, S. Weller, T. Gebel[*], W. Skorupa[**], T. Schumann[**]
Fraunhofer, Germany
[*]DTF Tech., Germany
[**]Helmholtz-Zentrum Dresden-Rossendorf, Germany

Ultra-slim flexible glass is an emerging flexible substrate material for flexible displays, devices or lighting. 100 μm thick flexible glasses with a maximum dimension of 250 x 300 mm² were deposited with ITO and IZO at room temperature. The films were refined by in-line flash lamp annealing in the millisecond time range.

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Workshop on LC Science and Technologies

Wednesday, December 9

13:30 - 14:55 **Ohmi 9**

LCT1: Fascinating High Resolution Panel Technologies

Chair: S. Ishihara, Osaka Inst. of Tech., Japan
Co-Chair: A. Kubono, Shizuoka Univ., Japan

LCT1 - 1: 13:30 ***Invited*** **The Latest IPS LCD Technology Realizing Super High Resolution and Wide Color Gamut**

I. Hiyama, R. Oke, K. Miyazaki, J. Maruyama, N. Sato, T. Kato, A. Hirota

Panasonic Liquid Crystal Display, Japan

We applied the unique pixel driving technology by a-Si TFT to 55-in. 8K4K panels and have achieved super high resolution and wide color gamut in the world's smallest size. This brings a new level of performance for the professional applications such as medical, broadcast and special industrial displays.

LCT1 - 2 13:55 **Reflective Color LCDs with High Image Quality Using LTPS TFTs in Low Frequency Driving**

H. Yamaguchi, Y. Kawata, Y. Matsuura, M. Akiyoshi, K. Takebayashi, T. Sano, A. Murayama, Y. Fukunaga, M. Tamaki, M. Mitsui, N. Takasaki, T. Nakamura, Y. Aoki, H. Hayashi

Japan Display, Japan

Image persistence and flicker are major issues for low frequency driving. Detailed investigation of the mechanism that produced these phenomena enabled us to reduce them to acceptable levels. We successfully developed a 7.0-in. WUXGA (1200×RGBW×1920) reflective color LCD driven by low temperature poly-silicon (LTPS) TFTs at 1Hz.

LCT1 - 3 14:15 **High Resolution Display Solution with LTPS Technology**

C. P. Xiang, Z. D. Zhang, H. Wu, Y. Z. Ma, B. P. Liu, B. Z. Liu, L. Wen, X. F. Zhou, B. P. Shen, J. Y. Li, Z. H. Zeng

Xiamen Tianma Microelect., China

The resolution of smartphone display will be increased to satisfy the demand of high performance. In this paper, we indicate the challenges of high resolution display: lower luminance, poor chromatism and serious technology process control; figure out the solutions and show the LCD display with a resolution of 847 ppi.

Also presented in Innovative Demonstration Session (see p. 205)

LCT1 - 4 **High Performance Active-Matrix Transparent Display**
14:35 **by PDLC and High Transmittance Backlight Module**

C.-H. Chen, C.-W. Su, J.-T. Lien
Chunghwa Picture Tubes, Taiwan

In this paper, we have succeeded to develop a 6.1-in. transparent LCD by using polymer-dispersed liquid crystal and high transmittance backlight module technology, which transmittance can be achieved 20% upward. In addition, there are some advantages, such as, polarizer free, driving voltage satisfied with active-matrix TFT, and so on.

----- Break -----

15:10 - 16:10 **Ohmi 9**

LCT2: Advanced LC Materials

Chair: I. Hiyama, Panasonic Liquid Crystal Display, Japan
Co-Chair: F. Araoka, RIKEN, Japan

LCT2 - 1 **Oligothiophene-Based Chiral LC Semiconductors:**
15:10 **Circularly Polarized Light Emission and Anomalous Photovoltaic Effect**

M. Funahashi, T. Hamamoto, Y. Funatsu, A. Seki
Kagawa Univ., Japan

Conventional organic semiconductors including liquid crystalline semiconductors are achiral. And conventional chiral LC compounds are not electroactive. In this presentation, we report circularly polarized light emission and luminescence color tuning from the N* phase of phenylterthiophene dimers and anomalously photovoltaic effect in the SmC* phase of phenylterthiophene derivatives.

LCT2 - 2 **Withdrawn**

LCT2 - 4L **Enhancing Azimuthal Anchoring for IPS and FFS**
15:30 **modes by Polymer Surface Stabilized Method**

K. Obayashi, H. Ozeki, Y. Iimura
Tokyo Univ. of A&T, Japan

To reduce the image sticking, we use a polymer surface stabilized method to enhance surface anchoring for a photo-alignment method. The method is applied not only to IPS, but also to FFS. The results are discussed by considering the differences surface electric field distribution for the two modes.

LCT2 - 3
15:50 **Gradual Transition from Ferroelectric to Antiferroelectric LC Phase for Binary Mixture System**

Z. Feng, K. Ishikawa
Tokyo Inst. of Tech., Japan

Phase transition of ferroelectric MC452 and antiferroelectric MC881 mixtures were measured by an improved simultaneous method. We confirmed the most easily deformable region in the Electric field and Temperature contour diagram of electric-field-induced birefringence arises from the divergence of helical pitch, which can be used in novel display technologies.

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

10:30 - 12:30 **Ohmi 6**

Poster LCTp1: Display Evaluations

LCTp1 - 1 **Improving L0 Leakage of LCD Panel with COA Structure by Optimizing Through Hole Profile of Color Filter and Shape of Second Metal**

J. Li, H. H. Chen, Y.-J. Lee
Shenzhen China Star Optoelect. Tech., China

Two methods have been carried out to improve the L0 leakage of LCD panel with the structure of COA: tuning the hole profile of RGB color filter, and redesigning the shape of second metal layer (M2). The result show that the L0 leakage was substantially improved.

LCTp1 - 2 **Research Gamma Curve of VA Mode and ADS Mode in Oblique Direction**

Y. Y. Qu, H. L. Zhang, H. B. Zhao, T. Dong, F. F. Wang, S. M. Lee, D. Wang, X. B. Shao
BOE Display Tech., China

Our experimental results show the difference of gamma curve in ADS mode and VA mode, Especially in the high gray scale, and analyze the cause.

LCTp1 - 3 **Analysis of the Flicker Shift of Advanced Super Dimension Switch Mode TFT-LCD**

C. Chen, S. Wang, Z. Zhang, H. Chu, J. Ma, J. Zhang, K. H. Park, Y. B. Lee, C. Che, S. K. Lee
BOE HF, China

We investigated the flicker shift behavior of ADS (Advanced Super Dimension Switch) mode TFT-LCD with different LC and PI. For the precisely explain the flicker shift behavior in different LC and PI test split, the residual DC Discharge characteristic was studied.

LCTp1 - 4 **Research of Optical Performance about TFT-LCD with Different Array Layer Combinations**

Z.D. Zhang, B.Y. Zheng, L. Wu, B.P. Shen, C.H. Tseng

Xiamen Tianma Microelect., China

We have developed different array layer combinations through simulation and experiment, in case of the device electrical performance, aimed to receive a perfect array layer combination .The combination have good optical performance in chromaticity, JNCD, view-angle and also have large margin in manufacturing process to achieve high yields.

10:30 - 12:30 **Ohmi 6**

Poster **LCTp2: Innovative Technology for Surface/Interface Control**

LCTp2 - 1 **Photoinduced In-Plane Alignment of Nematic LCs Doped with Photoalignable Composite Materials**

N. Kawatsuki, Y. Hashimoto, M. Kondo, T. Sasaki[*]*, H. Ono*[*]

Univ. of Hyogo, Japan

[*]Nagaoka Univ. of Tech., Japan

Photoalignment of low-molecular-liquid crystalline (LC) cell is explored without surface treatment of the substrates. A linearly polarized (LP) light exposure to a LC cell containing nematic LCs and a small amount of photoresponsive material generates homogenous LC orientation of the cell. Material design, mixture ratio and exposure condition are investigated.

LCTp2 - 2 **Two-Band Photo-Alignment Method for High Speed TN-LC Cell**

K.-W. Park, B.-J. Mun, J. H. Lee[*]*, B. K. Kim*[*]*, H. C. Choi*[*]*, G.-D. Lee*

Dong-A Univ., Korea

[*]LG Display, Korea

We proposed the high speed twisted nematic (TN) liquid crystal (LC) cell on the photosensitive polyimide (PI) embedded with reactive mesogens (RMs) by applying two-bend separated UV exposure method. Demonstration for electro-optical properties is performed by experiments and we finally confirmed the enhanced response time of photo-aligned TN LC cell.

LCTp2 - 3 **The Study of Pre-Tilt Alignment with Different Photo-Reactive Side Chains in Surface-Controlled VA Mode**

R. Zhao[*], C.-C. Hsieh[*], Y. Zhao[*], Y. Song[*], X. Li[*], C.-Y. Chiu[*], C.-Y. Lee[*], A. Lien[,**]*

[*]Shenzhen China Star Optoelect. Tech., China
[**]TCL Corporate Res., China

Surface-controlled vertical alignment is an upgrading method of PS-VA. In this study, we use reactive mesogen as side chains of polyimide and adopt UV curing process to investigate the pre-tilt alignment of liquid crystal. The pre-tilt formation and reliability performance of different side chains are discussed, respectively.

LCTp2 - 4 **Pretilt Angle Control of LCs with Homeotropic Alignment Using Photocurable Polymer**

C.-J. Hsu, B.-L. Chen, C.-Y. Huang

Nat. Changhua Univ. of Education, Taiwan

We proposed an approach to control pretilt angle of liquid crystals(LCs) by LC/NOA65 mixture in homeotropic LC cell, which features simple fabrication process without applied voltages during exposure and less scattering because of low polymer concentration. The pretilt angle can be controlled from 90° to ~3° with various NOA65 concentrations.

LCTp2 - 5 **Zinc Oxide Films for Controlling the Pretilt Angles of LC Devices**

C.-C. Liu, J.-W. Hu, S.-C. Jeng

Nat. Chiao Tung Univ., Taiwan

The tunable pretilt angles of liquid crystal (LC) molecules aligned on the inorganic zinc oxide (ZnO) film with controllable surface wettability are demonstrated. Our experimental results show that the pretilt angles of LCs on ZnO films can be successfully adjusted over a wide range.

LCTp2 - 6 **Random Alignment of Nematic LC on Graphene Films and the Electro-Optical Characteristics**

A. Nakamura, T. Nakagaki, A. Kubono

Shizuoka Univ., Japan

Fast response and a wide viewing angle of a liquid crystal display were achieved using a graphene CVD film as one of the electrodes. The high performances were associated with the specific alignment.

LCTp2 - 7 **Film Substrate Which Needs No Alignment Layer for LC Molecules**

T. Araishi, Y. Yoshida, Y. Kimura, S. Ishihara

Osaka Inst. of Tech., Japan

We have been investigating different film compositions for a flexible film substrate that does not need an alignment layer. In this study, we investigated factors that influenced the LC alignment on the film and demonstrated a good switching behavior in IPS mode film LCDs.

10:30 - 12:30 **Ohmi 6**

Poster **LCTp3: Optical Elements for Phase Control**

LCTp3 - 1 **The Optical Characteristic of a Polarization-Dependent Diffuser Based on NOA65-Doped E7**

W.-K. Lin, W.-C. Su

Nat. Changhua Univ. of Education, Taiwan

A polarization-dependent diffuser is fabricated with liquid-crystal (E7) and polymer (NOA65). In this study, the optical characteristic of the sample is researched, and the diffuser is proved it can be a see-through screen without applied voltage.

LCTp3 - 2 **Negative Dispersion-Negative Birefringence Retarder for the Compensation Film of LCDs**

A.K. Srivastava, S. Yang, H. Lee, H. Kim, S. Yeo, J.-H. Lee

Chonbuk Nat. Univ., Korea

We demonstrated negative dispersion half and quarter wave retarders by varying the angle (ϕ) between the extraordinary axes of two negative birefringence films and their retardation values. The optimum values of ϕ for half and quarter quarter-wave retarders were 40^{o} and 70^{o} respectively for different retardation values of the films.

LCTp3 - 3L **Electro-Optical Iris Diaphragm Based on Twist Nematic Liquid Crystal Films Coating with Poly(N-Vinyl Carbazole)**

S. T. Wu, A. Y.-G. Fuh, K. N. Chen

Nat. Cheng Kung Univ., Taiwan

This study develops an electro-optical light shutter that automatically determines the optimum transmittance upon the intensities of the exposed UV lights. The film applies photoconductive polymer poly(N-vinyl carbazole) based on twist nematic liquid crystals that could be operated under a parallel/cross-polarizer to adjust the light beam/ring in optic integrated system.

LCTp3 - 4L **Mechanism of Low Driving Voltage in Polymer Stabilized Reverse Mode Cell**

K. Inoue, R. Yamaguchi

Akita Univ., Japan

A mechanism of low driving voltage of 3 V is discussed in a polymer stabilized reverse mode cell. LC dielectric constants in large and small domains are estimated and the difference of LC reorientation voltage in each domains is indicated to mainly cause a strong light scattering.

----- Lunch -----

13:40 - 15:40 **Ohmi 6**

Poster LCTp4: IPS/FFS Display Modes

LCTp4 - 1 **A Novel Method to Simulate the Flexoelectric Effect in FFS LCD**

K.-C. Chu, S.-Y. Su, H.-W. Cheng, W.-C. Tsai

AU Optronics, Taiwan

We propose a method to simulate the flexoelectric effect (FEE) in positive/negative liquid crystals. The suitable flexoelectric coefficients for FEE calculations were obtained by comparing the pixel images between experiment and simulation. Using this method, the FEE simulations agree with the previous works and look forward to the FEE improvement effectively.

LCTp4 - 2 **Withdrawn**

LCTp4 - 3 **The Chromaticity Study of the Photo Alignment IPS LC Mode**

*Y. Zhao, Y. Song, C.-C. Hsieh, R. Zhao, X. Li, C.-Y. Chiu, C.-Y. Lee, A. Lien**

Shenzhen China Star Optoelect. Tech., China

**TCL Corporate Res., China*

A new photo alignment material for in-plane switching (IPS) has been presented We have investigated the effect of the manufacturing process and material composition on the alignment ability and panel chromaticity. An excellent chromatic performance and alignment stability can be achieved by optimized the composition of photo alignment material.

LCTp4 - 4 **The Study of Transmittance of Negative and Positive LC Effect on FFS/IPS Mode**

Y. Song, Y. Zhao, R. Zhao, C.-C. Hsieh, C.-Y. Chiu, C.-Y. Lee, A. Lien**

Shenzhen China Star Optoelect. Tech., China

**TCL Corporate Res., China*

The in-plane switching (IPS) and fringe field switching (FFS) liquid crystal mode has widely application for manufacturing high performance displays due to the wide viewing angle and high resolution. In this paper, we have investigated the transmittance of negative and positive liquid crystal effect on IPS and FFS mode.

LCTp4 - 5L **Suppression of Image Flicker in a Liquid Crystal Display Under Low-Frequency Driving**

S.-W. Oh, J.-H. Park, T.-H. Yoon

Pusan Nat. Univ., Korea

In case a liquid crystal display panel is driven by a low-frequency fringe field, image flickering phenomenon can be noticeable by the naked human eye. We investigated dependence of image flicker in a homogeneously-aligned liquid crystal cell on the sign of dielectric anisotropy, electrode structure, and applied voltage waves.

LCTp4 - 6L **Design and Simulation of OC-IPS, OC-FFs, and OC-HV-FLCD Exhibiting High Speed Response**

S. Kobayashi, H. Akiyama[*]

Tokyo Univ. of Sci. Yamaguchi, Japan
[*]DIC, Japan

A designing theory and simulation of optically compensated IPS, FFS and HV-FLCD has been developed and it is shown that τ_{off} is reduced over five-fold and more by setting the angle of optical compensator, +A plate is to be $3\pi/4+\alpha$, where $\alpha = -0.10 \sim 0.12$.

LCTp4 - 7L **Micro Vision Cell Parameter Comparison of FFS Photo Alignment LCD Using High and Low Power Exposure Energy**

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

HannStar Display, Taiwan

In this paper, we analysis the cell parameter of FFS LCD which are made with the same UV dosage and different exposure power of photo alignment technology. Decomposition photo reaction type PI material and 254 nm LPUV is used. The local area of sub-pixel cell parameter are compared and be discussed.

LCTp4 - 8L **Fast In-Plane Switching of a Liquid Crystal Cell by Using Parallel Patterned Electrodes**

J. Heo, T.-H. Choi, J.-W. Huh, T.-H. Yoon

Pusan Nat. Univ., Korea

We propose a LC cell with parallel patterned electrodes for fast response time. The proposed cell shows faster response time than that of the conventional FFS mode, because of smaller optimum thickness of the LC layer. The proposed cell exhibits wide viewing angle characteristics similar to the conventional FFS mode.

13:40 - 15:40 **Ohmi 6**

Poster LCTp5: Emerging LCD Technologies

LCTp5 - 1 **Polarizer-Free LCD Having Black Dyes**

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

Polarizer-free LCDs were prepared by doping a black dye into NLCs. To evaluate electro-optical performance, we developed a 3.5-in. AM TFT transparent LCD and a 3-in. PM LCD by using black dye doped-LC technology. The obtained LCDs exhibit good optical performance, fast response times and low driving voltage.

LCTp5 - 2 **Edge Emission Patterns from an LC/Dye Cell**

S. Itaya, N. D. B. M Azumi, M. Ohta, S. Ozawa, I. Fujieda
Ritsumeikan Univ., Japan

Edge emission from an LC/dye cell is more intense in certain angular ranges. Its spectrum varies with the emission angle in a complicated manner. Some effects might be due to self-absorption and re-emission by the dye material and others might be purely optical. Further experiments will verify these speculations.

LCTp5 - 3 **A Transparent Display Based on Dye-Doped LC Technology**

J.-N. Lin, C.-W. Su
Chunghwa Picture Tubes, Taiwan

In this paper, we have succeeded to develop a 4.7-in. transparent display by using dye-doped liquid crystal (DDLC) technology. The DDLC can be achieved low operating voltage, high transmittance, and good contrast ratio. Thus, the 4.7-in. colorful transparent display by using DDLC technology has good visibility and transparency.

LCTp5 - 4 **Dual-View Blue Phase LCD**

C.-T. Hsieh, C.-H. Chang, C.-Y. Lin[*], C.-Y. Tsui[*], C.-Y. Huang[*], C.-J. Hsu[*], C.-J. Tien[**], K.-Y. Lo[***]
AU Optronics, Taiwan
[*]Nat. Changhua Univ. of Education, Taiwan
[**]Cheng Shiu Univ., Taiwan
[***]Nat. Cheng Kung Univ., Taiwan

We design a blue phase dual-view display with high contrast ratio and low cross talk. The patterned-electrode provides inclined field parallel to the unintended viewing direction, creating zero phase retardation and dark state in the unintended viewing direction. The operation mechanism, device parameters are discussed.

LCTp5 - 5 **Withdrawn**

LCTp5 - 6 **Electric Field Effect on Polymerization Process of Polymer-Stabilized Blue Phase LC**

W.-H. Li, D.-C. Hu, Y.-J. Lee, A. Lien**, J.-G. Lu*

Shanghai Jiao Tong Univ., China
**Shenzhen China Star Optoelect. Tech., China*
***TCL Corporate Res., China*

The process of applying electric field during polymerization of polymer-stabilized blue phase LC (PS-BPLCs) is proposed to improve the driving capacity and contrast ratio of PS-BPLCs. By optimizing the process, the Kerr constant and hysteresis can be improved significantly. Meanwhile, it is also an effective way to improve the contrast ratio.

LCTp5 - 7L **Fundamental Study on Lateral Shearing Properties of Nematic LC Cells**

T. Nose, S. Ishisaka, K. Okano, N. Fujita, J. Murata, H. Muraguchi, N. Ozaki, M. Honma, R. Ito

Akita Pref. Univ., Japan

LC cell can be used as uniaxial crystal whose optic axis is oblique by applying a suitable voltage. Incident ordinary and extraordinary rays sprit laterally just a little, and the behavior is useful for differential-interference-contrast (DIC) observation. Then, lateral shearing properties are investigated for various types of LC cells.

LCTp5 - 8L **Response Properties of Twisted Nematic Liquid Crystal Gratings**

M. Honma, Y. Aki, K. Takahashi, R. Yamaguchi*, T. Nose*

Akita Pref. Univ., Japan
**Akita Univ., Japan*

We investigate the response properties of micropatterned twisted nematic liquid crystal (TN LC) gratings. The rise and decay times are discussed together with the theoretical expression of the response time. It is revealed that the measured response time obeys the similar formula to that for conventional uniformly aligned LC cells.

LCTp5 - 9L **Morphological Control of the Liquid Crystal Droplets in Molecular-Aligned Polymer for Substrate-Free LCDs**

D. Sasaki, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

To realize substrate-free liquid crystal displays with high contrast images, we have proposed a new molecular-aligned composite film of LC and polymer. We clarified that the aggregate morphology of twisted LC droplets can be controlled by the temperature and UV intensity during UV exposure through the photo mask.

LCTp5 - 10L **Enhanced Electro-Optic Characteristics of a Liquid Crystal Display Aided by Polymer Networks**

T.-H. Choi, Y. Choi, Y.-J. Park, J.-W. Kim, T.-H. Yoon

Pusan Nat. Univ., Korea

We confirmed that we can increase the cell gap in a polymer-networked cell for higher transmittance without sacrificing the response time. By employing a polymer-networked cell with a polymer concentration of 3 wt%, we achieved a relatively fast response time of 18 ms even at –20 ˚C.

LCTp5 - 11L **Driving Voltage Reduction of Flexible Blue Phase Liquid Crystal Devices Containing Polymer Walls**

H. Sakai, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

A flexible blue phase LCD with polymer wall structure has been proposed for high-contrast display. We clarified that the driving voltage largely depends on the collimation angle of UV light and monomer concentration during patterned UV irradiation. We successfully realized low driving voltage of blue phase LC with polymer walls.

LCTp5 - 12L **Fabrication of Flexible Ultra-Thin Liquid Crystal Devices Using Coat-Debond Plastic Substrates with Etched Post Spacers**

Y. Obonai, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

To realize flexible LCDs, high dimensional stability for temperature is required for plastic substrates. Using polyimide substrates formed by the coat-debond method, we have developed flexible LC devices with etched post spacers. As a result, we successfully achieved flexible LCDs that have high flexibility without degradation of optical characteristics.

13:40 - 15:40 **Ohmi 6**

Poster LCTp6: Liquid Crystal Lens

LCTp6 - 1 **LC Lens with Different Cell Gap**

R. Bao, G. Chen, H. Mai, M. Ye

SuperD, China

The dependence of optical power and decay time on cell gap of a liquid crystal lens are studied. The maximum optical power increases nearly linearly with the increase of cell gap, and the decay time increases approximately linearly with increasing cell gap squared.

LCTp6 - 2 **Thermally Controllable and Polarization Independent LC Lenses Fabricated on Flexible Substrates**

Y.-Y. Chiu, C.-Y. Chien, C.-R. Sheu
Nat. Cheng Kung Univ., Taiwan

In this study, a convex liquid crystal (LC) lens fabricated on flexible PDMS substrates is demonstrated. Due to PDMS surface providing a homeotropic LC alignment, the fabricated LC lenses are polarization independent and thermally tunable focuses. Furthermore, the LC lenses still keep lens functions even in bending situation.

LCTp6 - 3 **Withdrawn**

LCTp6 - 4 **Tunable Optical Deflector with Fresnel Type of LC Device**

G. Shibuya, H. Yoshida, M. Ozaki
Osaka Univ., Japan

We have developed a new type of tunable Fresnel deflector composed of liquid crystal. Novel structure of thin films makes a saw-tooth distribution of refractive index in the LC material. Optical tilt angle of ± 0.6 deg. was achieved to apply for optical image stabilizer (OIS) without any moving parts.

LCTp6 - 5 **Completely Preventing Disclination Lines Occurred in LC Lens Array via an Additionally Whole Photoresist Film**

P.-H. Tang, Y.-J. Chang, C.-R. Sheu
Nat. Cheng Kung Univ., Taiwan

A simple and effective method to prevent disclination lines in liquid crystal (LC) lens array is proposed. By means of an extra whole photoresist film coated on hole-patterned ITO (indium tin oxide) electrodes, there will be no disclination line when electrically operating LC lens arrays.

LCTp6 - 6L **2D-3D Switchable Auto-Stereoscopic Multi-View 3D Mobile Display Using Polarization Dependent Reactive Mesogen Lens Array Film**

M.-K. Park, K.-B. Son, M. Kim, H.-R. Kim
Kyungpook Nat. Univ., Korea

We demonstrate a 2D-3D switchable auto-stereoscopic 15-view 3D mobile display using polarization dependent reactive mesogen (RM) lens array film. In our active RM lens array with slim thickness, an ideal lens profile is obtained with short focusing behavior and a spherical aberration is eliminated by using the aspherical lens curvature.
Also presented in Innovative Demonstration Session (see p. 205)

----- Break -----

16:00 - 17:25 **Ohmi 9**

3D2/LCT3: Autostereoscopic 3D Displays

Chair: Y. Kuroki, Confort Vision Res. Lab., Japan
Co-Chair: S. Oka, Japan Display, Japan

3D2/ LCT3 - 1: 16:00 ***Invited*** **LC GRIN Lens Technology for Multi-Functional 3D Display**

S. Uehara

Toshiba, Japan

An LC GRIN lens is a significant component for 2D/3D display, because the lens function is easily changed due to an electrode design and driving method. We introduce our recent developments of three core technologies for the LC GRIN lens, those are, LC lens mode, driving method, and electrode structure.

3D2/ LCT3 - 2 16:25 **Video Capable Dual-Layer Autostereoscopic Display with Motion Parallax**

H. Suginohara, M. Sugano, K. Minami

Mitsubishi Elec., Japan

We have developed the prototype of video capable dual-layer autostereoscopic display. We implement Depth-Image-Based Rendering in an FPGA so that we can render the dual-layered individual viewpoint video following the viewer position in real-time. Our prototype can display a 3D video with motion parallax within +/- 20 degrees viewing area.

3D2/ LCT3 - 3 16:45 **Resolution Multiplication Method for Autostereoscopic 3D Display**

F. Mukhtarov, S. D. Hwang

Samsung Elect., Korea

In this paper we present new resolution multiplication methods for Displays, based on controllable variations of refractive index of liquid crystal prism array. Simultaneously with index variations the displayed contents need to be updated in time-sequential mode. Initial tests show promising results for both 2D and 3D types of displays.

3D2/ LCT3 - 4 17:05 **Wide Viewing Angle Autostereoscopic 3D Display with Eye-Tracking System**

Y. Hyodo, S. Oka, T. Koit, H. Sugiyama, Y. Maede, T. Ochiai, T. Takahashi, S. Komura

Japan Display, Japan

A new eye-tracking 3D panel was developed by smoothing the motion of a liquid crystal (LC) active barrier and by reducing crosstalk using new designs of supporting electrodes in the barrier and in-plane switching electrode of an LC panel. We demonstrated excellent visibility in a 3D viewing zone.

Also presented in Innovative Demonstration Session (see p. 206)

----- Break -----

17:40 - 18:40 **Ohmi 2**

LCT4: New Fast Response LCDs

Chair: N. Kawatsuki, Univ. of Hyogo, Japan
Co-Chair: K. Miyachi, Sharp, Japan

LCT4 - 1
17:40

Fast Twist-VA Bidirectional Field Switching Mode LCD

A. R. Geivandov, M. I. Barnik, I. V. Kasyanova, V. S. Palto, S. P. Palto

Shubnikov Inst. of Crystallography RAS, Russia

For the first time we have used bidirectional field switching mode for inducing twist in VA LC cell. The advantage of the new method is submillisecond speed of the switching achieved by excluding the field-off viscous-elastic relaxation of nematic LC molecules.

LCT4 - 2
18:00

Properties of Nano-Phase-Separated LCs with Fast Response

T. Fujisawa, K. Jang, F. Kodera, M. Gushiken, S. Kosaka, G. Sudou, H. Hasebe, H. Takatsu

DIC, Japan

A Nano-Phase Separated LCs, which is one of polymer/liquid crystal composite, realizes faster response than polymer sustained vertical aligned liquid crystals. In further improvement, the decay time less than 1 ms is achieved. In addition, a relatively fast decay time is attained even at a low temperature.

LCT4 - 3
18:20

LC Phase Modulators with Fast Optical Response and Low Light Scattering Realized via Processes of He-Ne Laser Holographic Exposure

C.-Y. Chien, Y. -W. Chen, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

Phase modulators play an important role in most electro-optical applications. In this study, a process of He-Ne laser holographic exposure is used to realize liquid crystal phase modulator with fast optical response and low light scattering. The fabricated phase modulator is capable of 2π phase modulation when applying voltages.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:30 **Ohmi 3**

FLX2/LCT5: Flexible LCDs

Chair: H. Funahashi, Kagawa Univ., Japan
Co-Chair: H. Okada, Toyama Univ., Japan

FLX2/LCT5 - 1: 9:00 ***Invited*** **Advanced Polymer and LC Technologies for High Quality Flexible Displays**

H. Fujikake, H. Sakai, A. Sato, E. Uchida, D. Sasaki, Y. Obonai, Y. Isomae, T. Ishinabe

Tohoku Univ., Japan

For a practical flexible liquid crystal display, fine polymer spacer walls and networks are formed in a nematic liquid crystal layer for stabilizing substrate gap. Total optical compensating design methods using plastic substrates are also presented for wide viewing angle, and flexible backlight is discussed for whole flexible display systems.

FLX2/LCT5 - 2 9:25 **Uniform Lying Helix of Cholesteric LC Aligned by Means of Coating Method with Electric Treatment**

N. Endo, M. Kimura

Nagaoka Univ. of Tech., Japan

The feature of Uniform Lying Helix (ULH) is its fast response speed whereas the alignment process of ULH is not simple. Previously we proposed a novel fabrication process of liquid crystal display (LCD) by means of slit coater. Paying attention to the shear flow force, we applied this method to align the ULH with using electric field treatment. Optimum fabrication condition and characteristics of ULH will be demonstrated.

FLX2/LCT5 - 3L: 9:45 ***Invited*** **Development of World's Largest 60-in. Roll Display**

M. Shigeta, M. Kawabata, K. Kobayashi, M. Teragawa

Sakai Display Prods., Japan

The 60-in. roll display with radius 500 mm has been developed. No alignment defect due to the displacement of the panel appears for UV2A mode, and excellent optical performance is confirmed.
As the roll display has the perspective features and texture gradient, the three dimensional sensation is enhanced by the physiological effects.

FLX2/ LCT5 - 4L 10:10 **Novel Alignment-Process-Free Flexible VA-LCDs with highly-Stable LC Alignment**

M. Yamamoto, K. Asanuma, Y. Iimura

Tokyo Univ. of A&T, Japan

We investigate fabrication processes of high-performance flexible VA-LCDs. It is shown that using special-shaped pole spacers and a PSS method gives multi-domain pixel structure with highly-stable LC alignment. A fabricated flexible VA-LCD is highly resistive against external stresses such as bend deformation.

----- Break -----

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 15:00 **Ohmi 5**

LCT6: IPS/FFS Display Modes

Chair: T. Ishinabe, Tohoku Univ., Japan
Co-Chair: H. Wakemoto, Japan Display, Japan

LCT6 - 1: 13:30 ***Invited*** **Analysis of Novel IPS Mode for Fast Response**

T. Matsushima, K. Takizawa

Japan Display, Japan

We developed a new fast response time in-plane switching (IPS) LCD that is three times faster than the optical performance obtainable in the conventional IPS mode. We also proposed an analytical model that considers the elastic energy function under electric field stress.

LCT6 - 2: 13:55 ***Invited*** **Development of Novel LC Compounds and Mixtures to Improve Transmittance for Np-FFS Mode**

Y. Matsumura, H. Tanaka, T. Maeda, T. Asakura, E. Machida

JNC Petrochem., Japan

To improve transmittance in FFS mode display with positive dielectric anisotropy (Np) LC mixture, we have designed and synthesized the novel Np compound (Compound J). The fast response, high reliability and high transmittance properties compared to the conventional technology are achieved by use of the LC mixture including Compound J.

LCT6 - 3 14:20 **The Influence of LC Dielectric Properties on Cell Transmittance in FFS-LCD**

C.-R. Huang, P.-C. Liao, Y.-L. Yeh, Y.-C. Chen, W.-H. Hsu

AU Optronics, Taiwan

The transmittance of fringe-field switching (FFS) LCD with positive liquid crystal is analyzed with different LC dielectric properties. An index for cell transmittance and a simplified physical model are presented.

LCT6 - 4 14:40 **Study on Flickering Behavior in Low-Frequency Driven AH-IPS LC Mode**

D.-J. Lee[,**], M.-K. Park[**], J.-S. Park[**], H. Lee[*], J.-H. Baek[*], J.-H. Lee[*], H. Choi[*], Y. M. Ha[*], H.-R. Kim[**]*

[*]LG Display, Korea

[**]Kyungpook Nat. Univ., Korea

We investigated the flickering behaviors of AH-IPS LC modes using positive dielectric LC and negative dielectric LC at the operating frequency of 0.5 Hz. We found out various origins causing the flickering phenomena and proposed adequate solutions for each cause.

----- Break -----

15:10 - 16:30 **Ohmi 5**

LCT 7: Innovative Technology for Surface/Interface Control

Chair: K. Ishikawa, Tokyo Inst. of Tech., Japan
Co-Chair: Y. Matsumura, JNC Petrochem., Japan

LCT7 - 1: 15:10 ***Invited*** **Photoalignment Materials for LCDs and Functional Films**

N. Kawatsuki

Univ. of Hyogo, Japan

This paper describes photoresponsive materials for photoalignment of liquid crystals (LCs) and photoinduced molecular reorientation for functional films. Axis-selective photoreaction of thin films generates photoinduced small optical anisotropy, which is amplified to attain molecular reorientation based on the self-organization due to LC characteristics of the material.

LCT7 - 2
15:35

Electrowetting of Nematic LCs

T. Unate, T. Nagase, H. Naito

Osaka Pref. Univ., Japan

We have studied electrowetting using polar materials of nematic liquid crystal instead of commonly used non-polar oils. The contact angle of the liquid crystal shows larger change in negative applied voltage than in positive applied voltage. These findings are expected to increase materials selections and develop novel devices.

LCT7 - 3
15:55

Reduction of Optical Scattering and Driving Voltage of PDLCs

G.-Y. Shim[*], H. G. Kim[*], J.-S. Park[*], D.-J. Lee[,**], J.-H. Baek[**], J.-H. Lee[**], B. K. Kim[**], H.-R. Kim[*]*

[*]Kyungpook Nat. Univ., Korea
[**]LG Display, Korea

A conventional polymer-dispersed liquid crystal using scattered and transparent light has a difficulty realizing a dark state in retardation layer between crossed polarizers. The PDLC that has the optically isotropic LC nanodroplets was fabricated and reduced driving voltages of the nanodroplet PDLC by doping nanoparticles with high K properties.

LCT7 - 4L
16:15

Quantitative Characterization of Uniaxial Anisotropy of Rubbed Polyimide Alignment Layer Using Reflection Ellipsometry

M. S. Park, S. M. Yang, S. U. Park[*], S. Y. Kim

Ajou Univ., Korea
[*]Ellipso Tech., Korea

The orientational angles and the magnitude of uniaxial anisotropy of rubbed PI surfaces are quantitatively characterized using an improved reflection ellipsometer.

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Workshop on Active Matrix Displays

Thursday, December 10

13:40 - 15:40 **Ohmi 6**

***Poster* AMDp1: Poster: Oxide TFT**
Special Topics of Interest on Oxide-Semiconductor TFT

AMDp1 - 1 **Stress Durability of CAAC-IGZO TFTs**

R. Honda[*], H. Baba[*], A. Suzuki[*], M. Hayakawa[**], N. Ishihara[*], H. Kanemura[**], Y. Shima[**], S. Saito[**], S. Matsuda[*], K. Dairiki[*], J. Koezuka[**], S. Yamazaki[,**]*

[*]Semiconductor Energy Lab., Japan
[**]Advanced Film Device, Japan

C-axis-aligned ab-plane-anchored crystalline In-Ga-Zn oxide (CAAC-IGZO) is a semiconductor material that has attracted attention in recent years. In this study, drain current stress tests for CAAC-IGZO TFTs were performed, and the TFTs under the stress were observed using emission microscopes to indicate hot-carrier effects.

AMDp1 - 2 **Correlation Among Crystal Morphology, Surface Shape, and Oxygen Vacancy Formations in In-Ga-Zn Oxide**

M. Nakashima, T. Hiramatsu, E. Kikuchi, Y. Yamada, M. Oota, K. Dairiki, S. Yamazaki

Semiconductor Energy Lab., Japan

The crystal orientations and surface shapes of In-Ga-Zn oxide (IGZO) thin films were examined by cross-sectional TEM. Furthermore, the correlation between crystallinity and oxygen vacancy was investigated by first-principles calculations. The results reveal that oxygen vacancies are less likely to be formed in crystalline than in amorphous IGZO.

AMDp1 - 3 **Behavior of a-IGZTO TFTs with BCE Structures Containing Floating Metal Electrodes**

M. Ochi, S. Morita, H. Goto, T. Kugimiya, M. Kanamaru[*], M. N. Fujii[**], Y. Uraoka[**]

Kobe Steel, Japan
[*]Kobelco Res. Inst., Japan
[**]NAIST, Japan

We report fabrication of back channel etch type oxide semiconductor TFTs equipped with floating metal electrodes on their channel region. The on-current was greatly enhanced by arranging of the additional electrodes. It is found that formation of parasitic TFTs also had a similar effect.

AMDp1 - 4 **Suppression of Photo-Bias Instability of Transparent Amorphous Indium Oxide Thin Film Transistors by in situ Nitrogen Doping**

C.-H. Chang, C.-C. Chang, P.-T. Liu, Y.-C. Tsai[*]

Nat. Chiao Tung Univ., Taiwan
[*]Appl. Materials, Taiwan

In this study, we analyzed the In_2O_3 thin films with different nitrogen flow rate during sputtering as the transistor's channel layer. The electrical analysis including device's reliability and material analysis were both examined.

AMDp1 - 5 **Related a-IGZO Oxide Structure Analysis for Reliability Improvement**

W.-T. Chen, K.-J. Chang, W.-P. Chen, C.-C. Nien, K.-K. Chen, H.-H. Lu, Y.-H. Lin

AU Optronics, Taiwan

Different device structures stress were studied in this study. Top gate TFT device showed good PBS/NBS results due to top gate metal shielding and thinner SiO_x to avoid gas/moisture permeation into the IGZO. The dual gate TFT device showed better PBIS/NBIS due to its nice electric field distribution.

AMDp1 - 6 **Simple Current-Biased Voltage-Programmed a-IGZO Pixel Circuit for High-Resolution AMOLED Displays**

F.-H. Chen, Y.-T. Liu, C.-M. Lu, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

A current-biased voltage-programmed amorphous indium-gallium-zinc-oxide pixel circuit which consists of three transistors and one capacitor is proposed for the use in high-resolution active-matrix organic light-emitting diode (AMOLED) displays. The simulation results confirm that the OLED current has immunity to the degradation of driving TFT, OLED, and carrier mobility.

AMDp1 - 7 **Development of High Performance AM-OLED Display Using IGZO TFT**

X.-W. Lv, Y.-H. Meng, C.-Y. Su, W.-H. Li, L.-Q. Shi, H.-J. Zhang, W. Shi, S.-M. Ge, T. Sun, C.-Y. Lee, A. Lien[*]

Shenzhen China Star Optoelect. Tech., China
[*]TCL Corporate Res., China

An optimized process of manufacturing IGZO TFT was developed. According to adjusting pattern sequence of GI, IGZO and ES, transfer characteristics and uniformity of TFTs were improved. Moreover, mura of panel is reduced greatly. Finally, a high performance 31-in. 4K2K AM-OLED display was fabricated.

AMDp1 - 8 Investigation of Stacking Multi-Layers Oxide Thin Film Transistors Fabricated by Sol-Gel Process

C. Y. Huang, C. E. Tsay, Y. W. Wang

Nat. Changhua Univ. of Education, Taiwan

The effects of multi-stack oxide semiconductor layers on TFT. ZnO based semiconductors are processed sequentially as active multi-layer through sol-gel process. Tin/zinc oxide is as the donor provider and gallium/zinc oxide is as the resist layer. The result highest mobility reaches 6.4 cm^2/Vs and on/off current ratio over 10^5.

AMDp1 - 9 High Reliable Indium Gallium Zinc Oxide Thin Film Transistor under Negative Bias Illumination Stress

J. Liu, J. Li, S. Qin, J. Lee, C. Lee

Shenzhen China Star Optoelect. Tech., China

We studied the influence of nitrogen plasma treatment on the indium gallium zinc oxide thin film transistor. Then we improved the performance of indium gallium zinc oxide through adding nitrogen into the deposition of silicon oxide insulator. Finally, we fabricated high reliable oxide thin film transistor under negative bias illumination stress.

AMDp1 - 10 Characteristics Improvements by Adopting Multi-Active Layer Structure in a-IGZO Thin Film Transistors

D. Xu, X. Duan, M. K. Baek, Y. Youn, C. Che, S. Lee

Hefei BOE Optoelect. Tech., China

This paper demonstrates a characteristics improvement method using multi-active layer structure in a-IGZO TFTs. The multi-active layer comprises bottom oxygen-rich (OR), middle oxygen-deficient (OD), and top OR a-IGZO layers, forming carrier-confinement structure. By using above-mentioned multi-layered IGZO active layer, TFT devices exhibited relatively better and more stable characteristics was gained.

AMDp1 - 11 Electrical Properties of a-IGZO TFT with Various Annealing Temperature

Y.-H. Hsieh, M.-C. Chen, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this paper, we use rf magnetron sputtering method to fabricate InGaZnO thin-film transistors. We use surface energy to identify the relationship between InGaZnO thin-film transistors with various annealing temperature. We also examine the InGaZnO TFT devices characteristic and hysteresis.

AMDp1 - 12 Comparison of Electrical Performance for a-IGZO Based Single Gate and Dual Gate Driving TFT Using TCAD

M. M. Billah, M. D. H. Chowdhury, J. Jang

Kyung Hee Univ., Korea

We compared electrical performances between single (SG) and dual (DG) driving a-IGZO TFTs using TCAD. DG-driving shows higher electric-field 2.59 (2.53) MV/cm and electron concentration 1.04×10^{19} (1×10^{19}) cm^{-3} at back (front) channel and thus bulk-accumulation TFT is possible. Using I-V & C-V measurements DG-driving shows higher carrier-concentration and lower E_C-E_F, leads to increase the drain current and mobility.

AMDp1 - 13 Withdrawn

AMDp1 - 14 Withdrawn

AMDp1 - 15 Investigation on Ambient Degradation of Amorphous InGaZnO Thin Film Transistors in an Unsealed Chamber

J. Xu, Q. Wu, L. Xu, H. Xie, S. Li[*]*, C.-Y. Lee*[*]*, A. Lien*[**]*, C. Dong*

Shanghai Jiao Tong Univ., China
[*]Shenzhen China Star Optoelect. Tech., China
[**]TCL Corporate Res., China

The device transfer characteristics of the unpassivated amorphous InGaZnO thin film Transistors were separately measured under ambient N_2, Ar, O_2, and moisture in an unsealed chamber, proving that moisture instead of oxygen, nitrogen, and inert gases was dominant in the ambient degradation effects under atmospheric conditions.

AMDp1 - 16L Reliability Improvement of Amorphous InGaZnO Thin-Film Transistors by Less Hydroxyl-Groups Siloxane Passivation

C. Kulchaisit, Y. Ishikawa, M. N. Fujii, H. Yamazaki, J. P. S. Bermundo, S. Ishikawa[*]*, T. Miyasako*[*]*, H. Katsui*[*]*, K. Tanaka*[*]*, K. Hamada*[*]*, Y. Uraoka*

NAIST, Japan
[*]JSR, Japan

We control the hydroxide content in amorphous InGaZnO surface by passivation to improve the thin-film transistor's (TFT) reliability. We achieved the stable device using an organic-inorganic hybrid material by controlling the OH bond, and found that the OH amount in the passivation is a key issue in oxide TFT reliability.

AMDp1 - 17L The Impact of Thermal-Assist UV/Ozone Treatment in Amorphous Zinc Oxynitride Thin Film Transistors

K.-C. Ok, H.-J. Jeong, H.-M. Lee, J.-S. Park

Hanyang Univ., Korea

We fabricated high mobility (μ_{sat} > 40 cm^2/Vs) and stable (ΔVth < ± 1 V @PBS and NBS for 1hr) amorphous zinc oxynitride thin film transistors (a-ZnON TFTs) using thermal assist UV/ozone treatment. The electrical characteristics of a-ZnON TFTs were investigated by chemical bonding properties.

AMDp1 - 18L Influence of Copper Source/Drain Metal on BCE Amorphous IGZO TFTs

C.-Y. Hou, L.-Y. Chiu, J.-J. Zeng, S.-F. Wu, S.-C. Lee, W.-C. Tsai

AU Optronics, Taiwan

BCE_structure IGZO TFT using copper as the source/drain metal, we have developed a copper-blocked process to prevent Cu from diffusing into the IGZO active layer. The device characteristics and reliability of Cu BCE_structure IGZO TFT can be improved by copper-blocked process.

AMDp1 - 19L Improvement of High Mobility Al-Doped InSnZnO Back Channel Etch Thin Film Transistor with Double-Layered Passivation of SiO_2/Al_2O_3

G.-J. Jeon, K.-H. Lee, H. Yeom, Y. Nam, G. B. Mun, I.-S. Kang[*]*, S.-H. K. Park*

KAIST, Korea
[*]*Nat. Nano-Fab Ctr., Korea*

N_2O plasma treatment was performed to back channel of Al-doped InSnZnO. TFTs were passivated with SiO_2 or SiO_2/Al_2O_3. While subthreshold swing and hysteresis of TFTs with SiO_2 single layer were degraded after post-annealing, TFTs with SiO_2/Al_2O_3 showed much better performance with 0.09 V/decade and 30.55 cm^2/Vs.

AMDp1 - 20L Reliability and Performance Study of ZnO Co-Sputtered InGaZnO Thin Film Transistors Under Various Ambient Conditions

N. Tiwari, R. N. Chauhan, P.-T. Liu, H.-P. D. Shieh

Nat. Chiao Tung Univ., Taiwan

ZnO co-sputtered IGZO TFTs were fabricated and systematically investigated the impact of various annealing environments on their performance characteristics. The characteristics were improved in N_2 ambient-displaying field effect mobility ~ 16.10 cm^2/Vs, threshold voltage ~ 1.5 V, sub-threshold swing ~ 0.21 V/decade and NBIS shifting ~ –2.75 V.

AMDp1 - 21L InZnO Capped with InZnO:Si Bi-Stack Layers for Enhanced Photo-Bias Stability and Performance in Metal Oxide Thin Film Transistors

R. N. Chauhan, N. Tiwari, Y.-H. Tai, P.-T. Liu, H.-P. D. Shieh

Nat. Chiao Tung Univ., Taiwan

A thin film transistor with bi-stack layers of silicon incorporated InZnO (IZO:Si) on InZnO layer is proposed to enhance device performance and negative photo-biased stability. The resulting device realizes as enhancement mode (V_{th} ~ 1.30 V) with mobility of 15.3 cm^2/Vs, sub-threshold swing of 0.20 V/decade, better stability ~ –0.75 V.

AMDp1 - 22L Oxide TFT Shift Register Circuit with DC-type Output Driver

S.-J. Song, H. Nam

Kyung Hee Univ., Korea

This paper demonstrates a DC-type oxide TFT shift register that connects large size pull-up TFTs to positive supply instead of alternating clock signals to reduce the power consumption of clock drivers. The power consumption is simulated as 0.237 mW at a 16-stage gate driver for a 120 Hz full-HD display.

AMDp1 - 23L High Performance Solution Oxide TFTs for AMOLED Applications

L. Y. Lin, C. C. Cheng, C. Y. Liu, M. F. Chiang, P. H. Wu, M. T. Lee, C. K. Lo, L. F. Lin, S. H. Kuo

AU Optronics, Taiwan

Solution-processed metal oxide TFT arrays have been fabricated for AMOLED application in this work. Two different kinds of TFT configurations have been introduced; the highest mobility is 4.24 cm^2/Vs for coplanar and 11.37 cm^2/Vs for island stop TFT structure. Characteristics and reliability of solution-processed metal oxide TFTs have been also presented in this work.

AMDp1 - 24L Comparison of Performance and Stability of Tungsten-doped Indium Oxide Thin Film Transistor with SiO, SiN and SiO/SiN as Gate Insulators

P.-W. Chen, C.-H. Chang, P.-T. Liu

Nat. Chiao Tung Univ., Taiwan

In this study, we investigated the performance and stability of thin-film transistors with tungsten-doped indium oxide as channel layer, which were deposited on SiO, SiN and SiO/SiN. Positive/Negative bias stress were performed to explore the electrical reliability of IWO TFT with different gate insulators.

AMDp1 - 25L High-Mobility and High-Stability ZnON Thin-Film Transistors for Next-Generation Display Applications

Y. S. Kim, J. H. Kim, H. S. Kim

Chungnam Nat. Univ., Korea

In order to improve the performances of zinc oxynitride thin-film transistors, heat treatment conditions of ZnON semiconductors were studied here. Thin film properties and the resulting TFT performances including the device stability were evaluated. High-stability ZnON devices with ultra-high field-effect mobility (μ_{FE}) values exceeding 50 cm^2/Vs were achieved.

AMDp1 - 26L Withdrawn

13:40 - 15:40 **Ohmi 6**

***Poster* AMDp2: Poster: Active-Matrix Devices**

AMDp2 - 1 491-ppi High Resolution a-Si TFT-LCD with High Transmittance and Slim Border

H. Y. Cheng, P. C. Yeh, H. C. Huang, C. S. Cheng, W. M. Huang

AU Optronics, Taiwan

We successfully demonstrated a novel 5.98-in. WQHD (1440*RGB*2560) mobile display used a-Si (Amorphous Silicon) backplane. The demonstration achieves 1.0 mm panel border and over 4% transmittance under 491PPI high resolution display. Compared to LTPS(Low Temperature Poly-Silicon) backplane, the a-Si structure has the competitive advantage on fabrication cost and process capability.

AMDp2 - 2 Poly-Si Hall Devices for Magnetic-Field Sensors - Sensitivity Enhancement by High-Voltage Application -

M. Kimura, A. Yoshikawa, T. Matsumoto, H. Shiga, T. Matsuda, T. Ozawa[*]*, K. Aoki*[*]*, C.-C Kuo*[*]

Ryukoku Univ., Japan

[*]*AU Optronics Japan, Japan*

We are developing poly-Si Hall devices for magnetic-filed sensors and succeeded in sensitivity enhancement by high-voltage. We achieved the magnetic-filed sensitivity of 5.13 V/T by applying 580 V, 1000 times higher than the previous sensitivity. This is owing to high carrier-velocity due to not only high-voltage but high carrier-mobility.

AMDp2 - 3 **Novel SPC Poly-Si TFTs for AMOLED Application**

Y. J. Hsu, R. Kakkad, Y. Li, X. Y. Zhou, X. X. Zhang, Y. C. Wu, H. Li

Shenzhen China Star Optoelect. Tech., China

We have demonstrated a 5.5-in. AMOLED display using novel SPC TFT which have significantly higher mobility (4-5 times) compared to those fabricated using conventional SPC poly-Si film. The Novel SPC TFTs are suitable for AMOLED back-plane fabrication due to their lower crystallization thermal budget and higher performance, and absence of ELA scanning mura.

AMDp2 - 4 **Novel Low-Power Negative Level Shifter for Negative High Voltage Generators Using LTPS-TFTs**

A. Ueda, M. Yoshida

Tokai Univ., Japan

In this paper, we propose a novel low-power level shifter based on low-temperature polycrystalline silicon thin-film transistors (LTPS-TFTs) for negative high-voltage generators. The proposed level shifter converts input clock signals whose amplitude switches between 0 and $+V_{DD}$ to output signals whose amplitude switches between 0 and $-2V_{DD}$.

AMDp2 - 5 **Novel a-Si:H Gate Driver Circuit with Sharing Pull-Down Structure**

M.-Y. Deng, P.-C. Lai, F.-H. Chen, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This work presents a novel gate driver circuit producing two output signals in one stage and sharing a pull-down circuit to reduce the layout area. Simulation results demonstrate that the circuit with ac-driving method maintains outputs at VL as threshold voltages of input and pull-down TFTs shift by 10 V.

AMDp2 - 6 **Precise Simulation of Brightness Variation on Whole AMOLED Panel Caused by Power Line Voltage Drop**

C.-H. Shim, C. Tsukii, S.-K. Kim, R. Hattori, T. Munakata[*]

Kyushu Univ., Japan

[*]*Jedat, Japan*

A precise simulation method to evaluate the brightness variation across an entire AMOLED panel with actual pixel numbers caused by power line voltage drop is presented. The voltage drop is evaluated for four types of simplified compensated pixel circuits which cover all of the AMOLED pixel circuits.

AMDp2 - 7 **Amorphous Silicon Integrated Memory Pixel Circuit with Low Power Consumption in TFT-LCD Application**

G.-Y. Zheng, P.-T. Liu, C.-Y. Tsai*, Y.-F. Tu**

Nat. Tsing Hua Univ., Taiwan
**Nat. Chiao-Tung Univ., Taiwan*

This paper presents integrated amorphous silicon thin film transistor (a-Si) memory pixel circuit which is composed of one N-type inverter block and coupling capacitor to achieve one second holding voltage for reducing the frequency to 1 Hz of data driver in static mode.

AMDp2 - 8 **New AMOLED Pixel Circuit with Resolution-Independent V_{TH} Compensation Capability**

C.-E. Lee, Y.-T. Liu, P.-S. Chen, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This work proposes a new active-matrix organic light-emitting diode (AMOLED) pixel circuit composed of five TFTs and two capacitors. The proposed pixel circuit can compensate for the V_{TH} variations of the driving TFT and the compensation capability can be unaffected by the resolution of displays through using parallel addressing scheme.

AMDp2 - 9 **Electrical Characteristics of Two-Step Gate Insulator Deposition on Low-Temperature Poly-Si TFTs**

Y.-S. Cho, W.-H. Son, Y.-K. Lee, H.-S. Lee, K.-H. Moon, W. -S. Son

LG Display, Korea

The gate insulator deposited at higher RF power induced higher plasma damage on the surface of active layer. It also can create additional defects, more especially at the Si/SiO_2 interface due to SiO_2 grow mechanism. Thus, we attempted two-step gate insulator deposition method to confirm the effect of SiO_2 interface characteristics.

AMDp2 - 10L **Self-Aligned Planar Metal Double-Gate Junctionless P-Channel Low-Temperature Poly-Ge TFTs with High-K Gate Dielectric on Glass Substrate**

Y. Nishimura, T. Nakashima, A. Hara

Tohoku Gakuin Univ., Japan

We demonstrate for the first time a self-aligned planar metal double-gate junctionless (JL) p-ch low-temperature (LT) poly-Ge TFT on a glass substrate with a high-k gate dielectric that showed superior performance compared to top-gate JL p-ch LT poly-Ge TFTs.

AMDp2 - 11L Research on Low-power Digital Driver AMOLED Display

H. Zhu, S. Hu, N. Yang, X. Gao, X. Huang

Kunshan New Flat Panel Display Tech. Ctr., China

We propose a digital driving technique using a novel 2T0C pixel circuit and a high speed analog shift register for an active-matrix organic light-emitting diode (AMOLED) to effectively reduce power consumption. A 2.8-in. QVGA AMOLED system using the proposed technique shows high image quality while allowing small power consumption.

AMDp2 - 12L A New LTPS Pixel Compensation Circuit for AMOLED Display

S. Hu, H. Zhu, N. Yang, T. Zhang, Z. Wang, X. Gao, X. Huang

Kunshan New Flat Panel Display Tech. Ctr., China

An AMOLED pixel circuit is proposed for improving the image quality of the display, which can compensate the threshold voltage variation and VDD IR drop. Simulation results showed that the current variation through OLED decreased to 10% comparing with the conventional pixel.

----- Break -----

16:00 - 17:25 **Ohmi 1**

AMD1: Oxide TFT: Crystalline Oxide
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: H. Kumomi, Tokyo Inst. of Tech., Japan
Co-Chair: M. Hiramatsu, Japan Display, Japan

AMD1 - 1: 16:00 ***Invited*** **CAAC-Oxide Semiconductor Material and Its Applications**

M. Tsubuku, S. Yamazaki

Semiconductor Energy Lab., Japan

C-axis-aligned a-b-plane-anchored crystal indium- gallium-zinc-oxide (CAAC-IGZO) has unique characteristics with a layered crystal structure. We found that the IGZO with new atomic ratios of In:Ga:Zn = 4:2:3 to 4:2:4.1 and its neighborhood also has the layered CAAC structure and the electrical characteristics is improved in mobility and reliability.

AMD1 - 2: 16:25 ***Invited*** **Change in Structure and TFT Performances of IZO, IGO and IGZO Films by Crystallization**

A. Suko, J. Jia, S. Nakamura, Y. Shigesato

Aoyama Gakuin Univ., Japan

How the a-IGZO films crystallize and how the crystallinity affects the electrical properties, hence the TFT performances, have been investigated in detail. HREM analyses revealed the crystallization behavior in detail. For the comparative purpose the crystallization behaviors of a-IGO and a-IZO films are also investigated.

AMD1 - 3
16:50

Improvement in Characteristics, Reliability and Dispersion of CAAC-IGZO FETs with Surrounded Channel Structure

M. Hayakawa[*], S. Matsuda[**], S. Saito[*], Y. Shima[*], D. Matsubayashi[**], M. Dobashi[*], K. Tsutsui[**], R. Honda[**], J. Koezuka[*], K. Okazaki[*], S. Yamazaki[,**]*

[*]Advanced Film Device, Japan
[**]Semiconductor Energy Lab., Japan

Crystalline In-Ga-Zn-O (IGZO) field-effect transistors (FETs) with their channels electrically surrounded by two gate electrodes on the top side and the bottom side (we refer to such a structure as "surrounded-channel (S-ch) structure") were fabricated. Characteristics, reliability and dispersion of crystalline IGZO FETs were improved due to their S-ch structure.

AMD1 - 4L
17:10

Double-Channel InZnO/AlSnZnInO Thin-Film Transistors with Ultra High Mobility

J. H. Choi, J.-H. Yang, S. Nam, H.-O. Kim, O-S. Kwon, E.-S. Park, C.-S. Hwang, S. H. Cho

ETRI, Korea

We report high performance double-channel InZnO/AlSnZnInO thin-film transistors with inverted staggered back channel etch structure. The field-effect mobility, Subthreshold slope, turn-on voltage, and on/off ratio were 51.2 cm^2/Vs, 0.15V/decade, –1.6V, and 3×10^9, respectively.

----- Break -----

17:40 - 19:10 **Ohmi 1**

AMD2: High Resolution Displays Using LTPS and Oxide TFTs
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: P. Heremans, imec, Belgium
Co-Chair: H. Hamada, Kinki Univ., Japan

AMD2 - 1: 17:40 ***Invited*** **2K4K 550-ppi In-Cell Touch LTPS TFT-LCD**

M. Tada, T. Nakamura, H. Kimura

Japan Display, Japan

2K4K 550-ppi in-cell touch LTPS TFT-LCD has been developed in which low power consumption is realized using RGBW pixel, local dimming and low frame-rate driving. This LCD can be driven in 30 Hz frame-rate by the advanced TFT process with narrower channel width and thinner insulator storage capacitance.

AMD2 - 2 **Withdrawn**

AMD2 - 5L 18:05 **Scalability Characteristics of Self-Aligned Top-Gate IGZO TFTs**

J. S. Seo, J. Noh, P. S. Yun, J. U. Bae, K.-S. Park, I. B. Kang

LG Display, Korea

To achieve the short-channel scalability characteristics of self-aligned IGZO TFTs we perform to control the diffusion region (ΔL, LDD) inside channel and to reduce the total resistivity of S/D extension region. As a result of this work, we realize the below L < 4 μm TFTs and improve its current driving ability.

AMD2 - 3 18:25 **Development of 32-in. 8K4K LCD with Oxide Semiconductor and GOA Technology**

M. Wang, Y. Zhao, Q.-M. Gan, F. Zhao, C.-K. Zhang, L.-Q. Shi, L.-M. Zeng, C. Dai, T. Lee, H-L. Hu, J. Wu, C.-Y. Chiu, C.-Y. Lee, A. Lien[*]

Shenzhen China Star Optoelect. Tech., China
[*]TCL Corporate Res., China

We have successfully developed a 32-in. 8K4K LCD prototype which has the highest pixel density (280PPI) in TV market. BCE type oxide semiconductor and photo- alignment FFS mode are used to gain enough aperture ratio. HSD method and GOA technology are also used to decrease COF quantity.

AMD2 - 4: 18:45 ***Invited*** **Over 800-ppi Liquid Crystal Display with High Aperture Ratio Using IGZO Platform**

S. Uchida, N. Ueda, K. Okada, A. Oda, K. Yamamoto, K. Yamamoto, N. Noguchi, T. Matsuo

Sharp, Japan

Using oxide semiconductor, we have developed a 806ppi (4K2K) LCD which pixel density reach 4K resolution smart-phone and Head-Mounted-Display (HMD). An excellent aperture ratio was achieved with patterning dimensions by a gh-line lithography manufacturing backplane. With i-line lithography, this technology can realize larger pixel density than 1000ppi which satisfy HMD demands.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:30 **Ohmi 1**

AMD3: Oxide TFT: Reliability
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: Y. Yamamoto, Japan
Co-Chair: K. Takatori, NLT Techs., Japan

AMD3 - 1: 9:00 ***Invited*** **Reliability of Oxide TFTs**

B. S. Bae, S. M. Shin, K. M. Yu, E.-J. Yun

Hoseo Univ., Korea

The negative shift of threshold voltage by light illumination was investigated for the oxide thin film transistor. By the light illumination, both the doubly ionized oxygen vacancy and charge trapping cause the negative shift of the threshold voltage.

AMD3 - 2: 9:25 ***Invited*** **Highly Reliable Oxide Thin Film Transistors for Flexible Devices**

Y. Uraoka, J. P. S. Bermundo, M. Fujii, Y. Ishikawa

NAIST, Japan

Oxide TFT were investigated for flexible display. Fluorinated SiN gate insulator greatly improved reliability of oxide TFT under bias stress. Excimer laser annealing was performed for the TFT with siloxane passivation for low temperature annealing. Amorphous InZnO was fabricated by spin-coating method and Ag paste was patterned by screen print.

AMD3 - 3 9:50 **Electrical Characteristics and Stability of Bottom Gate a-InGaZnO TFTs on Flexible Substrate**

H.-W. Li, C.-F. Yang, C.-P. Chang, C.-H. Tsai, H.-H. Lu
AU Optronics, Taiwan

The bottom gate a-IGZO TFTs with different buffer layers fabricated on PI substrate was investigated. The devices characteristics would not be affected by buffer layers, while applying the plasma treatment on PI substrate. Devices show a good performance, and the threshold voltage shift is less than 1 V under bias stress.

AMD3 - 4 10:10 **Novel BTS Model and Methodology for AC-Stress-Induced Long-Term Reliability in Thin-Film Transistors**

J. Jang, K. Jeon, J. Yang, J. Park, M. Seo, Y. Yoon, K. Kim, K. Jung, Y. Kim, M. Yoo
Samsung Display, Korea

A novel BTS (Bias-Temperature-Stress) model and methodology for predicting threshold voltage shifts (ΔV_{TH}) under AC stress is firstly proposed. In order to verify this model, TFTs of the amorphous silicon gate driver integrated in a LCD panel were measured, and the proposed model has ΔV_{TH} error rate of 11.7% on average.

----- Break -----

10:40 - 11:55 **Ohmi 1**

AMD4: TFT Fabrication Technologies
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: H. Minemawari, AIST, Japan
Co-Chair: Y. Fujisaki, NHK, Japan

AMD4 - 1: 10:40 ***Invited*** **Organic Blend Semiconductors for High Performance Thin-Film Transistor Applications**

T. D. Anthopoulos, J. Smith, S. Hunter
Imperial College London, UK

We report the development of p-channel organic small-molecule/polymer blend-based thin-film transistors with high hole mobility. Emphasis is placed on the use of molecular p-dopants as a mean to improve the transistors' operating characteristics as well as the operating frequency of integrated circuits such as multi-stage ring oscillators.

AMD4 - 2 11:05 **Development of All Solution Processed TFT in ESL Configuration**

M. Marinkovic, S. Bom, T. Balster*, K. Su, A. Merkulov, V. Wagner*, R. Anselmann*

Evonik Inds., Germany
**Jacobs Univ. Bremen, Germany*

Liquid-phase processed metal oxide and directly patternable etch-stop materials were successfully integrated in TFTs with ESL configuration. Fabricated devices exhibit the mobility of 14 cm²/Vs, the negligible contact resistance and good electrical stability. The up-scaling feasibility of process to large substrates and integration in high-end display devices will be presented.

AMD4 - 3L 11:25 **KrF Excimer Laser Annealing of a-InGaZnO Thin-Film Transistors with Solution Processed Hybrid Passivation Layers**

J. P. S. Bermundo, Y. Ishikawa, M. N. Fujii, T. Nonaka, H. Ikenoue**, Y. Uraoka*

NAIST, Japan
**Merck, Japan*
***Kyushu Univ., Japan*

We show how KrF excimer laser annealing (ELA) can be used as a low temperature annealing process to improve the properties of passivated amorphous InGaZnO thin-film transistors. We analyzed the effect of KrF ELA on the electrical properties, physical structure, chemical bonding and composition of a-InGaZnO.

AMD4 - 4L 11:40 **High Performance and Uniformity of Poly-Si Thin-Film Transistors using Solid-Phase Crystallization on YSZ Layers by Two-step PLA Method**

L. T. K. Mai, S. Horita

JAIST, Japan

Poly-Si TFTs were fabricated by two-step PLA method on two kinds of substrates, glass and YSZ/glass. TFTs on YSZ/glass show much better performance and uniformity of device-to-device, e.g., average mobility ~80 cm^2/Vs and its standard deviation ~18 cm^2/Vs, respectively, compared with ~40 cm^2/Vs and ~28 cm^2/Vs on glass, respectively.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 15:00 **Ohmi 1**

AMD5: Oxide TFT: Applications
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: Y. Uraoka, NAIST, Japan
Co-Chair: M. Inoue, Huawei Techs., Japan

AMD5 - 1: 13:30 ***Invited*** **Properties of Oxide-Semiconductor TFTs under Mechanical Strain for Flexible Electronics**

P. Heremans[,***], A. de Jamblinne de Meux[*,***], B. Hou[**], A. Tripathi[**]*

[*]imec, Belgium
[**]Holst Ctr., the Netherlands
[***]Univ. of Leuven, Belgium

We report on the mechanical properties of a-IGZO transistors. We find that the charge carrier mobility of a-IGZO transistors is remarkably independent of strain. We explain these experimental results by ab-initio modeling of amorphous IGZO semiconductor material. We compare a-IGZO to covalent semiconductors, a-Si and LTPS, and to organic transistors.

AMD5 - 2: 13:55 ***Invited*** **Novel Technologies for Source and Drain Resistance Reduction in Short-Channel Self-Aligned InGaZnO Thin-Film Transistors**

K. Sakuma, K. Ota, T. Irisawa, C. Tanaka, K. Ikeda, D. Matsushita, M. Saitoh

Toshiba, Japan

We have successfully demonstrated a low-resistance source and drain (S/D) region of InGaZnO-TFT using Ar ion implantation (Ar I/I) and self-aligned metallization processes. These silicon-compatible technologies are very promising for high performance and high density InGaZnO TFT as BEOL Tr. in 3D LSIs.

AMD5 - 3 14:20 **Advanced Compensation Technologies for Large-Size UHD OLED TVs**

S. Takasugi, H.-J. Shin, M.-K. Chang, S.-M. Ko, H.-J. Park, J.-P. Lee, H.-S. Kim, C.-H. Oh

LG Display, Korea

In this paper, we present novel OLED display panel compensation technologies for large-size UHD OLED TVs considering variations of threshold voltage, mobility, channel size, OLED efficiency, and OLED uniformity. Using these technologies, we have successfully launched 55-, 65- and 77-in. UHD OLED TVs.

AMD5 - 4 14:40 **Dual-Gate Self-Aligned a-IGZO TFTs Using 5-Mask Steps**

M. Nag[,**], F. De Roose[*,**], A. Bhoolokam[*,**], K. Myny[*], A. Kumar[***], S. Steudel[*], J. Genoe[*,**], W. Dehaene[**], G. Groeseneken[*,**], P. Heremans[*,**,***]*

[*]imec, Belgium
[**]Katholieke Univ. Leuven, Belgium
[***]Holst Ctr., the Netherlands

We report a dual-gate (DG) self-aligned (SA) a-IGZO TFT process that comprises only five mask steps. The top-gate (TG) is SA which enables high speed operation. The secondary bottom-gate (BG) enables to improve parameters such as on-current (I_{ON}) and the sub-threshold slope (SS^{-1}) substantially when both gates are connected together.

----- Break -----

15:10 - 16:35 **Ohmi 1**

AMD6: Oxide TFT: Solution Processes
Special Topics of Interest on Oxide-Semiconductor TFT

Chair: T. D. Anthopoulos, Imperial College London, UK
Co-Chair: H. Kumomi, Tokyo Inst. of Tech., Japan

AMD6 - 1: 15:10 ***Invited*** **Oxide-Channel Ferroelectric-Gate Thin Film Transistors Prepared by Solution Process**

E. Tokumitsu, T. Shimoda

JAIST, Japan

Features of oxide-channel ferroelectric-gate thin film transistors (FGTs) are presented at first. Next, some recent topics, solution process and new printing process for TFT fabrications are presented. In particular, we demonstrate sub-micron channel FGTs fabricated by solution process with newly developed nano-rheology printing (n-RP) without using conventional lithography.

AMD6 - 2: 15:35 ***Invited*** **Stable Metal Semiconductor Field Effect Transistors on Oxide Semiconductor Channels Grown via Mist-CVD**

G. T. Dang, T. Kawaharamura[*], M. Furuta[*], S. Saxena, M. W. Allen

Univ. of Canterbury, New Zealand
[*]Kochi Univ. of Tech., Japan

We demonstrate the successful production of transparent metal-semiconductor field-effect-transistors (MESFETs), using reactively-sputtered silver oxide Schottky gates on In-Ga-Zn-O, Zn-Sn-O, SnO_2, and Ga_2O_3 channels, grown by non-vacuum, solution-processed Mist Chemical Vapor Deposition (Mist-CVD). We examine the performance and stability of these devices and discuss their suitability for display applications.

AMD6 - 3
16:00

Highly Reliable All-Printed Oxide TFT of High Work-Function Metal Electrodes with Low Contact Resistance by Doped Oxide Semiconductor

Y. Hirano, S. Matsumoto, R. Saotome, Y. Sone, S. Arae, M. Kusayanagi, Y. Nakamura, N. Ueda, K. Yamada

Ricoh, Japan

We have developed all-printed TFT with high work-function metal electrodes and novel oxide semiconductor in which carriers are generated by doping technique to make good contact with the electrodes. The TFT after forming planarization layer exhibited high mobility around 10 cm^2/Vs and high reliability against bias-temperature stress and illumination tests.

AMD6 - 4L
16:20

Self-Aligned Top-Gate InGaZnO Thin-Film Transistor Fabricated at 150°C Using Coatable Organic Insulator

T. Toda, Y. Magari, M. Furuta

Kochi Univ. of Tech., Japan

We fabricated self-aligned, top-gate InGaZnO thin-film transistors (IGZO TFTs) with a coatable organic insulator, Zeocoat, at a maximum process temperature of 150˚C. The IGZO TFT with a channel protection layer showed good switching properties; saturation mobility: 10.7 cm^2/Vs, subthreshold swing: 0.19 V/dec., and hysteresis: 0.2 V.

----- Break -----

16:50 - 18:25 **Ohmi 1**

AMD7: Advanced Si Technologies

Chair: B. S. Bae, Hoseo Univ., Korea
Co-Chair: T. Noguchi, Univ. of the Ryukyus, Japan

AMD7 - 1:
16:50

Invited **Solution-Processed LTPS on Paper**

R. Ishihara[,**], M. Trifunovic[*], P. Sberna[*], T. Shimoda[**]*

[*]Delft Univ. of Tech., the Netherlands
[**]JAIST, Japan

We introduce a novel method that allows polysilicon formation on paper directly from the liquid-silicon ink. Using this method, polysilicon TFTs were created at a maximum temperature of only 150˚C. This method allows printing of silicon devices on inexpensive, temperature sensitive substrates such as PET, PEN or paper.

AMD7 - 2: 17:15 ***Invited*** **Prospect of Low-Temperature Poly-Si, Poly-SiGe, Poly-Ge TFTs on Glass Substrate**

A. Hara, T. Meguro, Y. Nishimura, S. Nibe, H. Ohsawa

Tohoku Gakuin Univ., Japan

Now a day, mainstream of high on-current TFTs are oxide TFTs. However, polycrystalline group-IV TFTs are also attractive as system on panel due to capability of integration of CMOS circuit. In this paper, feasibility of low-temperature poly-Si, -SiGe, -Ge TFTs will be discussed based on our experimental data.

AMD7 - 3: 17:40 ***Invited*** **Smart Pixel TFT Circuits for High Image Quality AMOLED Displays**

O.-K. Kwon, K. Oh, N.-H. Keum

Hanyang Univ., Korea

We briefly review previously reported smart AMOLED pixel circuits using LTPS TFTs. Moreover, recent trend and state-of-the-art smart pixel TFT circuits are discussed.

AMD7 - 4 18:05 **Appearance of p-Channel TFT Performance with Metal Source-Drain Using BLDA Aiming for Low-Cost CMOS**

T. Ashitomi, T. Harada, K. Shimoda, T. Okada, T. Noguchi, O. Nishikata[*]*, A. Ota*[*]*, K. Saito*[*]

Univ. of the Ryukyus, Japan

[*]*ULVAC, Japan*

p-type top-gate TFT was fabricated with low temperature process below 490˚C using BLDA without adopting ion-implantation. In place of impurity doping, Au was used for source-drain region. After hydrogenation, the formed TFT showed typical p-type Vg-Id characteristics.

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Supporting Organizations:
Technical Committee on Electronic Information Displays, Electronics Society, IEICE
Thin Film Materials & Devices Meeting

Workshop on FPD Manufacturing, Materials and Components

Thursday, December 10

10:30 - 12:30 **Ohmi 6**

Poster **FMCp1: Materials and Components**

FMCp1 - 1 **Microstructure, Electric Properties and Chemical Bonds of Lead-Free Piezoelectric Thin Films**

C.-W. Su, C.-C. Chen, S.-Y. Chu, C.-C. Tsai[*]*, C.-H. Hung*[**]

Nat. Cheng Kung Univ., Taiwan
[*]Tung Fang Design Univ., Taiwan
[**]Nat. Kaohsiung Normal Univ., Taiwan

The lead-free non-stoichiometric piezoelectric $(Na_{0.5}K_{0.5})NbO_3$ films and lithium dopants $Li_x(Na_{0.5}K_{0.5})_{1-x}NbO_3$ were fabricated by sol-gel processing on $Pt(111)/TiO_2/SiO_2/Si(100)$ substrates. The effects of lithium doping on the microstructures and electrical properties of the samples were investigated. Finally, we found the remnant polarization and piezoelectric coefficient were improved effectively through doping lithium.

FMCp1 - 2 **High Energy Density for Energy Harvesting Devices of $(Ba_{0.98}Ca_{0.02})(Ti_{0.94}Sn_{0.06})O_3$ Piezoelectric Ceramics Fabricated by SiO_2 Modified**

Z.-Y. Chen, C.-C. Tsai[*]*, C.-S. Hong*[**]*, S.-Y. Chu, W.-H. Chao, H.-H. Hsieh*[*]

Nat. Cheng Kung Univ., Taiwan
[*]Tung Fang Design Inst., Taiwan
[**]Nat. Kaohsiung Normal Univ., Taiwan

The development of lead-free material system becomes the current trend for replacing the lead-based ones. This project aims to explore the $(Ba_{0.98}Ca_{0.02})(Ti_{0.94}Sn_{0.06})O_3$ doped x mol% SiO_2 (BCTS-xSi) materials system. This piezoelectric ceramic compound is a new test that with high energy density and to achieve the drive LED light.

FMCp1 - 3 **Recrystallization of Single Crystal 6,13-bis (triisopropylsilylethynyl)pentacene within LC**

H.-B. Park, H.-T. Jang, J.-H. Kim, C.-J. Yu

Hanyang Univ., Korea

We investigate the recrystallization of 6,13-Bis(triisopropylsilylethynyl) (TIPS) pentacene within liquid crystal. Single crystalline structure of the TIPS pentacene was grown up to a few hundred micro-meters within liquid crystal as a solvent. The large anisotropy of the single crystalline TIPS pentacene flake also was observed.

FMCp1 - 4 Characterization of Two Dimensional MoS_2 Produced by RF-Sputtering and Thermal Evaporation Methods

Y. J. Kim, T. K. Park, H.-N. Lee

Soonchunhyang Univ., Korea

We fabricated two dimensional (2D) MoS_2 thin-film using sputtering and thermal evaporation methods. Dependence of the MoS_2 thin-film characteristics on the deposition method and after-deposition heat treatment conditions was examined. Using the MoS_2 active layers, 2D thin-film transistors are being developed.

FMCp1 - 5 Slicing and Halftoning Algorithm for High Quality Color 3D Printing

C.-I. Lin, Y.-P. Sie, T.-H. Lin, P.-L. Sun

Nat. Taiwan Univ. of S&T, Taiwan

This paper focuses on color reproduction for light-curable type 3D printing technology. We proposed a volumetric slicing method with halftoning algorithm to simultaneously convert the color of 3D models into printable layers. The experimental result shows our method is able to improve the color quality, particularly for light-curable 3D printing.

FMCp1 - 6L $SrTiO_3$ Modified Lead-Free Ceramics Materials for Energy Harvesting Applications

H.-H. Su, C.-S. Hong[*], C.-C. Tsai[**], S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan
[*]Nat. Kaohsiung Normal Univ., Taiwan
[**]Tung Fang Design Inst., Taiwan

In this study, composition of potassium sodium niobate based ceramics were synthesized by the conventional solid-state reaction process. The phase formation and microstructures using X-ray diffraction and scanning electron microscope. When x = 0.003 had the best electrical property of k_p = 45% and d_{33} = 245 pC/N.

FMCp1 - 7L Disk-Type Piezoelectric Transformer of the CuF_2-Doped Potassium Sodium Niobate Lead-Free Ceramics for Driving LED Bar

C.-M. Weng, S.-Y. Chu, C.-C. Tsai[*], C.-S. Hong[**]

Nat. Cheng Kung Univ., Taiwan
[*]Tung Fang Design Inst., Taiwan
[**]Nat. Kaohsiung Normal Univ., Taiwan

In this paper, the development of $(Na_{0.5}K_{0.5})NbO_3 + xCuF_2$ ($NKNCF_x$, x = 0 - 3.5 mol%) ceramics were investigated. The best piezoelectric properties of $NKCF_x$ ceramics with k_p = 48%, Q_m = 2331 were obtained at x = 1.5. Furthermore, disk-type transformers have been developed for driving LED bar using proposed ceramics.

FMCp1 - 8L **Large-Area Uniform Film Formation and Optical Anisotropy of Soluble Organic Semiconductor Single Crystals in Liquid Crystal Solutions**

T. Matsuzaki, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

To achieve organic TFTs with high mobility, we examined large-area uniform-thickness orientation-controlled film formation of organic semiconductor single crystals by liquid crystal solvents. We clarified 800 nm-thick crystal films (maximum length: over 10 mm) have optical slow axes and stronger ultraviolet absorption axes perpendicular to rubbing direction of substrates.

10:30 - 12:30 **Ohmi 6**

Poster **FMCp2: Display Optics and Information Technologies**

FMCp2 - 1 **Emiflective Display with High Brightness Characteristics**

D.-M. Lee, S. I. Jo, Y.-J. Lee, J. H. Han, C.-J. Yu, J.-H. Kim

Hanyang Univ., Korea

We propose a high brightness emiflective display operated in a whole pixel configuration consisting of the OLED and TN LC cell which are used for backlight and reflector, and switching device, respectively. Emission and reflection mode acts simultaneously under dim environment without any optical path difference giving higher brightness characteristics.

FMCp2 - 2 **The Effect Phosphor-Gel Concentrations on the Extraction Light of White Light Emitting Diode**

T.-S. Zhan, C.-H. Chiang, K.-C. Cheng, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this article, the characteristics of extraction light of conventionally packaged white LEDs with different phosphor-gel concentrations were investigated. To dismiss the affections of other parameters as much as possible, all the samples were adjusted to have identical CIE coordinates, color temperature and curvature.

FMCp2 - 3 **Improved Lumens per Watt Efficiency of LED Using Light Recycling Technology for Lighting Applications**

K. Li

Wavien, USA

A standard white LED made from a blue LED coated with a yellow phosphor layer has lower efficiency at lower color temperature. This paper discloses the use of the recycling light technology for making low color temperature LEDs such that the lumens/watt efficiency is higher.

FMCp2 - 4L **The Design of Emit Structures for Hot Spot Free with All Kinds of Patterns in LGP**

Y. W. Chang, S. Liao, S. Y. Tsai
AU Optronics, Taiwan

We successfully develop a kind of emit structure named TAPS which could enhance BLU emitting efficiency >4% and improve LCM picture quality simultaneously without any side effects. TAPS is specially effective with bottom vcut pattern design, and could reduce hot spot area from 6 mm to 2 mm (300% improved).

10:30 - 12:30 **Ohmi 6**

Poster FMCp3: Manufacturing Technologies

FMCp3 - 1 **Issues and Developments of 1.2 µm Resolution Technologies for FPD Mass-Production**

N. Yabu, N. Izumi, Y. Nagai, T. Ooyanagi, M. Ando, K. Nagano
Canon, Japan

Although DUV is effective to obtain high resolution and large DOF, there are still some issues for FPD mass-production, such as CD difference between inner- and outer-lines for line & space pattern and high dose for contact hole. We investigate these issues by simulations and exposure tests.

FMCp3 - 2 **Design Consideration on Optical Fiber Layout for Laser Backlight Applications**

T. Kojima, T. Zanka, I. Fujieda
Ritsumeikan Univ., Japan

For a backlight unit based on a curved optical fiber, how the optical power is distributed inside a light-guide is mainly determined by its layout design. In experiment, we show that uniformity of light extraction is improved by positioning curved portions at four quadrants in a square light-guide.

FMCp3 - 3 **Fabrication of Quasi-Black Mask for LCDs by Selective Coating Technique Using an Electro-Spray Deposition Method**

Y. Kudoh, Y. Uchida, T. Takahashi
Kogakuin Univ., Japan

A novel technique to fabricate a quasi-black mask (q-BM) has been proposed; the q-BM was composed by the vertical and the hybrid orientation areas, which patterned by separation coating technique using an electro-spray deposition method. That can be formed easily without additional masks for the BM by using our technique.

FMCp3 - 4 **Cell Slimming for Curved Display to Enhance Strength**

S. M. Huang, J. K. Lu, C. -H. Liao, H. K. Chang, W. C. Wang, S. K. Lin

AU Optronics, Taiwan

Curved display is an extending application of the glass substrate. Ideal glass material can withstand a certain bending stress and forming a curvature, but defects of glass surface from process reduce bending degree. In this researching, we study and recommend a improving cell slimming process for enhance strength of panel.

FMCp3 - 5 **Research on Effect of the Multi Factors to Improve via Etch Uniformity and Profile**

X. Chang, Z. Cao, Z. Wang, C. Gao, J. Gao*, W. Deng, B. Zhang, J. Lv, Y. Choi*

Chongqing BOE Optoelect., China
**BOE Tech. Group, China*

In this paper, the effect of factors to Via etch uniformity and profile were researched at ICP etcher on G8.5 substrate. we find the best condition of Via etch can be got only using about ten sheet glasses, which is helpful for the application in other process development and optimization.

10:30 - 12:30 **Ohmi 6**

Poster FMCp4: Film Technologies

FMCp4 - 1 **Darkness Colorimetry of VA-LCDs : Factors and Performance**

L.-X. Chen, C.-T. Kang, C. Ning

Shenzhen China Star Optoelect. Tech., China

Color of dark status of VA-LCDs has been studied. It is found that the polarizer and color filter as well as voltage settings of 0 gray and backlight unit influence the result. This paper also illustrates the mechanism of these factors and gives some design suggestion.

FMCp4 - 2 **Growth of C_8-BTBT Films during Drop-Casting under an External Temperature Gradient**

N. Iizuka, T. Zanka, Y. Onishi, I. Fujieda

Ritsumeikan Univ., Japan

We generated a temperature gradient in a substrate by heat stages and drop-casted a C_8-BTBT solution on it. The growth direction of the thin film was initially along this external temperature gradient and it was reversed later. An AFM image confirmed 3nm-steps on the film region formed earlier.

FMCp4 - 3 **Viewing Angle Control Device Based on Array of Optical Micro-Rods with High Aspect Ratio**

K. Shiota, M. Okamoto, H. Tanabe

NLT Techs., Japan

We have successfully demonstrated a multi-axial viewing angle control film that ensures privacy from prying eyes from all directions. It consists of a light-transmitting portion formed using optical micro-rods with a high aspect-ratio and a shielding portion formed of cross stripes. The viewing angle can be controlled to within +/−30.

FMCp4 - 4L **Diffusion Angle Control of Light Diffusing Films Having Alternative Polymer Layer Structure**

S. Seo, M. Nishizawa, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

We focused on the light diffusing film having alternative polymer layer structure, and investigated the effects of ultraviolet illuminance and combination ratio of monomers on the layer structure and light diffusion property to control diffusion angle range. Moreover, we proposed a novel evaluation method using reflected light from layer structure.

----- Lunch -----

16:00 - 17:15 **Ohmi 3**

FMC1: Materials and Components

Chair: R. Yamaguchi, Akita Univ., Japan
Co-Chair: T. Tomono, Toppan Printing, Japan

FMC1 - 1: 16:00 ***Invited*** **High-Speed On-Chip Light Emitters Based on Nanocarbon Materials**

H. Maki

Keio Univ., Japan

We report the electrically driven, high-speed light emitters based on nanocarbon materials such as carbon nanotubes and graphene. This emitter, with the advantages of ultrafast response speeds, a small footprint and integration on silicon, can enable novel architectures for photonic and optoelectronic integrated devices.

FMC1 - 2: 16:20 ***Invited*** **Liquid Crystals for High Performance Organic Field Effect Transistors**

J. Hanna, H. Iino

Tokyo Inst. of Tech., Japan

We discuss how liquid crystallinity can be utilized for film fabrication process and for improvement of device performance, and demonstrate them with a highly ordered smectic liquid crystal of Ph-BTBT-10, which gives us excellent mobility of over 10 cm^2/Vs in its small variation, in addition to high thermal durability up to 200°C.

FMC1 - 3 16:40 **Coating ZnO:Zn Nanoparticles with Alumina for Polymer Protection**

J. Silver, R. Li, G. R. Fern, P. Bishop, B. Thiebaut**

Brunel Univ. London, UK
**Johnson Matthey Tech. Ctr., UK*

Using a modified preparation large nanoparticles of ZnO and ZnO:Zn were coated (without destroying the luminescent properties of the latter), but the coating is a layer of AZO not Al_2O_3. Large nanoparticles of ZnO:Zn were coated with a layer of ZnO by using only $(NH_4)HCO_3$ in the absence of Al_2SO_4.

FMC1 - 4L 17:00 **The Electrical and Optical Properties of Dielectrophoresis Purified Silver Nanowires Film as Transparent Electrode**

C. Wei, W. Fu

Tatung Univ., Taiwan

The sheet resistance and optical transmittance were investigated by dielectrophoresis purified silver nanowires coated on glass. The results show the DEP purified AgNWs exhibit better electric resistance and optical transmittance. DEP force that dispersed the agglomerated AgNWs is the mechanism.

----- Break -----

17:40 - 18:55 **Ohmi 3**

FMC2: Display Optics and Information Technologies

Chair: K. Kurokawa, Entegris Japan, Japan
Co-Chair: A. Fujita, JNC, Japan

FMC2 - 1: 17:40 ***Invited*** **Recent Progress of Visible Light Communication**

S. Haruyama

Keio Univ., Japan

New devices for visible light communication are proposed such as image sensor as receiver and DMD as transmitter. Capability of image sensor to detect accurate direction of incoming data and of DMD to control direction of transmitted data will be a key enabler to realize useful applications.

FMC2 - 2: 18:00 ***Invited*** **Requirements for Diagnostic Monitors and Supporting Latest Image Processing Technologies**

Y. Bamba, M. Ogaki, M. Kita, S. Tokurei[,**], K. Shiotsuki[***], J. Morishita[*], A. Hayashi, Y. Ohoto*

EIZO, Japan
[*]Kyushu Univ., Japan
[**]Yamaguchi Univ. Hospital, Japan
[***]Oita Univ. Hospital, Japan

Medical monitors have many special requirements distinguished in guidelines and standards of countries which are introduced in this paper. Then, this paper describes our image processing technology necessary for diagnostic monitors, performance of which should be the highest in medical monitors, to have an optimized display performance in image sharpness.

FMC2 - 3 18:20 **Panels with 100% Coverage of Adobe in LED Light Source Used Displays and Lifetime Estimation**

I.-H. Hsieh, S. CW. Wang, S. Hsieh

AU Optronics, Taiwan

We have performed several high color gamut (HCG) displays which achieve 90% up Adobe RGB coverage and 100% up NTSC (CIE 1931), thereby providing lifetime estimation. The 100% Adobe RGB coverage panels' LED light source solutions are discussed.

FMC2 - 4L 18:40 **Prototyping of LED Color Generator for Imaging Systems with Wide Gamut**

H. Suzuki, H. Urabe[*], M. Katoh[**], Y. Shimodaira[*]

Nobuo Elect., Japan
[*]Shizuoka Univ., Japan
[**]Papalab, Japan

For colorimetric image capture and reproduction a "ruler" is required to characterize color reproduction property of imaging systems. Prototyping of a programmable light emission system as the ruler was made. It employs plural LEDs and aims to display colors over wider gamut than conventional printed color targets.
Also presented in Innovative Demonstration Session (see p. 205)

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:00 **Ohmi 5**

FMC3: Manufacturing Technologies

Chair: T. Arikado, Tokyo Electron, Japan
Co-Chair: T. Nonaka, Merck Performance Materials, Japan

FMC3 - 1: 9:00 ***Invited*** **Planarized Stainless Steel Foil for Flexible Substrate**

N. Yamada, S. Yamaguchi, J. Nakatsuka, Y. Hagiwara, K. Uemura*

Nippon Steel & Sumitomo Metal, Japan
**Nippon Steel & Sumikin Materials, Japan*

In order to study the possibility of metal foil as a flexible substrate, stainless steel foil with a planarization layer was produced by both spin-coating and R2R-coating. Outgas from the planarization layer was found to be negligibly small. Prototype OLED lighting device was successfully fabricated on both substrates.

FMC3 - 2: 9:20 ***Invited*** **High Resolution Printed Patterning by Using Seamless Roller Mold (SRM) Technology**

T. Tanaka, T. Kitada, M. Abe, N. Ito, M. Oshikata, M. Ataka, T. Kishiro*, S. Matsui***

Asahi Kasei, Japan
**Holon, Japan*
***Univ. of Hyogo, Japan*

For the future electronics devices, like printed electronics, Asahi-Kasei has been developing SRM fabrication technology. We got fine and accurate patterns on the roller surface by development applied process of conventional EB lithography, named rEBL process. This paper shows the detail of rEBL process and demonstrated patterns on plastic substrates.

FMC3 - 3 9:40 **Ultra Thin LTPS-TFT LCD by Using New Technology**

C.-H. Liao, T.-C. Fan, M.-C. Tsai, L.-K. Chia, W.-S.Wang, C.-H. Chan, J.-K. Lu, N. Sugiura

AU Optronics, Taiwan

A new technology was developed and applied to LTPS TFT-LCD. A newly optimized adhesion layer SiON successfully provided easily peeling of the glass from the carrier even after LTPS high temperature process. Finally an ultra thin LTPS TFT-LCD whose total thickness is 0.915 mm was realized by the new technology.

FMC3 - 4 **Withdrawn**

----- Break -----

10:40 - 11:40 **Ohmi 5**

FMC4: Film Technologies

Chair: Y. Yang, China Star Optoelect. Tech., China
Co-Chair: Y. Saitoh, FUJIFILM, Japan

FMC4 - 1
10:40 **Control of Three Dimensional Birefringence of an Uniaxial Oriented Film by Using Two Different Types of Nanoparticles**

K. Takatoh, M. Akimoto, N. Yasutomo, T. Abo**

Tokyo Univ. of Sci. Yamaguchi, Japan
**Kaneka, Japan*

For LCD optical compensation films, both controls of ΔN_{xy} and ΔP have been expected. It was found that by using plural number of nanoparticles possessing different type of refractive index distributions, like $n_x < n_y = n_z$ and $n_x n_y > n_z$, both of two birefringence ΔN_{xy} and ΔP of uniaxial stretched film could be controlled.

FMC4 - 2
11:00 **Development of Super Retardation Film (SRF) and Its Application to Substrates of Polarizing Plates**

Y. Sasaki, K. Murata, T. Oya, T. Suzuki

TOYOBO, Japan

COSMOSHINE SRF is a new PET film which eliminated iridescence (Rainbow-mura) derived from birefringence. In this report, the application of SRF to the substrate of polarizing plates is proposed. By this application, the reliability of LCDs is remarkably improved.

FMC4 - 3
11:20 **Simulation and Design of MIM Nanoresonators for Color Filter Applications**

S. Banerjee

Sumitomo Chem., Japan

We simulated metal-insulator-metal nanoresonator structures that can be realized by sandwiching an insulator layer between two metal grating layers with subwavelength periods and heights. Results indicate that such structures employing relatively low refractive index polymeric materials can function as color filters with reasonably narrow bandwidths in transmission mode.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

15:10 - 16:10 **Ohmi 9**

FMC5: Augmented Reality and Virtual Reality

Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: K. Käläntär, Global Optical Solutions, Japan
Co-Chair: I. Amimori, SN Partners, Japan

FMC5 - 1: 15:10 ***Invited*** **Real-Time Dynamic Holographic 3D Display in Materials to Future Holographic 3D Televisions**

H. Gao, J. Liu, C. Zeng, Q. Yao, P. Liu, Y. Yu, H. Zheng, Z. Zeng

Shanghai Univ., China

We have realized real-time dynamic holographic 3D display in materials, which makes it possible to build large-size, high resolution, and video rate true 3D television or projector. In this talk, we will present property of our holographic display materials and their applications in future 3D displays.

FMC5 - 2: 15:30 ***Invited*** **Aerial Three-Dimensional Display Based on Retro-Reflective Optical Imaging**

D. Miyazaki, Y. Maeda[*], S. Onoda, Y. Tokubo, S. Murakami, R. Tamaki, T. Mukai

Osaka City Univ., Japan
[*]Parity Innovations, Japan

Imaging with a retro-reflective optical element can provide floating image formation with a wide view angle, because it has low-distortion in spite of high numerical aperture. Three-dimensional display technologies based on retro-reflection with mirror arrays, a dihedral corner reflector array and a roof mirror array are described.
Also presented in Innovative Demonstration Session (see p. 205)

FMC5 - 3 15:50 **Polarization State Analysis for Polarized Aerial Imaging by Retro-Reflection (PAIRR)**

M. Nakajima[*], K. Onuki[*], I. Amimori[**], H. Yamamoto[,***]*

[*]Utsunomiya Univ., Japan
[**]SN Partners, Japan
[***]JST, CREST, Japan

This paper investigates polarization state of the reflected light from retro-reflector in order to improve the brightness of the polarized aerial imaging by retro-reflection (PAIRR). We have confirmed the importance of the effective reflectance. Then, we have found one of the suitable prism type reflector for the PAIRR.

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

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

Evening Get-Together with Wine

Tuesday, Dec. 8, 2015
18:00 – 20:00
Hiei (2F)
Otsu Prince Hotel
(Sponsored by Merck Ltd., Japan)
See page 12 for details

IDW Best Paper Award

IDW Outstanding Poster Paper Award

These awards will go to the most outstanding papers selected from those presented at IDW ’15.
The 2015 award winners will be announced on the IDW website: http://www.idw.or.jp/award.html

Workshop on EL Displays and Phosphors

Thursday, December 10

9:00 - 10:25 **Ohmi 2**

PH1: Phosphors for Lighting Application
Special Topics of Interest on Lighting Technologies

Chair: A. Meijerink, Utrecht Univ., the Netherlands
Co-Chair: K. Wani, TAZMO, Japan

PH1 - 1: 9:00 ***Invited*** **High Directional LED Lighting for Forming Pattern, HOLOLIGHT: Its Business Developments and Prospects**

T. Ikeda

Pi Photonics, Japan

HOLOLIGHT is a unique patented LED lighting for forming pattern comprising square, round, line and arch. They have a lot of applications for inspection, stage, architecture, road, safety, art, sightseeing, laboratory, entertainment and so on.
Also presented in Innovative Demonstration Session (see p. 205)

PH1 - 2: 9:25 ***Invited*** **The GE TriGain Phosphor Based upon $K_2SiF_6:Mn^{4+}$ and Its Use in LED Lighting and LCD Backlights**

A. A. Setlur, F. Garcia, J. E. Murphy, S. P. Sista

GE Global Res., USA

Narrow-emitting downconverters, like GE's TriGain $K_2SiF_6:Mn^{4+}$ phosphor, improve both brightness and color quality for general lighting and LCD backlights. We discuss the performance of TriGain phosphors, focusing on how better phosphor chemistry gives higher efficiency, reliability, and lower phosphor usage. TriGain phosphors are commercially available from GE Lighting.

PH1 - 3 9:50 **The Synthesis, Characterisation and Potential of Eu^{3+} Doped Molybdate Phosphors for White Light Emitting Diodes**

A. Lipman, M. Fathullah, R. Stone, G. R. Fern, T. G. Ireland, C. Frampton, J. Silver

Brunel Univ. London, UK

A wide variety of Eu^{3+} doped molybdate phosphors were synthesised using the solid state reaction route and their photoluminescent properties were compared. Their crystal structures were investigated. A relationship between cell size and emission intensity was apparent. The implications of this for phosphor design are discussed.

PH1 - 4L 10:10 **White LEDs Using Sharp β-sialon:Eu Phosphor and K_2SiF_6:Mn Phosphor for Wide-Color Gamut Display Application**

K. Yoshimura, H. Fukunaga, M. Izumi, M. Masuda, T. Uemura, K. Takahashi, R.-J. Xie*, N. Hirosaki**

Sharp, Japan
**NIMS, Japan*

Sharp β-sialon:Eu ($Si_{6-z}Al_zO_zN_{8-z}$:Eu $0<z<0.1$) green phosphor is suitable for wide-color gamut white LEDs backlighting system because of its sharp and asymmetric emission spectrum shape. In this work, red phosphors are investigated for the purpose for improvement of the display color gamut.
Also presented in Innovative Demonstration Session (see p. 206)

----- Break -----

10:30 - 12:30 **Ohmi 6**

Poster PHp1: Phosphors

PHp1 - 1 **Photoluminescence Study of Symmetry-Related Transitions in the Spectrum of Y_2O_3:Tb^{3+}**

D. den Engelsen, J. Silver, T. G. Ireland, G. R. Fern, P. G. Harris

Brunel Univ. London, UK

Herein we describe the results of a study on the photoluminescence of cubic nanosized Y_2O_3:Tb^{3+}. These results confirm our earlier conclusions based on cathodoluminescence about the energy flow from excited Tb^{3+} in a S_6 lattice site to Tb^{3+} in a C_2 site.

PHp1 - 2 **Blue and Red Cathodoluminescent Emission of Y_2O_3:Eu Phosphor Studied as a Function of Temperature in a Transmission Electron Microscope**

G. R. Fern, A. Lipman, J. Silver, A. Howkins, T. G. Ireland, P. Marsh, D. den Engelsen

Brunel Univ. London, UK

Combined EELS, CL and STEM imaging are used to characterize and study Y_2O_3:Eu to confirm the variation in CL properties and photoluminescent properties observed. The synthetic procedures used have facilitated this material to manifest a strong blue emission at low temperature with the expected red emission dominating at room temperature.

PHp1 - 3 **Withdrawn**

PHp1 - 4 **Multiple Quantum Dot Layers by Electrospray Method for White Light Emitting Diodes**

J. Jeong, N. Kim, H. Chae

Sungkyunkwan Univ., Korea

We made the white QD-LED by staking of R, G and B quantum dots with electrospray deposition. We studied on the device controlling carriers by changing hole transport layer. It was analyzed for förster resonance energy transfer. The maximum brightness and current efficiency reached 1,112 cd/m^2 and 2.60 cd/A.

PHp1 - 5 **Withdrawn**

PHp1 - 6 **Photoluminescence Properties of ZnO Nanorods on AZO Substrates Synthesized by Different Methods**

C. Li, S. Hou

Kochi Univ. of Tech., Japan

The ZnO nanorods on AZO thin films were synthesized by chemical bath deposition and reducing annealing methods. Both kinds of ZnO nanorods showed vertical alignment with high transmittance. However, the photoluminescence from ZnO nanorods obtained from annealing method had much strong blue-green intensity. The emission mechanism is discussed in detail.

PHp1 - 7 **Enhancement of Powder EL Performance by Mixing Two Kinds of ZnS Phosphors with Donor or Acceptor Type Activator**

K. Wani, T. Kanda, E. Hashimoto

TAZMO, Japan

Enhancement of luminance and efficacy was observed for powder dispersed type inorganic EL, in which two kinds of ZnS phosphor powders were mixed as emission materials in the phosphor layer. The enhancement was observed when one type of phosphor is Cu-activated, and the other is Al or Cl-activated.

PHp1 - 8L **Continuous Hydrothermal Synthesis of YVO_4:Eu,Bi Nanophosphor Using Flow Channel and Microwave Heating**

T. Kunimoto, Y. Fujita, H. Okura[*]

Tokushima Bunri Univ., Japan

[*]*Merck, Japan*

A continuous solution synthesis of nanophosphor was succeeded through the rapid hydrothermal method using a microwave heating. The internal quantum efficiency of YVO_4:Eu,Bi nanophosphor obtained by microwave heating is about 30% at 320 nm as high as that obtained by conventional autoclave treatment.

PHp1 - 9L **Influence of Fe Doping for Luminescent Properties of Phosphors**

K. Akao, H. Kominami, K. Hara, Y. Nakanishi

Shizuoka Univ., Japan

We investigated the influence of the phosphors on Fe-doping. D-A pair and oxygen-defect phosphor was strongly influenced, on the other hand, $SrTiO_3$:Pr showed different property by Fe-doping. Interestingly, CL property was almost independent of Fe-addition. It is thought that Fe might be formed the conductive layer on the phosphor surface.

PHp1 - 10L **Synthesis and Luminescent Properties of Eu Doped Sr-Al-O Phosphor**

T. Akahori, H. Kominami, K. Hara, Y. Nakanish

Shizuoka Univ., Japan

Eu-doped Sr-Al-O phosphor for phosphorescent material was studied. According to increase of firing temperature, $SrAl_2O_4$ phase became dominant. Annealing in reduced atmosphere was necessary to obtain Eu^{2+} emission. The phosphor fired for 6 hours showed the highest PL intensity. Preparation with reduced Sr ratio was important to avoid $Sr_3Al_2O_6$ formation.

PHp1 - 11L **Preparation and Luminescent Properties of Ultra Violet Emitting $ZnAl_2O_4$ Thin Film by Thermal Diffusion**

T. Ito, H. Kominami, Y. Nakanishi, K. Hara

Shizuoka Univ., Japan

$ZnAl_2O_4$ film was prepared by ZnO deposition on sapphire and thermal diffusion by annealing. From XRD and CL, it is shown that UV emitting $ZnAl_2O_4$ layer was formed and the crystallinity was improved by annealing time. It is thought that sufficient thermal diffusion occurs between the Al_2O_3 substrate and ZnO film.

PHp1 - 12L **The Study of Enhanced Photoluminescence : $CaTiO_3:Pr^{3+}$ Red Phosphors by the Ammonolysis Method**

*S. H. Lee, S. J. Lee, H. S. Lee, W. B. Son, S. J. Kim, Y. S. Kim, S. Kikkawa**

Hyosung RnD Ctr., Korea

**Hokkaido Univ., Japan*

The produced phosphors were characterized with regards to enhance photoluminescence properties. The ammonolysis method treated samples shown that red emission was enhanced from $CaTiO_3:Pr^{3+}$ phosphors and qualifies these phosphors for further consideration as promising candidates for UV region convertible phosphors in light-emitting devices.

PHp1 - 13L **Great Influence of Inorganic Salts for Controllable Synthesis of YF_3:Yb^{3+}/Er^{3+} Nanocrystals**

G. Murali, R. K. Mishra, J. M. Lee, B. H. Lee, H. G. Ham, J. H. Kim, D.-K. Lim[*], S. H. Lee

Chonbuk Nat. Univ., Korea
[*]Korea Univ., Korea

Shape controllable synthesis of YF_3:Yb^{3+}/Er^{3+} upconversion nanoparticles is of significant importance for understanding the shape dependent properties as well as for exploration of potential applications. Herein, YF_3:Yb/Er nanorods and nanoneedles were selectively synthesized using $CaCl_2.2H_2O$ and KNO_3 inorganic salts, respectively.

PHp1 - 14L **Electroluminescence from DC Biased ZnS:Mn Phosphor Layers Having Cu_2O Semiconductor**

K. Hashimuko, K. Yanagihara, N. Miura

Meiji Univ., Japan

DC inorganic electroluminescence (EL) devices having p-type Cu_2O semiconductor were proposed. The phosphor layers were formed on n-p-n structure which acts as not only current control but also hot electron source. P-type Cu_2O was prepared by oxidization of Cu sheet. This device shows the electroluminescence from low driving voltage region.

PHp1 - 15L **Reduced Efficiency Roll-off in Inverted Quantum-Dot Light Emitting Diodes Using Metal Oxide ETL**

E. Hwang, H.-M. Kim, J. Lee, J. Kim

Kyung Hee Univ., Korea

This research reviews the reduced efficiency roll-off property of yellow-emitting quantum-dot light-emitting diodes (Y-QLEDs) using metal oxide electron transport layer (ETL). The efficiency roll-off is improved from 27% to 10% at 10,000 cd/m^2 with increasing the ETL thickness up to 120 nm.

PHp1 - 16L **First Principle Calculations for Estimating Charge Transfer State Energy of Eu^{3+} Centers in Ionic and Covalent Host Materials**

R. Yoshimatsu[,**], M. Okada[*], T. Ishigaki[***], K. Ohmi[*], S. Watanabe[****]*

[*]Tottori Univ., Japan
[**]Denka, Japan
[***]TiFREC, Japan
[****]Nagoya Univ., Japan

The first principles calculations have been performed for estimating the charge transfer state (CTS) energy of Eu^{3+} centers activated in several ionic and covalent host materials. It has been found that the CTS energy correlates well with the effective charge values of La ions in each host material.

10:30 - 12:30 **Ohmi 6**

***Poster* PHp2: Phosphors for Lighting Application**
Special Topics of Interest on Lighting Technologies

PHp2 - 1 **The Enhancement on Photoluminescence Characteristics of $Ba_{1-x}ZrSi_3O_9:xEu^{2+}$ Phosphors by Sr^{2+} Substituting**

K.-C. Cheng, C.-H. Chiang, T.-S. Zhan, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this article, single-phase $Ba_{(1-x)}ZrSi_3O_9:xEu^{2+}$, Sr^{2+} phosphors were synthesized via the solid-state reaction method. The crystal structure and luminescence properties were investigated using X-ray diffraction and photoluminescence measurements, respectively. An increase of the dopant Sr^{2+}, increased the emission intensity of the phosphors.

PHp2 - 2 **Effects of Fluxes on Luminescent Properties of YAG:Ce Phosphors and Their Application to White Light-Emitting Diodes**

C.-H. Chiang, T.-S. Zhan, K.-C. Cheng, S.-Y. Chu

Nat. Cheng Kung Univ., Taiwan

In this work, the dependence of amount of the fluxes (H_3BO_3 and BaF_2) on the luminescence of $Y_{2.95}Al_5O_{12}:0.05Ce^{3+}$ phosphors and their application to white light-emitting diodes were investigated. The difference in luminescent properties of phosphor prepared with BaF_2 and H_3BO_3, was well explained by the powder morphology.

PHp2 - 3 **High Directivity Light Source Based on Photonic Crystal Structure**

C. C. Chiu, F.-L. Hsiao

Nat. Changhua Univ. of Education, Taiwan

The light-emitting diodes (LED) have been widely applied in projector displays and backlight. Especially, 3D display need highly directional and High brightness light source. Some research also proved to limit the light in specific area with the characteristics of photonic crystal band gap so as to enhance the light extraction rate.

PHp2 - 4 **Synthesis and Luminescent Properties of Novel Ce^{3+}- and Eu^{2+}-Doped $La_3Br(SiS_4)_2$ Bromothiosilicate Phosphors for White LEDs**

S.-P. Lee, T.-M. Chen

Nat. Chiao Tung Univ., Taiwan

Novel Ce^{3+}- and Eu^{2+}-doped $La_3Br(SiS_4)_2:Ce^{3+}/Eu^{2+}$ bromothiosilicate phosphors were prepared in a sealed ampule. The $La_3Br(SiS_4)_2:Ce^{3+}$ phosphor is excitable at 370 to 400 nm and generates a cyan emission, and the $La_3Br(SiS_4)_2:Eu^{2+}$ phosphor can be excited over a broad range from UV to blue and generates a red broadband emission.

----- Lunch -----

16:00 - 17:10 **Ohmi 2**

PH2: Phosphor for General

Chair: A. A. Setlur, GE Global Res., USA
Co-Chair: R.-J. Xie, NIMS, Japan

PH2 - 1: 16:00 ***Invited*** **Light from Lanthanides**

A. Meijerink

Utrecht Univ., the Netherlands

Lanthanides form a prominent class of luminescent ions for wLEDs and displays. Here we discuss important challenges including temperature quenching in YAG:Ce and narrow band emitting QDs. Recent development for the emerging class of Ln-doped luminescent nanocrystals will be discussed.

PH2 - 2: 16:25 ***Invited*** **Chemical Control of Crystal Structure and Photoluminescence in Oxonitridosilicate Phosphors**

R.-S. Liu

Nat. Taiwan Univ., Taiwan

To improve the color rendering index, correlated color temperature and thermal stability of layer-structured $MSi_2O_2N_2$:Eu (M = Sr, Ba) phosphors, cation substitutions have been used to adjust their luminescent properties. This study serves as a guide in developing oxynitride luminescent materials with controllable optical properties based on variations in local coordination environments through cation substitutions.

PH2 - 3 16:50 **Studies on the Infrared Emitting ZnCdS:Cu, In, Cl Phosphors –Phosphors for Marking, Coding, and Identification–**

J. Silver, P. J. Marsh, G. R. Fern

Brunel Univ. London, UK

$Zn_{1-x}Cd_xS:Cu_{0.03\%}$,Cl infrared emitting phosphors have been synthesized by an aqueous thermal decomposition method. Co-doping $Zn_{1-x}Cd_xS:Cu_{0.03\%}$ with In^{3+} increased the infrared emission intensity by up to 50% over that of the equivalent $Zn_{1-x}Cd_xS:Cu_{0.03\%}$ phosphor with no indium co-doping, with the highest intensities being where x = 0.7-0.8.

----- Break -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:00 **Ohmi 8**

PH3: Phosphor Application

Chair: J. Silver, Brunel Univ. London, UK
Co-Chair: R.-S. Liu, Nat. Taiwan Univ., Taiwan

PH3 - 1 9:00 **Inverted Quantum Dot Light-Emitting Diodes with CdSe/ZnS and $CuInS_2$/ZnS Quantum Dots**

M. Hishinuma, J. Maki, T. Fukuda, N. Kamata, Z. Honda
Saitama Univ., Japan

Since quantum dot light-emitting diodes have been interested as novel emitting devices due to the high stability and the controlled emission wavelength, several structures have been investigated. In this study, we succeeded in stabilizing the current density-voltage characteristics by optimizing the washing process of the synthesized $CuInS_2$/ZnS quantum dot.

PH3 - 2: 9:20 ***Invited*** **Polarized Emission of Quantum Rods Dispersed Nanofiber Sheet**

M. Hasegawa, Y. Hirayama, S. Dertinger
Merck, Japan

We fabricated a sheet of aligned electrospun polymer nanofibers embedded with semiconductor quantum rods and confirmed the production of polarized fluorescence emission. The thickness and polarization ratio of the sheet were 1.5 microns and 0.6, respectively. We also examined the effect of electrospinning parameters on the polarization ratio.

PH3 - 3 **Withdrawn**

PH3 - 4L 9:45 **Seeded Growth in Continuous Flow: Synthetical Insights into CdSe/CdS Nanorods for Optoelectronic Devices**

T. Jochum[*], J. S. Niehaus[*], H. Weller[,**]*
[*]Ctr. for Appl. NanoTech., Germany
[**]Univ. of Hamburg, Germany

Hereby we present a novel synthetic approach for producing high quality CdSe/CdS nanorods for optoelectronic devices. The synthesis is based on the continuous flow technique allowing high reproducibility, user friendly handling and facile up-scaling procedure for industrial demand.

----- Break -----

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

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

PH

Workshop on Field Emission Displays, CRTs and Plasma Displays

Friday, December 11

10:40 - 10:45 **Ohmi 3**

Opening

Opening Remarks
10:40

H. Mimura, Shizuoka Univ., Japan

10:45 - 12:25 **Ohmi 3**

FED1: Advanced Technologies and FE Mechanism

Chair: M. Nagao, AIST, Japan
Co-Chair: Y. Neo, Shizuoka Univ., Japan

FED1 - 1: 10:45 ***Invited*** **Coherent Electron Source: Single-Atom Electron Emission Source**

C. Oshima

Waseda Univ., Japan

We review our recent results concerned with basic electron emission properties of single-atom electron sources, and their applications to the low-energy SEM and TEM. Except their energy widths, all the others such brightness, stability, collimation of the observed electron beams have been excellent in comparison with conventional ones.

FED1 - 2 11:25 **Field Emission Characteristics from Molybdenum (100) Surface with Thin Yttrium Oxide Layer**

*T. Kawakubo, T. Kitani, H. Nakane**

Nat. Inst. of Tech. Kagawa College, Japan
**Muroran Inst. of Tech., Japan*

In this research, we observed the electron emission from yttrium oxide/ molybdenum(100) emitter sample which is a molybdenum sharp needle modified yttrium oxide.

FED1 - 3
11:45

Deposition of Glycine Molecules on Tungsten Emitter and Observation of Its Surface with Field Ion Microscope

N. Nyuba, M. Okada, H. Tsuji, Y. Gotoh
Kyoto Univ., Japan

Glycine was deposited on a tungsten needle, and its surface was observed by field ion microscope. The position of the field desorbed spots was analyzed by calculating the image intensities before and after desorption. It was found that bright spots were localized around the ridge.

FED1 - 4
12:05

Surface Activation of GaAs Photocathode and Its Photoemission Characteristics

T. Masuzawa, K. Mitsuno, Y. Hatanaka, Y. Neo, H. Mimura
Shizuoka Univ., Japan

In this study, surface activation process of GaAs photocathode was investigated. Spectral sensitivity of the photocathode with different surface conditions showed that surface activation by alternative Cs and O exposure forms negative-electron-affinity surface on GaAs, enhancing its photoemission.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 15:10 **Ohmi 3**

FED2: FEA Fabrication Process and Novel Materials

Chair: F. Wakaya, Osaka Univ., Japan
Co-Chair: H. Shimawaki, Hachinohe Inst. Tech., Japan

FED2 - 1
13:30

Revised Fabrication of Volcano-Structured Double-Gate Spindt-Type FEA

M. Nagao, Y. Gotoh[*], T. Masuzawa[**], Y. Neo[**], H. Mimura[**]
AIST, Japan
[*]Kyoto Univ., Japan
[**]Shizuoka Univ., Japan

Volcano-structured double-gate Spindt-type FEA is fabricated for the image sensor application. The fabrication is revised in order to improve the beam focusing characteristics. The beam spot diameter of 50 μm is achieved at the emission current of 1 μA which is necessary for imaging operation.

FED2 - 2
13:50

Effect of Electrode Geometry on Focusing Property of Volcano-Structured Double-Gate Spindt-Type FEAs

Y. Gotoh, H. Tsuji, M. Nagao[*]

Kyoto Univ., Japan
[*]AIST, Japan

Effect of the electrode geometry on the focusing properties of volcano-structured double-gate Spindt-type FEAs was investigated by computer simulation. Several different geometries of the gate and the focusing electrode were examined, and it was found that the radius of the focusing electrode gave no significant difference in the focusing property.

FED2 - 3
14:10

Electrostatic-Focusing FEA-HARP Image Sensor with Volcano-Structured Spindt-Type FEA

Y. Honda[,**], M. Nanba[*], K. Miyakawa[*], M. Kubota[*], M. Nagao[***], Y. Neo[**], H. Mimura[**], N. Egami[****]*

[*]NHK, Japan
[**]Shizuoka Univ., Japan
[***]AIST, Japan
[****]Kinki Univ., Japan

An electrostatic-focusing FEA-HARP (high-gain avalanche rushing amorphous photoconductor) image sensor with volcano-structured Spindt-type FEA was fabricated and tested. Experimental results showed that higher electron-beam current was extracted from the volcano-structured FE than from conventional double-gated FE and this sensor could obtain images by utilizing the effect of electrostatic focusing.

FED2 - 4
14:30

Field Emission from Volcano-Structured Silicon Field Emitter Arrays under Pulsed Laser Illumination

H. Shimawaki, M. Nagao[*], Y. Neo[**], H. Mimura[**], F. Wakaya[***], M. Takai[***]

Hachinohe Inst. of Tech., Japan
[*]AIST, Japan
[**]Shizuoka Univ., Japan
[***]Osaka Univ., Japan

We investigate the photoresponse of a p-type silicon field emitter array under irradiation of laser pulses for generating of pre-bunched electron beam. The measured rise and fall times of the emission current were improved to less than 2 ns by using the emitters with volcano structure.

FED2 - 5 14:50 **Fabrication of GOS (Graphene/Oxide/ Semiconductor) Type Electron Emission Devices**

S. Tanaka, K. Murakami, M. Nagao, J. Fujita*

Univ. of Tsukuba, Japan
**AIST, Japan*

The graphene was used as the topmost electrode for the metal/oxide/ semiconductor type electron emission devices. The 3~4 layer graphene electrode on the thin oxide layer was directly deposited by gallium vapor-assisted chemical vapor deposition. The maximum electron emission efficiency was approximately 0.2%.

----- Break -----

15:20 - 16:40 **Ohmi 3**

FED3: Flexible Light Source Using Plasma Technologies

Chair: H. Kajiyama, Tokushima Bunri Univ., Japan
Co-Chair: T. Shiga, Univ. of Electro-Commun., Japan

FED3 - 1 15:20 **A Mechanism of Photochromic Transition of Semiconductor Nanoparticles**

H. Kajiyama, T. Kawamoto, K. Uchino, K. Takata**, S. Inoue****

Tokushima Bunri Univ., Japan
**Kyushu Univ., Japan*
***Kansai Univ., Japan*
****Hiroshima Univ., Japan*

Semiconductor nanoparticles are synthesized using a VHF plasma assisted chemical vapor deposition apparatus. Such nanoparticles show a photochromic transition by UV irradiation. The effects of particle size and baking temperature on the stability of the photochromic states are investigated. The possible mechanisms of the photochromic transition are discussed.

FED3 - 2 15:40 **Pulse Lighting Effect on the Photosynthesis of Leaf Vegetables**

S. Nagahara, T. Kono, S. Funai, H. Kajiyama

Tokushima Bunri Univ., Japan

The effects of pulsed lighting on leaf vegetables are investigated using a new type of plasma light source. It is confirmed that pulsed lighting is the efficient way to promote photosynthesis with less energy. The electric power consumption of plasma light source is estimated to be 10% of LED.

FED3 - 3L **Dependence of Luminous Efficacy on Electrode**
16:00 **Gap in Ultra Thin Discharge Tube**

K. Komatsu, T. Shiga

Univ. of Electro-Commun., Japan

Luminous efficacy in the ultra thin discharge tube having a cross section 1.0 mm × 0.55 mm increases as the electrode gap increases. When the discharge tube with 4 mm gap is driven at 100 kHz, 325 V, green luminance and luminous efficacy are 3900 cd/m^2 and 10.2 lm/W.

FED3 - 4L: ***Invited*** **Current Status of the Flexible Surface Light**
16:15 **Source Development Using LAFi Technology**

K. Awamoto, H. Hirakawa, B. Guo, T. Shinoda

Shinoda Plasma, Japan

A Luminous Array Film (LAFi) technology, that is a flexible surface light source device, can generate light from visible to deep ultraviolet. We developed a new device structure of LAFi, and found the good characteristics without mercury for a deep UV light source for medical and several industrial applications.

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Supporting Organizations:
JSPS 158th Committee on Vacuum Nanoelectronics
Technical Meeting on Plasma Science and Engineering

Workshop on OLED Displays and Related Technologies

Wednesday, December 9

13:30 - 14:45 **Ohmi 1**

OLED1: Advanced OLED Technologies I

Chair: K. Monzen, Nissan Chem., Japan
Co-Chair: T. Wakimoto, Merck, Japan

OLED1 - 1: 13:30 ***Invited*** **Recent Progress on the Understanding of Molecular States in OLED Films: Molecular Orientation, Packing, and Mixing**

D. Yokoyama

Yamagata Univ., Japan

Along with the continuous progress on the device performance of OLEDs, the importance of fundamental understanding of their amorphous films has been increasing to further improve their efficiency and stability. This presentation reviews the recent progress on the understanding of molecular states, especially focusing on molecular orientation, packing, and mixing.

OLED1 - 2: 13:50 ***Invited*** **Recent Advances in Understanding of the Electronic Processes in OLEDs**

J.-J. Kim

Seoul Nat. Univ., Korea

Recent advances in the understanding of the electronic processes including the triplet harvesting by fluorescent molecules, emitting dipole orientation of phosphorescent dyes and its influence on efficiency, degradation and recombination in OLEDs are discussed based on our most recent works using Intermolecular excited state charge transfer complexes.

OLED1 - 3 14:10 **Durability of Flexible Display Using Air-Stable Inverted Organic Light-Emitting Diodes**

T. Tsuzuki, G. Motomura, Y. Nakajima, T. Takei, H. Fukagawa, T. Shimizu, M. Seki[*]*, K. Morii*[**]*, M. Hasegawa*[**]*, T. Yamamoto*

NHK, Japan
[*]NHK Eng. Sys., Japan
[**]Nippon Shokubai, Japan

We fabricated passive matrix flexible displays using air-stable inverted OLEDs to examine their adaptability to the display fabrication process and to evaluate the durability of the displays. The display, which was encapsulated with a low-barrier film (WVTR: 3×10^{-4} g/m^2/day), exhibited clear moving images even three months after fabrication.

OLED1 - 4 **Withdrawn**

OLED1 - 5L 14:30 **High Aperture Ratio Organic Light Emitting Diodes (OLED) Pixels with 640 ppi Resolution Realized by CA i-Line Photolithography**

T.-H. Ke[*], P. Malinowski[*], A. Nakamura[**], S. Steudel[*], D. Janssen[**], Y. Kamochi[***], I. Koyama[***], Y. Iwai[***], P. Heremans[,****]*

[*]imec, Belgium
[**]FUJIFILM Elect. Materials, Belgium
[***]FUJIFILM, Japan
[****]Holst Ctr., the Netherlands

We realized high resolution OLED pixels with aperture ratio (AR) scaling via photolithography. Surface coverage of the patterned organic layers is nearly 80%. Passive OLED arrays with AR of 34% are realized with subpixel pitch of 20 μm. The lifetime of the patterned OLED is increased by increasing AR in pixel design.

----- Break -----

15:10 - 16:45 **Ohmi 1**

OLED2: OLED for Lighting Applications
Special Topics of Interest on Lighting Technologies

Chair: Y. Kijima, JOLED, Japan
Co-Chair: H. Kuma, Idemitsu Kosan, Japan

OLED2 - 1: *Invited* Recent Advances in OLED Lighting
15:10

M. Boesing, F. Lindla, A. Koehnen, V. Gohri[*], M. Ruske[*], S. Hartmann, E. Meulenkamp[*]

Philips Business Ctr. OLED Lighting, Germany
[*]OLEDWorks, USA

In this work we present our most recent advances w.r.t. OLED lighting panel performance: By employing a new (improved) device structure in combination with an internal light extraction concept and a highly reflective top contact, we are able to drastically increase light extraction efficacy of the panel.

OLED2 - 2 15:30 **Blue Light Efficiency Enhancement of OLED by Thin Film Included Micro-Particles and Copper Sulfate Solution**

C.-H. Chiu, W.-C. Chien[*], C.-H. Chien[*], Y.-H. Chen[*]

Chunghwa Picture Tubes, Taiwan
[*]Tatung Univ., Taiwan

Copper sulfate solution and PDMS were used as the base material of optical film. Two kinds of micro metal oxide particles were chosen to be doped into the optical film. The optical thin film attached to the OLED can enhance 77% blue light intensity and increase color temperature of 550 K.

OLED2 - 3
15:50

High Efficient and Stable Quantum Dots Film with Interdiffused Structure as Down-Conversion Material Utilized in Blue Organic Light Emitting Diode for Solid-State Lighting Application

V. Arasu, D. Jo, B. Kim, H. Chung

Sungkyunkwan Univ., Korea

QDs Down-conversion film with thin, efficiently dispersed, non-agglomerated were fabricated by 'Polymer-free Nanoparticles Adhesion Technique'. The achieved down-conversion enhancement were 15% The major focuses were on development of high photoluminescence (91%), nearly zero interface and Interdiffused-core/alloy/shell structure QDs materials synthesized by simple and reproducible one-pot hydrothermal injection method.

OLED2 - 4
16:10

Fabrication of High Efficiency Color-Conversion Layer for Hybrid OLED Lighting

B. Kim, D. Jo, D. Yoon, H. Chung

Sungkyunkwan Univ., Korea

Hybrid OLED has been used with blue OLED and giving color changing layer to generate the white emission. In order to achieve high CRI and efficiency, we have developed facile and efficient fabrication method for color conversion layer, called as Adhesive Transfer, yielding the high packing density and out-coupling efficiency.

OLED2 - 5L
16:30

Soluble Bipolar Red Host Material for Solution Processed Organic Light Emitting Diodes

S.-R. Park, Y.-R. Cho, M. C. Suh

Kyung Hee Univ., Korea

We have fabricated highly efficient red phosphorescent organic light emitting diodes (OLEDs) by solution process combined with thermally evaporated blue common layer structure. To obtain high performances, we designed and synthesized a new bipolar host material with benzocarbazole and triphenyltriazine moieties (11-[3-(4,6-diphenyl-[1,3,5]triazin-2-yl)phenyl]-11H-benzo[a]carbazole, RH).

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

9:00 - 10:15 **Ohmi 1**

OLED3: OLED Materials

Chair: T. Ikuta, JNC Petrochem., Japan
Co-Chair: S. Naka, Univ. of Toyama, Japan

OLED3 - 1: *Invited* 9:00 Molecular Design of High Efficiency Thermally Activated Delayed Fluorescent Emitters

D. R. Lee, S. K. Jeon, W. Song, J. Y. Lee
Sungkyunkwan Univ., Korea

We designed several triazine and carbazole based thermally activated delayed fluorescent emitters as high efficiency and stable emitters. It was found that a molecular design derived from the triazine and carbazole could improve the external quantum efficiency up to 25% and provide reasonable lifetime.

OLED3 - 2 9:20 Improvement Efficiency of Blue Fluorescence Device with TADF Host Material

W. Song, J. Y. Lee
Sungkyunkwan Univ., Korea

A blue fluorescence device of emission layer (EML) structure of CzAcSF:DPEPO:TBPe (1:1:0.5%) showed a high quantum efficiency of 17.7% compared to a quantum efficiency of 4.4% of conventional TBPe device. The blue fluorescence device with EML structure of CzAcSF:TBPe showed quantum efficiency of 14.1%.

OLED3 - 3 9:40 UV-Ozone-Treated Ultra-Thin Li-Doped NiO Film as Anode Buffer Layer on Organic Light Emitting Diodes

H.-W. Lu, P.-C. Kao, S.-Y. Chu
Nat. Cheng Kung Univ., Taiwan

In this paper, the UV-ozone treated 5 wt% Li_2CO_3-doped NiO layers for 0.5 nm as anode buffer layer were prepared by thermal evaporation. The current density enhanced from 235 to 530 mA/cm^2, luminance enhanced from 7588 to 17730 cd/m^2, and efficiency enhanced from 3.2 to 3.34 cd/A.

OLED3 - 4L 10:00 **Efficient Blue Thermally Activated Delayed Fluorescence Material with Carboline Donor Moiety**

B. Y. Kang, J. M. Lee, G. H. Kim, J. Y. Lee, J. H. Kwon

Kyung Hee Univ., Korea

We report two synthesized blue thermally activated delayed fluorescence (TADF) emitters, 4,5-bis-α-carboline-9-yl-phthalonitrile (α-2CbPN) and 4,5-bis-δ-carboline-9-yl-phthalonitrile (δ-2CbPN). Synthesized δ-2CbPN emitter shows about 92% photoluminescence quantum yield with excellent TADF process. Fabricated blue OLED with the δ-2CbPN emitter shows 23% maximum external quantum efficiency.

----- Break -----

10:30 - 12:30 **Ohmi 6**

***Poster* OLEDp1: OLED Poster**

OLEDp1 - 1 **Flexible OLED Lighting Panel with Capacitive Coupling Wireless Power Supply**

Y. Murozono, R. Hattori, T. Yagi[*]*, K. Omata*[*]

Kyushu Univ., Japan
[*]Konica Minolta, Japan

An organic light-emitting diode (OLED) lighting panel is powered by a capacitive-coupling wireless-power transmission system with a wide power-receiving position. The panel consists of only OLEDs with flexible plastic substrate and rectifying diodes, which result in a very simple and ultrathin lighting device.

OLEDp1 - 2 **Inorganic High Gas Barrier Films Deposited by PECVD Using a Novel Precursor, TG-4E, for OLED Devices**

H. Chiba, K. Tokuhisa

Tosoh, Japan

Inorganic high gas barrier films were deposited by PECVD using a novel precursor, TG-4E, and tetraethoxysilane (TEOS), and these films were colorless, transparent, and flat. The water vapor transmission rate (WVTR) of a three-layer coated film deposited from TG-4E achieved 4.1×10^{-5} g/m^2/day under 40˚C, 90%RH condition.

OLEDp1 - 3 **Fabrication and Analysis of Tandem-Structure Dual-Function Photovoltaic Organic Light Emitting Diodes**

D.-J. Kim, H.-N. Lee

Soonchunhyang Univ., Korea

We designed and fabricated dual-function photovoltaic organic-light-emitting-diodes (PVOLEDs) with a common electrode structure. The light-emission function and the power conversion function of PVOLEDs are analyzed and reported here. 21000 cd/m^2 luminance and 2.8% power conversion efficiency were obtained.

OLEDp1 - 4 **The Application of Cyclic Tryphenylamine Compounds to Wet-Processable OLED**

K. Ishitsuka, T. Sugioka, S. Funyuu, H. Sawamoto[*]*, R. Ohata*[*]*, K. Ogino*[*]

Hitachi Chem., Japan
[*]*Tokyo Univ. of A&T, Japan*

The spectroscopic character, energy level and hole transport property of cyclic triphenylamine (CTPA) compounds were investigated to determine novel hole transport material for wet-processable organic light-emitting diodes (OLEDs). It was shown that CTPA have suitable hole transport properties and energy level for the hole transport layer material of OLED.

OLEDp1 - 5 **Vertical Organic Light Emitting Transistors in the Presence of Various ETL Materials**

S. I. Yoo[*]*, J. W. Kim*[*]*, J. S. Kang*[*]*, G. J. Yoon*[*]*, W. Y. Kim*[*,**]

[*]*Hoseo Univ., Korea*
[**]*McMaster Univ., Canada*

We fabricated vertical organic light emitting transistors (VOLETs) with various ETL materials to investigate physical and electrical properties about carrier injection in the device performance. ETL materials(Alq3, TPBi and 3TPYMB) were selected for VOLET based upon low electron mobility and minimum energy barrier between EML and ETL.

OLEDp1 - 6 **Energy Transfer of Triplet Excitons between EML and ETL Materials in Single Emissive White Phosphorescent OLEDs with Three Primary Colors**

J. W. Kim[*]*, S. I. Yoo*[*]*, J. S. Kang*[*]*, G. J. Yoon*[*]*, S. E. Lee, Y. K. Kim, W. Y. Kim*[*]

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

Performance of collisional quenching process between ETL materials and blue phosphorescent dopant was analyzed through spectroscopic study to verify loss of diffusive triplet excitons between them. EQE of the white PHOLED with TmPyPB as ETL is higher than the others with Bphen and TPBi due to preventing collisional quenching process.

OLEDp1 - 7 Fabrication of Multi-Layer Inverted Organic Light Emitting Diodes by a Spin Coating Method

J. Hasegawa[*], M. Takada[*], T. Nagase[,**], T. Kobayashi[*,**], H. Naito[*,**]*

[*]Osaka Pref. Univ., Japan
[**]The Res. Inst. for Molecular Elect. Devices, Japan

We characterized multi-layer inverted organic light emitting diodes (iOLEDs) fabricated by a spin coating method. The device showed the highest brightness of 15,500 cd/m^2 and maximum current efficiency of 10 cd/A.

OLEDp1 - 8 High-Efficiency and Color Tunable Hybrid White OLED Devices

H.-L. Huang, B. Balaganesan, H.-M. Kuo, C.-J. Lin, T.-C. Chao

eRay Optoelect. Tech., Taiwan

The novel phosphorescent host for phosphorescent yellow dopant was designed and prepared with easy scale-up reaction procedures. Under 10 mA/cm^2, the hybrid WOLED can be tuned from warm white 32.1 lm/W@(0.50,0.43), 24.3 lm/W@CIE(0.46,0.41) to cold white 15.0 lm/W @CIE(0.38,0.37) under different thickness of the blue layer.

OLEDp1 - 9 Optimization of Organic Photodetector Using OLED Lighting Device

J. S. Kang[*], S. I. Yoo[*], J. W. Kim[*], G. J. Yoon[*], W. Y. Kim[,**]*

[*]Hoseo Univ., Korea
[**]McMaster Univ., Canada

We studied optical characteristics of OLED lighting device controlled by an OPD using 5,12-dihydro-5,12-dimethylquino[2,3-b]acridine-7,14-dione (DMQA) as donor and bisbenzimidazo[2,1-a :1',2-b']anthra[2,1,9-def :6,5,10-d'e'f']diisoguinoline-10,21-dione, with cis isomer (PTCBI) as acceptor. OPD was optimized throughout optical and electrical characterization of red, green and blue emission in mono color OLED.

OLEDp1 - 10 A Green Thermally Activated Delayed Fluorescent Material Based on Dual Emitting Core Design

H.-M. Kim, J.-Y. Lee

Sungkyunkwan Univ., Korea

DDCzPDCN with a donor-acceptor structure was synthesized for effectively separating HOMO and LUMO, so that the gap between singlet energy and triplet energy can be reduced. We fabricated a device for electroluminescence properties of the synthesized compound. The device showed external quantum efficiency of 10.6%.

OLEDp1 - 11 Electrooptic Characteristics of Organic Light Emitting Diode Using an Index Mitigating Scattering Layer

H. Jung, T. W. Gong, J. S. Gwag
Yeungnam Univ., Korea

In order to improve the external efficiency, PLED structures with a scattering layer which exists for mitigating index mismatching layer are proposed. The experimental data showed that the coupling-out efficiency of PLED was improved by 18% for inner scattering layer and by 48% for outer scattering layer.

OLEDp1 - 12 Enhancement of OLED Light Extraction Efficiency with Patterned Structure and Micro-Lens Array

Z. Zhang, B. Kim, H. Chung
Sungkyunkwan Univ., Korea

Light extraction of OLED has been widely developed for light emitting. We fabricated high efficient OLED devices by using novel modified substrate. The gathered lights can be extracted by micro-lens-array. By applying the modified structure, highly efficiency enhanced OLED device can be achieved simply.

OLEDp1 - 13 AC-Operated Electrochemiluminescent Device Containing Ruthenium(II) Complex with High Emission Intensity and Long Device Lifetime

S. Tsuneyasu, K. Ichihara, K. Nakamura, N. Kobayashi
Chiba Univ., Japan

Electrochemiluminescence (ECL) is an emission phenomenon from electrochemically generated excited state. In this study, we introduced TiO_2 nanoparticle in Ruthenium(II) complex-based ECL electrolyte in order to improve ECL properties of AC-operated ECL device. As a result, the ECL intensity and long term stability of the device were improved by adding TiO_2 nanoparticle in ECL solution.

OLEDp1 - 14L Phosphor-Converted Flexible White OLEDs from Fluorescent Blue OLEDs

S. H. Kim, C. Kim[*], Y. Chae[*], S. H. Lee[*], S. M. Cho[*]
SABIC Korea, Korea
[*]Sungkyunkwan Univ., Korea

Phosphor-converted flexible white organic light-emitting diodes (OLEDs) were fabricated with fluorescent blue OLEDs. The maximum power efficiency of the white OLEDs was 35 lm/W. The 8.4 lm/W power efficiency of original blue fluorescent OLEDs was enhanced to 17.5 lm/W by applying a light scattering layer and micro-lens array.

OLEDp1 - 15L A Deep Blue TADF Emitter as Potential Replacement for Conventionally Used Emitter Systems

G. Liaptsis

CYNORA, Germany

The replacement of conventional fluorescent blue emitters by TADF related systems, which can either be copper based or truly organic, allows for a reasonable decrease in power consumption of light-emitting devices and enables a deeper blue emission compared to recently used triplet emitters without losses in efficiency.

OLEDp1 - 16L Novel Bis-Cyclometalated Iridium(III) Complexes with π-Extended Cyclometalated Ligands Showing Highly Efficient Red Phosphorescence

S. Yagi, L. Sun, N. Okamura, T. Maeda, H. Nakazumi, Y. Masahiro[*]

Osaka Pref. Univ., Japan
[*]TANAKA Holdings, Japan

Highly efficient red phosphorescent bis-cyclometalated iridium(III) complexes were developed using π-extended cyclometalated ligands. The aromatic ancillary ligand with bulky substituents is essential to obtain high photoluminescence quantum yields (> 0.40 in PMMA). Using the developed complexes as an emitting dopant, OLEDs were fabricated, emitting reddish orange to deep red.

OLEDp1 - 17L Enhanced Efficiency and Stability of Organic Light-Emitting Diodes with a P-I-N-P Structure

L. Zhang, Z.-K. Wang, L.-S. Liao

Soochow Univ., China

Organic light-emitting diodes (OLEDs) with P-I-N-P structure were developed. This P-I-N-P-based device showed lower driving voltage, higher efficiency and longer operational lifetime than conventional P-I-N-based device. The improved device performance is ascribed to a superior conductivity and a protection of electron transporting layer by the p-doped layer.

OLEDp1 - 18L Solution-Processed Yellow OLED with Longer Lifetime

J.-Y. Liao, J.-S. Lin, H.-C. Yeh, P.-C. Huang, H.-L. Huang[*], M.-R. Tseng

ITRI, Taiwan
[*]eRay Optoelect. Tech, Taiwan

A solution-processed yellow device, composed of a novel POT-09 emitter, with a longer lifetime is studied. Lifetime tests of different initial brightness are recorded and power factors for LT50, LT70, and LT95 are also correlated. The half lifetime at initial 1000 nits is estimated as 6,745 hours.

OLEDp1 - 19L Highly-Efficient Solution-Processed Organic Light-Emitting Diodes

H.-C. Yeh, J.-S. Lin, C.-H. Chou, J.-L. Liou, J.-Y. Liao, M.-H. Chang, T.-C. Chao, M.-R. Tseng*

ITRI, Taiwan
**e-Ray OptoElect. Tech., Taiwan*

PB-05, PG-15, PY-03 and PR-13 are newly synthesized iridium complexes. A solution-processed white emission OLED using PY-03 and PB-05 as dopants exhibits high performance with current efficacy of 32.3 cd/A and power efficacy of 25.3 lm/W at 1,000 cd/m^2.

OLEDp1 - 20L Low Operating Voltage Vertical Organic Light-Emitting Transistor Using Oriented Molecular Thin Film

S. Kobayashi, H. Fukagawa, K. Kudo**, Y. Watanabe*

Tokyo Univ. of Sci. Suwa, Japan
**NHK, Japan*
***Chiba Univ., Japan*

We proposed a novel OLET for displays. In the OLET, the OLED is formed on the vertical organic transistor. We succeeded to obtain luminance of 1000 cd/m^2 at gate voltage of –2 V. ON/OFF ratio of luminance is 10^3 at gate voltage of –2 V to 0 V.

OLEDp1 - 21L Enhancement of Hole-Injection Efficiency by Utilizing a Novel P-Doping Step-Like Architecture for Organic Light-Emitting Devices

C.-T. Tsai, S.-Y. Chu, P.-C. Kao, Y.-H. Liu*

Nat. Cheng Kung Univ., Taiwan
**Nat. Chiayi Univ., Taiwan*

This study demonstrated a step-like hole injecting architecture to improve efficiency for OLEDs. A novel p-doping structure utilizing combinations of two organic layers with different doping concentration composed of MoO_3 and NPB observed to facilitate hole-injection therefore accomplished a maximum luminance of 31250 cd/m^2 and a significant increase in efficiency.

OLEDp1 - 22L Introduction of Nanoscatter Medium to Suppress the Viewing Angle Dependence of Organic Light Emitting Diodes with Strong Microcavity Effect

B. Pyo, H. S. Kim, M. C. Suh

Kyung Hee Univ., Korea

A nanoscatter layer was utilized to suppress the viewing angle dependence of top-emitting organic light emitting diodes (TEOLEDs). It could be controlled by its shapes such as concave and convex. It could be optimized by applying thin film encapsulation (TFE) on the top of OLEDs device. The viewing angle dependence was diminished after application of nanoscatter layer although the current efficiency collected from the normal direction was reduced by 15~20%.

OLEDp1 - 23L **ITO/Al-Ni Alloy Films for Anode Electrodes in Top-Emission OLEDs**

K. Nishiyama, N. Jiko, M. Ochi, T. Kugimiya, H. Okuno, M. Kanamaru**

Kobe Steel, Japan
**Kobelco Res. Inst., Japan*

We report Al-Ni-Cu-La anode electrodes for top-emission organic light-emitting diodes (OLEDs) enabling low driving voltage of OLEDs same as Ag-Zn Alloy anode electrodes. The Al-Ni-Cu-La anode electrodes that are annealed and alkaline cleaned can be directly contacted with ITO by forming Al_3Ni precipitates.

----- Lunch -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:00 **Ohmi 2**

OLED4: Advanced OLED Technologies II
Special Topics of Interest on Printed Electronics

Chair: T. Komatsu, JOLED, Japan
Co-Chair: T. Fukuda, Saitama Univ., Japan

OLED4 - 1
9:00 **Solution-Processed All Phosphorescent Small Molecule White Multi-OLED System**

K. Oikawa, T. Iwasaki, T. Tsujimura, Y.-J. Pu, T. Chiba*, S. Ohisa*, J. Kido**

Konica Minolta, Japan
**Yamagata Univ., Japan*

White light emitting multi-OLED with small-molecule all-phosphorescent system comprising two light emitting units and a charge generating layer (CGL) has been successfully developed for the first time in the world. In this paper, our proprietary solution-based process technologies, especially small-molecule phosphorescent materials and layer stack design technologies, will be discussed.

OLED4 - 2 9:20 **Novel Materials for Highly Efficient Long-Lived Solution-Processed Phosphorescent Red OLED Devices**

A. Hayer, P. Stoessel, N. Koenen, H. Heil, P. Levermore, B. Burkhart, K. Stegmaier, E. Böhm, H. Buchholz

Merck KGaA, Germany

We demonstrate highly efficient, long-lived ink-jet printable red phosphorescent materials. We show a series of new red emitters with high photoluminescence quantum efficiency, narrow spectra, excellent stability and very good printability. We further improve device performance by developing adapted hole transport layers.

OLED4 - 3 9:40 **OLED Dry Film Uniformity Compensation by Inkjet Process**

C.-Y. Lin, C.-Y. Lo

Nat. Tsing Hua Univ., Taiwan

Dry-film uniformity issue from wet-processed OLED because of the coffee-ring effect was improved by compensating the first inkjet-printed PEDOT:PSS with a second inkjet-printed one. Compensation volume, drop arrangement, and printing sequence were studied for optimized and improved film uniformity in this work.

----- Break -----

10:40 - 12:00 **Ohmi 2**

OLED5/FLX3: Flexible OLED and OTFT

Chair: Y. Sakai, Mitsubishi Chem. S&T Res. Ctr., Japan
Co-Chair: T. Kamata, AIST, Japan

OLED5/ FLX3 - 1: 10:40 ***Invited*** **Flexible OLED Fabricated with Fully R2R Process and Their Evaluation Technology**

Y. Mitamura, T. Minakata, A. Sugimoto, M. Tanamura, Y. Ohzu, A. Suzuki, N. Ibaraki, H. Tomiyasu

Chem. Materials Evaluation & Res. Base, Japan

Flexible organic light-emitting diodes (OLEDs) on continuous plastic film have been successfully fabricated with full roll-to-roll (R2R) processes and exhibit good stability and high performance comparable to OLEDs on glass. Degradation due to penetration of moisture have been studied qualitatively and respectively.

OLED5/ FLX3 - 2 11:00 **Accurate Evaluation of Water Vapor Transmission for Flexible OLEDs**

A. Suzuki, A. Uehigashi

Chem. Materials Evaluation & Res. Base, Japan

An evaluation technique for determining the water vapor transmission rate (WVTR) has been developed using our reference films with multiple pinholes created strategically. The WVTR was reliably obtained at a level of 10^{-5} g/m^2/day. The films can be widely applied to accurately calibrate several WVTR measurement systems.

OLED5/ FLX3 - 3 **Withdrawn**

OLED5/ FLX3 - 5L 11:20 **Solution-Processed, Air-Stable N-Type Organic Single Crystal Microribbon Transistors**

C.-Y. Tan, P.-Y. Tseng, C.-W. Wang, C.-Y. Hung, C.-W. Tsai, G.-W. Hsieh

Nat. Chiao Tung Univ., Taiwan

We used halogen-substituted perylene diimide derivatives to form self-assembled microribbons for organic field effect transistors. Devices based on a network of microribbons have showed typical n-channel field effect behaviors with average ON/OFF current ratio >10^3 and revealed remarkable stability under ambient air over 90 days.

OLED5/ FLX3 - 4 11:40 **Solution Processed P-Type Top-Gate Small-Molecular Organic TFT**

H.-C. Hsiao, Z.-X. Jiang, S. Su, H.-Y. Xu, M. Zeng, B. Sun, C.-Y. Lee, H. Zhou[*]*, S. Zhang*[*]

China Star Optoelect. Tech., China
[*]*Peking Univ., China*

A p-type organic thin film transistor (OTFT) technology on plastic substrates was developed, in which, a small molecular organic semiconductor (OSC) material was used as channel layer. The fabricated p-OTFT at processed temperature below 120˚C shows a high hole mobility of 3.4 cm^2/Vs and an excellent performance stability under gate electrical stress.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

Supporting Organizations:
The Japanese Society of Printing Science and Technology
The Society of Photography and Imaging of Japan

Workshop on 3D/Hyper-Realistic Displays and Systems

Thursday, December 10

9:00 - 10:20 **Ohmi 9**

3D1: Holography

Chair: M. Date, NTT, Japan
Co-Chair: T. Koike, Hosei Univ., Japan

3D1 - 1: 9:00 ***Invited*** **Occlusion Processing in Computer Holography – With a Focus on Switch-Back Technique –**

K. Matsushima
Kansai Univ., Japan

A powerful technique called the switch-back technique is presented for occlusion processing. The technique allows us to process polygon-by-polygon light-shielding very fast. The computation times for various sizes of computer-generated holograms as well as optical reconstruction are presented for verifying the performance and validity of the technique.

Also presented in Innovative Demonstration Session (see p. 206)

3D1 - 2: 9:20 ***Invited*** **Electronic Holography Using Multiple Spatial Light Modulators**

H. Sasaki, K. Wakunami, Y. Ichihashi, R. Oi, T. Senoh, K. Yamamoto
NICT, Japan

We introduce methods of using multiple SLMs to increase the size of 3D images that are displayed using electronic holography and compensation for luminance differences between these SLMs. We apply these methods to a 16 (4×4) 4K×2K-pixel SLM-system to improve the image quality of a large full-parallax holographic three-dimensional image.

3D1 - 3 9:40 **Moire Noise Reduction in the Off-Axis Holographic Display**

W. Seo, J. Seo, H. Song, J. An, G. Sung, S. Kim, C.-S. Choi, H. Kim, Y.-T. Kim, Y. Kim, H.-S. Lee, S. Hwang
Samsung Advanced Inst. of Tech., Korea

We realized a 10.1-in. off-axis holographic display with viewing distance 1 m and maximum depth over 50 cm. To reduce the Moire noise, which is the typical problem in the off-axis digital reconstruction method using RGB stripe pixels, we introduced 1) multi-frame sequences and 2) the same modulation period for RGB colors.

3D1 - 4: 10:00 ***Invited*** **Lensless Holographic Projection and Its Related Work**

T. Shimobaba, Y. Nagahama, T. Kakue, T. Ito
Chiba Univ., Japan

We describe our latest results for holographic projection, including lensless zoomable holographic projection, the speckle reduction technique which is named random phase-free method, and color zoomable holographic projection with the random phase-free method and color space conversion method in order to increase the image quality and accelerate the calculation time.

----- Break -----

10:30 - 12:30 **Ohmi 6**

Poster **3Dp1: 3D/Hyper-Realistic Displays**

3Dp1 - 1 **Optical Design of the Stereo Imaging Capsule Endoscopy System**

C.-H. Lin[*], K.-Y. Hsu[*], C.-Y. Chen, B.-S. Lin[**], P.-J. Wu[**]
Nat. Taiwan Univ. of S&T, Taiwan
[*]Nat. Yunlin Univ. of S&T, Taiwan
[**]Nat. Chiao Tung Univ., Taiwan

With the spectral characteristics of a micro-prism array plate, the left/right stereo image pair could be acquired merely by using a single lens block-shoot in the capsule endoscopy system. The acquired stereo image pair is further proceeded the depth analysis to make up the insufficient depth information.

3Dp1 - 2 **Waving-Hand Steganography on Aerial LED Screen Formed with AIRR**

M. Takahashi[*], H. Yamamoto[,**]*
[*]Utsunomiya Univ., Japan
[**]JST, CREST, Japan

We propose a kind of steganography on aerial LED screen. Our proposed steganography employs a high-frame-rate LED display to embed a secret image in successive 16 fields that are changed at 960 Hz. Then, our aerial imaging technology is used the retro-reflective material and a half mirror.

3Dp1 - 3 **A Proposal for Objective Evaluation System for Optical and Electro-Optical Characteristics of See-Through Type Near-Eye Display Devices**

Y. Tang, Y. Yang, Y. Zheng, X. Li, B. Wang
Southeast Univ., China

An objective evaluation system with multiple characteristics and their test methods is required for the emerging near-eye display devices. A proposal with four types of characteristics is proposed, which are common display type, transparent display type, binocular convergence type and near-eye display type.

3Dp1 - 4 **Comparisons of Viewing Depth Enhancement in Integral Imaging System Operated with Double Lens Arrays and Double Liquid Crystal Lens Arrays**

W.-Y. Lu, C.-R. Sheu

Nat. Cheng Kung Univ., Taiwan

The capability of viewing depth is an important factor in integral imaging (InIm) system. In this study, double lens arrays are used to enhance the range of viewing depth. In addition, we compare the operation with double lens arrays and double liquid crystal lens arrays.

3Dp1 - 5 **Depth Evaluation from Monocular Motion Parallax by Passive Head Movement with Different Amplitudes**

K. Oko, S. Yamada, H. Mizushina, S. Suyama

Tokushima Univ., Japan

Perceived depth differences of motion parallax between by active head movement and by passive head movement have been estimated. Perceived depth by passive head movement is almost the same as one by active head movement, which can provide a 3D impact to stereoblind people by only monocular motion parallax.

3Dp1 - 6 **How to Converge Long Wave-Length Sound by Small-Aperture Crossed-Mirror Array**

R. Kujime[*], H. Mizushina[,**], S. Suyama[*], H. Yamamoto[*,**]*

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

We can successfully converge much longer wave-length sound than aperture size of crossed-mirror array (CMA) by using ultrasounds for carrier wave. Although CMA usually needs to have much larger aperture than its wave length for converging sound wave, this proposed method can converge very long wave-length sound by small-aperture CMA.

3Dp1 - 7 **Multi-Image Arc 3D Display with Narrow Scratches by Using Non-Overlapping Method at Cross Points**

S. Nishiyama, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We proposed Multi-image Arc 3D display which can change various 3D images by using projector. Multi-image Arc 3D display can successfully switch three 3D images by changing the illuminating arcs. 3D image spot size on the arc can be decreased to less than 1 mm in Multi-image Arc 3D display.

3Dp1 - 8 **Wide Vertical Viewing Zone in Arc DFD (Depth-Fused 3D) Display**

K. Yoshioka, S. Nishiyama, H. Mizushina, S. Suyama

Tokushima Univ., Japan

We have proposed a new arc DFD display by the fusion of DFD display and arc 3D display. This new display has merits of compact, simple and thinner structure and large depth. In this paper, we evaluated vertical viewing zone in arc DFD display, resulting in wide vertical viewing zone.
Also presented in Innovative Demonstration Session (see p. 207)

3Dp1 - 9 **Stereoscopic Display by Using a New Radial Parallax Barrier for All Surrounding Viewpoints**

R. Ozaki, H. Yamamoto[*]*, H. Mizushina, S. Suyama*

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

In order to realize stereoscopic display for all surrounding viewpoints, a new circularly configuration with a radial parallax barrier has been proposed. Six-view auto-stereoscopic images can be successfully obtained by continuous change of stereoscopic images and corresponding area of parallax barrier, which is the fundamental results for all surrounding view.

3Dp1 - 10 **An Autostereoscopic Display Combining Parallax Barrier and Volumetric Images Using Non-Negative Edge Filter**

B. Yu, H. Kakeya

Univ. of Tsukuba, Japan

We propose an autostereoscopic display system based on parallax barrier and volumetric imaging. The proposed system detects the viewer's eyes and the layered images are adjusted so that they may reproduce the original image. The use of non-negative edge filter mitigates image deterioration due to eye-tracking delay.
Also presented in Innovative Demonstration Session (see p. 207)

3Dp1 - 11 **Rendering Architecture for Photorealistic Simulation of Light Field Display**

T. Koike

Hosei Univ., Japan

We discuss about a rendering architecture for photorealistic simulation of light field display. We use path tracing to render sub images for each lens, and merge these sub images to a final photorealistic image. We have also compared rendering times and images between existing method and our method.

3Dp1 - 12 **Tunable Magnification of Fourier Hologram by Using a Zoom Lens**

S.-K. Lin, W. K. Lin, W.-C. Su

Nat. Changhua Univ. of Education, Taiwan

A hologram is reconstructed on the Fourier plane of a zoom lens. By changing the effective focal length of the zoom lens, the magnification of the holographic image becomes tunable without changing its image location.

3Dp1 - 13 **Improvement of Reconstructed Image Quality of 3D Display Using 1D Phase Modulation SLM by Iterative Fresnel Method**

R. Toritani, K. Masuda, P. Xia, K. Nitta, O. Matoba

Kobe Univ., Japan

A three-dimensional display using a phase-mode 1D spatial light modulator is proposed. Optimization of phase distribution by using iterative Fresnel method and a dummy area can improve the reconstructed image quality. Numerical results show that the contrast of the reconstructed image is improve.

3Dp1 - 14 **Improvement of Image Quality of Three-Dimensional Display Using a Binary Phase Distribution**

K. Masuda, Y. Saita, R. Toritani, P. Xia, K. Nitta, O. Matoba

Kobe Univ., Japan

A method to improve the quality of the reconstructed 3D image by using a binary phase distribution is presented. The proposed method consists of two sub-methods that are the optimization of binary phase distribution by modified Fresnel ping-pong algorithm and temporally average of the speckle patterns. The results are presented.

3Dp1 - 15 **A Naked-Eye 3D Display Using Liquid Crystal Lenticular Lens with Low Cell Gap**

J.-H. Chen, Q.-S. Liao, Q. Wei, C.-M. Yang, C.-Y. Chiu, C.-Y. Lee, A. Lien[*]

Shenzhen China Star Optoelect. Tech., China
[*]*TCL Corporate Res., China*

A 32" naked-eye 2D/3D display with 4K panel using Liquid-crystal-Lenticular (LCL) lens was fabricated. To be compatible with photo process and decrease 2D/3D switching time, cell gap was designed as 6.2 μm, and to overcome electric field inefficiency triggered by low cell gap, multi-electrode driven mode was employed.

3Dp1 - 16 **A Novel Driving System for AMOLED 3D Display**

H. Li, Y. Jin, S.-S. Syu, M.-J. Jou

Shenzhen China Star Optoelect. Tech., China

Most of 3D system solutions suffer problems including flicker, high frame rate and loss of luminance. CSOT will illustrate a novel 3D driving architecture to improve luminance with lower frame rate that can also reduce system complexity and total power consumption in paper.

3Dp1 - 17 **Developing a Quality Normal Map Acquisition Device Based On LED Array**

C.-H. Wang, Y.-L. Liu, T.-H. Lin

Nat. Taiwan Univ. of S&T, Taiwan

This study focuses on how to general normal map from a self-fabricated device. A normal map indicates the local surface geometry which is stored as R-G-B pixels to represent local [x, y, z] vectors. Therefore, we propose a practical solution to directly retrieve image channels with corresponding lighting sources to synthesize a quality normal map.

3Dp1 - 18L **Real-Time Electroholography Using Multi-GPU Cluster System with a Single Spatial Light Modulator and Infiniband Network**

N. Takada, H. Niwase, H. Araki, Y. Maeda, M. Fujiwara, H. Nakayama[*], T. Kakue[**], T. Shimobaba[**], T. Ito[**]

Kochi Univ., Japan
[*]Nat. Astronomical Observatory of Japan, Japan
[**]Chiba Univ., Japan

The practical use of electroholography is limited by the complexity of the computer-generated hologram. We propose real-time electroholography using the multi-GPU cluster system with 13 GPUs (NVIDIA GeForce GTX TITAN X). Finally, we succeed to display reconstructed 3D movie consisting of 95,949 object points at about 30 fps.

3Dp1 - 19L **Gradation Expression of Time-Division Color Electroholography Using LCD Panels**

M. Fujiwara, N. Takada, H. Araki, H. Niwase, Y. Maeda, S. Ikawa, H. Nakayama[*], T. Kakue[**], T. Shimobaba[**], T. Ito[**]

Kochi Univ., Japan
[*]Ctr. for Computational Astrophysics, Japan
[**]Chiba Univ., Japan

Electroholography requires grayscale representation of reconstructed 3D image to realize 3D television. We propose gradation representation of reconstructed 3D image from the binary hologram drawn in black and gray on bit-plane. Finally, we succeed to display color gradation 3D image reconstructed by the proposed method.

3Dp1 - 20L **Image Quality Improvement of Electroholography by Using Spatiotemporal Division Method**

Y. Maeda, N. Takada, H. Niwase, H. Araki, M. Fujiwara, S. Ikawa, H. Nakayama[*], T. Kakue[**], T. Shimobaba[**], T. Ito[**]

Kochi Univ., Japan
[*]Ctr. for Computational Astrophysics, Japan
[**]Chiba Univ., Japan

We propose spatiotemporal division electro-holography for high-definition reconstruction of 3D object composed of huge number object points. Finally, we succeed to display a reconstructed high-definition image and movie of 3D object consisting of about 900,000 points.

3Dp1 - 21L **Design and Light Modulation of Sub-micron LC Pixels with Dielectric Shield Walls for Wide-Angle Holographic Displays**

Y. Isomae, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

To achieve electric holographic displays with wide field of view, it is necessary to fabricate sub-micron pixel structures. To suppress fringe electric field leakage, we have proposed dielectric shield wall structures. In this paper, we discussed effects of the wall structures on the reconstructed images and alignment of LC.

3Dp1 - 22L **The Effects of Crosstalk on Fusion and Protrusion of Stereoscopic Image**

S. Chou, T. Yamakawa, F. Kinoshita, T. Kojima[*], M. Miyao

Nagoya Univ., Japan
[*]Chubu Gakuin Univ., Japan

We carried out an experiment to evaluate the influence of crosstalk on stereoscopic images. During the experiment, subjects subjectively judged the protrusion of images under different crosstalk ratios. This study found a relationship between the limit of fusion, protrusion and the crosstalk ratios.

3Dp1 - 23L **Using Auxiliary Images to Extend the Fusional Limits For Stereoscopic Images**

S. Kamino, T. Yamakawa, F. Kinoshita, C. Uneme, T. Kojima[*], M. Miyao

Nagoya Univ., Japan
[*]Chubu Gakuin Univ., Japan

In this study, we conduct an experiment with 104 participants, to show using auxiliary images are useful to extend the fusional limits of stereoscopic images. The experiment showed how much the fusional limit was increased by using auxiliary images.

3Dp1 - 24L The Training Effect to the Fusional Limit of Stereoscopic Images

T. Yamakawa, Y. Honda, F. Kinoshita, I. Morita, T. Kojima[*]*, M. Miyao*

Nagoya Univ., Japan
[*]*Chubu Gakuin Univ., Japan*

There is variation in the fusional limit that people can recognize from the protrusion of stereoscopic images. The fusional limit is different depending on personal experience. In this study, we verified that an observer's fusional limit with stereoscopic images can be improved with visual training.

3Dp1 - 25L Verification of Image Distance in a Projection Type Virtual Image Display Using Lens Array

T. Iwaya, T. Yendo

Nagaoka Univ. of Tech., Japan

Head Up Display (HUD) is promising to be a key device of AR on automobile. However conventional HUD has not sufficient viewing field because of single-axis optics of imaging. We propose a novel HUD using small caliber optics. In this paper, we confirm the virtual image is located at infinite distance.

3Dp1 - 26L Elemental Images Resizing Method to Compress Integral Three-dimensional Image Using 3D-HEVC

K. Hara, J. Arai, M. Kawakita, T. Mishina

NHK, Japan

We propose a method for changing the sizes of elemental images based on an integer multiple before coding. The method was evaluated using the PSNR and subjectively evaluated using the MOS of coded integral 3D images using 3D-HEVC. The results suggest the proposed method is superior to a conventional method.

3Dp1 - 27L The Accommodation Responses for Still Images of Integral Photography

H. Imai, Y. Katayose, S. Yano, M.-C. Park[*]

Shimane Univ., Japan
[*]*KIST, Korea*

In integral photography, three-dimensional images are displayed based on the principle of light field reproduction. For this reason, it is said that the conflict between convergence and accommodation is not aroused. We examined the accommodation response for still images of integral photography.

3Dp1 - 28L **Evaluation of Autostereoscopic Imaging Performance with Respect to Color Sub-pixel Arrangements via Computer Graphic Processes**

Y. W. Chen, L. Y. Wu, C. R. Sheu

Nat. Cheng Kung Univ., Taiwan

In this paper, parallax images for usage of lenticular lens autostereoscopic simulation were generated by computer graphic processes, which were further used to evaluate autostereoscopic imaging performance with respect to various sub-pixel arrangements. Generally, it shows better distinguishability to evaluate imaging performance than previous work by camera recording parallax images.

3Dp1 - 29L **Study on the Implementation of the Low Cross-Talk Glasses-Free 3D Display**

K. Choi, J.-H. Lee, Y. Choi, D. Nam

Samsung Elect., Korea

This article investigates the cause of the 3D cross-talk explains how to minimize the 3D cross-talk when realizing a 3D image in a glasses-free 3D display system. In particular, the article presents an optimal light output pattern in which light goes through a 3D optical plate with the resulting 3D spatial light distribution minimizing cross-talk.

3Dp1 - 30L **Study on Generating Binary Colors for Monochrome 3D Intraoral Laser Scanner**

Y.-L. Liu, Y.-C. Chen, T.-H. Lin, P.-C. Hu[*]

Nat. Taiwan Univ. of S&T, Taiwan
[*]Metal Inds. R&D Ctr., Taiwan

Nowadays, the intraoral scanner has become more and more popular for orthodontic treatment. However, most of current intraoral scanners can't automatically recognize the difference between the crown and gingiva. In this paper, we present an intensity compensation method to separate the crow and gingiva.

3Dp1 - 31L **Virtual Reality/Head-Up Display Systems Using Smart Phones**

K. Li

Wavien, USA

Many smart phones have built-in gyroscope and GPS capabilities. This paper describes optical systems making use of the built-in GPS and gyroscope functions of smart phones and allows them to be used in Head-Up-Displays (HUD) and Virtual Reality Displays (VRD) applications.

3Dp1 - 32L **A Novel LED Display Architecture Using 4 Color Sub-Pixel Rendering**

D.-S. Kim, T. Shigeta, S.-K. Im, H.-S. Lee

Samsung Elect., Korea

We have developed a novel LED display architecture with RGGB 4 sub-pixels rendering. LED light control filter algorithm is proposed in order to reduce color fringes by sub-pixel rendering which is a method of perceptual enhancement. The results show that it has 2 times higher perceptual resolution without artifacts.

----- Lunch -----

16:00 - 17:25 **Ohmi 9**

3D2/LCT3: Autostereoscopic 3D Displays

Chair: Y. Kuroki, Comfort Vision Res. Lab., Japan
Co-Chair: S. Oka, Japan Display, Japan

3D2/ LCT3 - 1: 16:00 ***Invited*** **LC GRIN Lens Technology for Multi-Functional 3D Display**

S. Uehara

Toshiba, Japan

An LC GRIN lens is a significant component for 2D/3D display, because the lens function is easily changed due to an electrode design and driving method. We introduce our recent developments of three core technologies for the LC GRIN lens, those are, LC lens mode, driving method, and electrode structure.

3D2/ LCT3 - 2 16:25

Video Capable Dual-Layer Autostereoscopic Display with Motion Parallax

H. Suginohara, M. Sugano, K. Minami

Mitsubishi Elec., Japan

We have developed the prototype of video capable dual-layer autostereoscopic display. We implement Depth-Image-Based Rendering in an FPGA so that we can render the dual-layered individual viewpoint video following the viewer position in real-time. Our prototype can display a 3D video with motion parallax within +/- 20 degrees viewing area.

3D2/ LCT3 - 3 16:45

Resolution Multiplication Method for Autostereoscopic 3D Display

F. Mukhtarov, S. D. Hwang

Samsung Elect., Korea

In this paper we present new resolution multiplication methods for Displays, based on controllable variations of refractive index of liquid crystal prism array. Simultaneously with index variations the displayed contents need to be updated in time-sequential mode. Initial tests show promising results for both 2D and 3D types of displays.

3D2/ LCT3 - 4 17:05

Wide Viewing Angle Autostereoscopic 3D Display with Eye-Tracking System

Y. Hyodo, S. Oka, T. Koito, H. Sugiyama, Y. Maede, T. Ochiai, T. Takahashi, S. Komura

Japan Display, Japan

A new eye-tracking 3D panel was developed by smoothing the motion of a liquid crystal (LC) active barrier and by reducing crosstalk using new designs of supporting electrodes in the barrier and in-plane switching electrode of an LC panel. We demonstrated excellent visibility in a 3D viewing zone.

Also presented in Innovative Demonstration Session (see p. 206)

----- Break -----

17:40 - 19:00 **Ohmi 9**

3D3: Wavefront/Light Field Recording and Rendering

Chair: T. Shimobaba, Chiba Univ., Japan
Co-Chair: J. Arai, NHK, Japan

3D3 - 1
17:40 **Acceleration of Computer-Generated Hologram by Optimizing Arrangement of Wavefront Recording Planes**

N. Hasegawa, T. Shimobaba, T. Kakue, T. Ito
Chiba Univ., Japan

In a three-dimensional display by computer-generated holograms (CGHs), fast CGH calculation is required. The wavefront recording plane (WRP) method is able to reduce the calculation amount by placing WRPs in the vicinity of an object. In this paper, we optimized arrangement of WRPs to accelerate CGH generation.

3D3 - 2
18:00 **Fast Calculation of Stereoscopic Viewpoints via Fourier Slice Transformation**

J. Zhao[*], J. Xia[*], C. Chen[*], Z. Yang[**], J. Chen[**]
[*]Southeast Univ., China
[**]China Star Optoelect. Tech., China

We propose a method of calculating the multiple viewpoints for auto-stereoscopic display based on Fourier slice theorem. A set of two-dimensional (2D) projection images were recovered from a 2D image and a depth mapping. The proposed method was operated in the frequency domain, so that the algorithm was much faster.

3D3 - 3
18:20 **Light Field Subpixel Rendering Framework on Special Subpixel Structures**

J. Park, D.-K. Nam
Samsung Elect., Korea

Recently, various subpixel structures like PenTile are introduced from mobile to TV devices. Light field subpixel rendering for displays comprised with those special subpixel structures need to consider more than subpixel structure conversion. We propose a light field subpixel rendering framework on those special subpixel structures.

3D3 - 4
18:40 **Increased Perspective Size of Light Field Cameras Using a Reflector System**

K. Li
Wavien, USA

The perspective size of the light field camera is limited by the pupil size of the camera lens. In this paper, a reflector system will be presented such that the pupil size of the camera lens is increased by large reflectors such that a larger perspective size can be achieved.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:20 **Ohmi 9**

3D4/VHF6: Autostereoscopic and Head-Mounted Displays
Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: Y. Takaki, Tokyo Univ. of A&T, Japan
Co-Chair: S. Uehara, Toshiba, Japan

3D4/ VHF6 - 1 9:00 **HaptoMIRAGE: An Active-Shuttered Real Imaged Auto-Stereoscopic Display**

Y. Ueda, H. Nii[*], K. Minamizawa, S. Tachi[**]

Keio Univ., Japan
[*]IIJ Innovation Inst., Japan
[**]Univ. of Tokyo, Japan

HaptoMIRAGE is an auto-stereoscopic display that does not require the viewer to wear devices like 3D glasses. it is convenient to produce content such that real objects and 3D virtual objects are combined. Furthermore, multiple users can share the 3D view from their respective viewpoints.

3D4/ VHF6 - 2 9:20 **Dual Orthogonal Flat Panel Autostereoscopic Display Using Visible Gap Contraction Prism**

H. Imai, N. Takanashi

NEC, Japan

We have developed a dual orthogonal flat panel autostereoscopic display using visible gap contraction prism. Since the prism contracts the visible gap region between two orthogonal panels optically, it is possible to diminish visual discomfort for viewer in observing stereoscopic images.

3D4/ VHF6 - 3 9:40 **Sense of Height and Virtual Body in Head-Mounted Display Environments**

T. Shibata, T. Inoue[*]

Tokyo Univ. of Social Welfare, Japan
[*]Kanagawa Inst. of Tech., Japan

When using a head-mounted display, we cannot see our own body. We conducted an experiment to evaluate effects of virtual body on the user's sense of height and fear of heights. The results showed that the virtual body increased the user sense of height slightly and fear of heights significantly.

3D4/ VHF6 - 4 10:00 **Development of Poor Man's 3D-AR Platform for Amateur Game Creators**

Y. Yoneda, E. Dong, T. Fujita, H. Kiriyama, K. Takemura, K. Iwasaki, R. Urushihara[*]*, T. Ichii*

Tokyo Inst. of Tech., Japan
[*]Ochanomizu Univ., Japan

For 3D-AR by amateur creators, development of a low-cost and easy to use platform is necessary. The system should be composed of low-cost devices such as tablet-PCs and USB-cameras. However, the performance of each device is low. We'll show the way to cover the performance by combination of available sensors.
Also presented in Innovative Demonstration Session (see p. 206)

----- Break -----

10:40 - 12:00 **Ohmi 9**

3D5: 3D/Hyper-Realistic Display Systems
Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: H. Sasaki, NICT, Japan
Co-Chair: M. Tsuchida, NTT, Japan

3D5 - 1: 10:40 ***Invited*** **2D/3D Compatible Microstereopsis Display Using Patterned Retarder 4KTV**

Y. Kuroki

Comfort Vision Res. Lab., Japan

The effectiveness of good depth perception with microstereopsis video images of a 4KTV with patterned retarders was confirmed. This enables group viewing by persons wearing and without 3D-glasses. This development will lead toward the wide use of 2D/3D compatible motion images with low cost at high resolutions such as 8K.

3D5 - 2: 11:00 ***Invited*** **See-Through Three-Dimensional Displays with Motion Parallax for Precise Image Superposition**

Y. Takaki

Tokyo Univ. of A&T, Japan

See-through displays can render digital information on real scenes. When see-through displays provide three-dimensional (3D) images having motion parallax, 3D images can be precisely superimposed on real objects. Two see-through displays with motion parallax are demonstrated: the super multi-view windshield display and the see-through integral imaging display.

3D5 - 3: 11:20 ***Invited*** **See-Through Projection System**

T. Higuchi, T. Yoshikawa, K. Hashikawa, M. Akagi, T. Yoshizawa, K. Iwawaki, Y. Ito, H. Kogoma, N. Saegusa

Pioneer, Japan

We developed a new display system, “See-through projection system”, consist of a projector and a transparent screen. Our system can be seen both bright images on the screen and the background images through the screen. We introduce applications of See-through projection system.

3D5 - 4: 11:40 ***Invited*** **Floating Image Display Based on a Dihedral Corner Reflector Array**

Y. Maeda

Parity Innovations, Japan

A floating image display using a dihedral corner reflector array, which forms distortion-free real image based on retro-reflection, and its applications are introduced as a future multimedia device. In one instance, an observer can see a floating image by the naked eye and manipulate it by touching the floating image.

Also presented in Innovative Demonstration Session (see p. 206)

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 14:50 **Ohmi 9**

3D6: Floating and Omnidirectional Display Systems

Chair: Y. Maeda, Parity Innovations, Japan
Co-Chair: K. Yamamoto, NICT, Japan

3D6 - 1 13:30 **Evaluation Method of Sharpness on Aerial Image Formed with AIRR**

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

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

This paper proposes a method to evaluate sharpness on aerial image that is formed with aerial imaging by retro-reflection (AIRR). The proposed method employs calculation of contrast transfer function (CTF) on recorded aerial image with a camera. Performance of retro-reflectors is evaluated with CTF curves. Furthermore, F-number dependency is investigated.

3D6 - 2
13:50

Aerial Imaging by Retro-Reflection with Transparent Retro-Reflector (AIRR with TRR)

Y. Tokuda[,**], K. Onuki[*], M. Takahashi[*], S. Onose[*], T. Okamoto[*], M. Hirose[**], H. Yamamoto[*,***]*

[*]Utsunomiya Univ., Japan
[**]Univ. of Tokyo, Japan
[***]CREST, Japan

We propose a novel design of aerial displays. Our proposed design employs a transparent retro-reflector (TRR) for aerial imaging by retro-reflection (AIRR). AIRR with TRR can reduce a hardware space. Furthermore, AIRR with TRR can show images on TRR planes and can realize both a dual-view and dual-layered aerial display.
Also presented in Innovative Demonstration Session (see p. 206)

3D6 - 3
14:10

Superimposed 3D Display Viewable from 360 Degrees

H. Kato, T. Yendo

Nagaoka Univ. of Tech., Japan

We propose a novel 3D display that 3D image can be superimposed on the real object, and viewable from 360 degrees. The display consist of high speed projector and rotating thin strip of mirror.
Also presented in Innovative Demonstration Session (see p. 206)

3D6 - 4
14:30

A Method to Make 360 Degree Contents for Realistic 3D Image Display Using Direct Light Scanning

X. Luo, H. Horimai[*], X. Tan

Beijing Inst. of Tech., China
[*]3Dragons, Japan

The realistic 3D image display using Direct Light Scanning Method, so-called Holo-Table have been introduced last year. In this paper, an image processing method for the Holo-Table is proposed. Real parallax images from a 360 degree scanning camera are used, and a 3D scene from any directions can be displayed.
Also presented in Innovative Demonstration Session (see p. 207)

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Supporting Organizations:
Holographic Display Artists and Engineers Club (HODIC),
The Optical Society of Japan
Technical Group on Three-Dimensional Image Technology, ITE

Workshop on Applied Vision and Human Factors

Wednesday, December 9

13:30 - 14:55 **Ohmi 7**

VHF1: Display Metrology

Chair: J. Bergquist, Nokia, Japan
Co-Chair: N. Hiruma, NHK, Japan

VHF1 - 1: 13:30 ***Invited*** **Metric for Quantifying Relative Display Gamut Size**

K. Masaoka

NHK, Japan

The Rec. 2020 area-coverage ratios for wide-gamut displays in the xy chromaticity diagram are much more correlated to the volume-coverage ratios in color-appearance spaces than the area-coverage ratios in the u′v′ chromaticity diagram. We recommend a single metric using the xy diagram for calculation of the Rec. 2020 area-coverage ratio.

VHF1 - 2 14:00 **Characterization of the Spectral BRDF & BTDF of Optical Components for Displays and Lightings**

P. Boher, T. Leroux, V. Collomb-Patton, T. Bignon

ELDIM, France

Realistic optical simulation of the stack of a LC display requires the accurate and easy to obtain optical properties of each of its components. In the present paper we show how to obtain rapidly the spectral BRDF and BTDF of different display components using Fourier optics system with different illumination configurations.

VHF1 - 3 14:20 **Near-Field Analysis on Curved AMOLED Display by Directional Imaging Photometric Measurements**

S.-W. Hsu, Z.-Y. Chung

ITRI, Taiwan

By a method based on directional imaging photometric measurements and near-field analyses, the photometric properties of curved AMOLED display can be widely studied. The dependences of tri-stimulus values on vertical photometric angle, photometric azimuth and surface coordinates were carried out and investigated on a demonstrated sample.

VHF1 - 4L **Novel Sparkling Quantification Method on TFT LCD**
14:40 **at Off-axis Viewing Angle**

Y.-H. Chiang, T.-W. Hsu, S.-C. Lin, C.-H. Liao, J.-J. Su
AU Optronics, Taiwan

An innovative sparkling quantification CCD system at off-axis viewing angle with excellent human factor correlations has been built up. The CCD measurement result not merely shows exceedingly high linear relationship with a great number of human eye observation results, but shows greater degree of consistency than human eye.

----- Break -----

15:10 - 16:25 **Ohmi 7**

VHF2: Display Image Quality

Chair: T. Kurita, NHK Media Tech., Japan
Co-Chair: K. Sakamoto, Panasonic, Japan

VHF2 - 1 **Image Quality Comparison between ULED and**
15:10 **OLED Based on Perception Study**

J. Wang, J. Cao[*]*, X. Li, W. Liu*[*]*, J. Yang*[*]*, S. Huang*[*]*, Y. Zhang*[*]*, S. Gao*[*]
Southeast Univ., China
[*]*Hisense Elec., China*

A perception experiment using pair-comparing method is designed and conducted to compare the performance between OLED and ULED in different image quality evaluation items. Due to different display mechanism, the two types of technologies show advantages against the other in dark scene and bright scene respectively.

VHF2 - 2 **High Visual Performance of Transparent Liquid**
15:30 **Crystal Display by Using Image Optimization**

C.-T. Su, C.-W. Su, J.-T. Lien
Chunghwa Picture Tubes, Taiwan

In this paper, the image quality has succeeded to enhance of 6.1-in. transparent display by using image firmware analysis. Moreover, comparing the image optimization for purity, gamma, photometric exposure and sharpness was studied. Our results demonstrate a significant different from each parameter adjustment, which reveal a great potential property.

VHF2 - 3
15:50 **An Algorithm of Backlight Mura Reduction for Direct-Lit LEDs**

P. S. Kuo, Y. H. Fu, W. Q. Zhao, H. Zhang, J. W. He, L. W. Chu, Y. Y. Chen

Shenzhen China Star Optoelect. Tech., China

The penetration rate of direct-lit LEDs begins to transcend the edge-lit LEDs in 2014. For the sake of further shrinkage of the module thickness, an algorithm for reducing backlight mura of direct-lit LEDs is proposed in the first time. A quantification procedure of backlight mura is also described.

VHF2 - 4L
16:10 **Implications of the Number of Local Dimming Zones and Native LCD Contrast on Visual Quality of HDR Displays**

D. M. Hoffman, N. Stepien, W. Xiong

Samsung Display, USA

We used a paired comparison methodology on an RGB OLED panel to create image quality emulations of HDR displays based on liquid crystal with local dimming. The native panel contrast was most important for visual quality. Increasing local dimming zone count had a comparatively modest impact on image quality.

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

9:00 - 10:35 **Hiei**

VHF3: Human Factors

Chair: Y. Hisatake, Japan Display, Japan
Co-Chair: T. Shibata, Tokyo Univ. of Social Welfare, Japan

VHF3 - 1:
9:00 ***Invited*** **Aging of the Eye and Vision Centered Design of Display**

T. Kawamorita

Kitasato Univ., Japan

Age-related optical and physiological changes in the eye produce progressive reduction in visual performance. The reduction in visual performance cause decrease of readability and legibility of display. My presentation will discuss the aging of the eye, especially optical structure and properties, and the vision centered design of electronic display.

VHF3 - 2 9:30 **Visual Characteristics of After-Image under Dark Surround Conditions**

H.-C. Li, P.-L. Sun, R. Luo

Nat. Taiwan Univ. of S&T, Taiwan

Three psycho-visual experiments were carried out to investigate the visual afterimage characteristics of high luminance LED under dark surround conditions. The result shows that the intensity of illumination, exposure time and luminance of background are the primary factors influencing characteristic of afterimage.

VHF3 - 3 9:50 **Cosmetic Color Mapping Technology Applying to Facial Images**

L. Lu, Y.-P. Pi, H.-S. Chen

Nat. Taiwan Univ. of S&T, Taiwan

This study proposes a cosmetic simulated method, which can make a raw image reproduce preferred or natural cosmetic effect. We proposed a workflow, including the operations of DRMF, image morphing and cosmetic color separation. Three adjusting coefficients are designed to adjust the lightness, detail and color of cosmetic simulated results.

VHF3 - 4L: 10:10 ***Invited*** **Modeling the Visibility of Temporal Light Artifacts**

M. Perz, D. Sekulovski, I. Vogels[*], I. Heynderickx[*]

Philips Res., The Netherlands
[*]Eindhoven Univ. of Tech., the Netherlands

This paper describes temporal light artifacts with a focus on flicker and presents the state of the art of quantifying the visibility of these artifacts. The results of new experiments are compared against previous measures of display flicker.

----- Lunch -----

13:40 - 15:40 **Ohmi 6**

Poster VHFp1: Applied Vision and Human Factors

VHFp1 - 1 **Verification of the Personal Authentication Using the Hand Shape Image That Holds the Doorknob**

Y. Ueda, F. Saitoh

Gifu Univ., Japan

We propose a personal authentication system using hand shape images that holds the doorknob. This method performs biometrics authentication using physical character focused on hand shape that holds the doorknob. The experimental results show that the proposed system yields sufficient accuracy for personal authentication.

VHFp1 - 2 **Study of User Interface Using Cursor Operation Based on Iris Position in Eye Area**

K. Ohshima, F. Saitoh

Gifu Univ., Japan

In the previous conference, we propose a new cursor control method for Interface to support physically handicapped people by user's eye movement using moving images taken by a video camera. To discriminate of cursor's moving direction, the detection of eye area and estimation of iris position are used.

VHFp1 - 3 **Image Template Matching Based Order of Image Density in Local Area**

T. Sugiyama, F. Saitoh

Gifu Univ., Japan

We propose an efficient method based on a new similarity function, the order of image density (ODM). The experimental results show that the proposed method had equal or better robustness to shading, inclination, occlusion and noise in comparison with the conventional method.

VHFp1 - 4 **Extraction of Handwriting Lines from Document Images Based on Concentration Variance of the Local Area**

Y. Note, F. Saitoh

Gifu Univ., Japan

This paper proposes the method to extraction handwriting lines from document images including the handwritten by writing instruments. Distinction of handwritings by image feature materializes the extraction whatever their concentration. Experimental results show the proposed method for the five types of writing instruments are effective and incorrect extraction less.

VHFp1 - 5 **Outdoor Display Performance Predictions Using Spectral BRDF Measurements**

P. Boher, T. Leroux, T. Bignon, V. Collomb-Patton

ELDIM, France

A method to compute accurately the optical properties of displays under any type of parasitic illumination is presented. Emissive and reflective properties are obtained using a new generation of multispectral Fourier optics instrument. Examples of application on isotropic automotive display and anisotropic OLED display are presented.

VHFp1 - 6 **Development and Application of Hyperspectral Two-Dimension Display**

*M. Saika, K. Yoshida, T. Satoh, M. Yamada, K. Uchikawa**

Topcon, Japan
**Tokyo Inst. of Tech., Japan*

We have developed a hyperspectral two-dimensional display, which covers full color gamut and generates hyperspectral two-dimensional 32-primary-color and 120×160-pixel images at 48 frames-per-second. This display system can easily provide various visual stimuli for vision science and human factor research.

Also presented in Innovative Demonstration Session (see p. 207)

VHFp1 - 7 **Evaluation of a Real-Time Automatic Coloring System for Freehand Line Drawings**

S. Kurata, H. Mori, F. Toyama, K. Shoji

Utsunomiya Univ., Japan

We evaluate performance of the entire proposed system to colorize a freehand line image drawn on a PC screen displaying a user-selected reference image, e.g., a color photograph, with low contrast as a model. A major evaluation item is about the function for the real-time updating of the coloring result.

VHFp1 - 8 **Comparison of Brain Activation between Reading and Listening e-Books**

*H. Isono, K. Onoguchi**

Tokyo Denki Univ., Japan
**Yokogawa Solution Service, Japan*

We have studied the effects of differences in e-book reading method (i.e., between visual reading and listening) on brain activation and content comprehension. The results showed brain activation to be higher with visual reading as compared with listening of the text read aloud or presented as computer synthesized speech.

VHFp1 - 9 **Personal Authentication Based on Lip Shapes Pronouncing Vowels Analysis by Picture Processing**

T. Senga, F. Saitoh

Gifu Univ., Japan

This paper proposes an individual authentication system using lip images speaking vowels. Since small changes are likely to occur each time when user speaks vowels, the block segmentation matching is used in the proposed method. The experimental results show that the proposed system has enough accuracy to certify individual.

VHFp1 - 10 **Color Natural Images Sharpening Processing Based on Human Visual Characteristics**

J. Miyachi, F. Saitoh

Gifu Univ., Japan

This paper proposes a method for sharpening an image paid attention on Mach-Effect that is one of human visual characteristics and lateral inhibition known as factor of Mach-Effect. A sharpening process is done by using two-dimensional normal distribution based on the model of lateral inhibition.

VHFp1 - 11L **Optimizing Image Contrast of Two Types of Transparent Displays Using Adaptive S-Curves**

P.-L. Sun, H.-P. Chien

Nat. Taiwan Univ. of S&T, Taiwan

Methods for characterizing the colors of T-LCD and Glasses-LCD under various lighting conditions are introduced. The color characteristics of the two devices are quite different. The image contrast can be improved adaptively by a sigmoidal tone curve and slight chroma compensation.

----- Break -----

16:00 - 17:25 **Hiei**

VHF4: Color and Vision

Chair: K. Masaoka, NHK, Japan
Co-Chair: T. Nakatsue, Sony, Japan

VHF4 - 1: 16:00 ***Invited*** **Observer Metamerism in Displays**

Y. Asano[*,**]

[*]*Rochester Inst. of Tech., USA*
[**]*Motorola Mobility, USA*

Observer metamerism is a phenomenon where two spectrally different stimuli are matched for one person but mismatched for another person due to individual differences in color responses. This work discusses issues of observer metamerism in displays and introduces a possible solution called personalized color imaging.

VHF4 - 2 16:30 **Memory Colors of Familiar Objects in Abnormal and Normal Color Visions**

J.-W. Jian, H.-S. Chen, N.-C. Hu, R. Luo

Nat. Taiwan Univ. of S&T, Taiwan

This study investigated memory colors for people with color vision deficiency (CVD), then built up the memory color model for CVD. The rating data were analyzed by modified bivariate Gaussian function, it's possible to distinguish CVD from NCV according to the distributions of the memory-color rating ellipses.

VHF4 - 3 16:50 **Measured and Calculated Value of the Helmholtz-Kohlrausch Effect for Natural Images under the Ambient Lighting Conditions**

S. Hashimoto, T. Shizume, G. Ohashi, H. Takamatsu[*]*, Y. Shimodaira*

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

According to the calculated values by an estimated equation, the phenomenon of the Helmholtz-Kohlrausch effect occur under the ambient lightings. The purpose of this study is, therefore, to verify the phenomenon by the subjective evaluation experiment.

VHF4 - 4L 17:10 **Proper Pixel Density of Circle Display for Smart Watch**

T.-U. Kim, W. Seo, J. Jang, T.-Y. Park

LG Display, Korea

This study proposed a proper pixel density for circle display of smart watch. The image quality of samples was evaluated with inner and edge section by subjective evaluation. From this study, circle displays with resolution of 519 ppi or more is required.

----- Break -----

17:40 - 18:50 **Hiei**

VHF5: Color Rendering

Chair: Y. Asano, Rochester Inst. of Tech., USA
Co-Chair: A. Yoshida, Sharp, Japan

VHF5 - 1: 17:40 ***Invited*** **Recommendation of Color Rendering Index Value for Wide-Gamut UHDTV Production**

H. Iwasaki, T. Hayashida[*]*, K. Masaoka*[*]*, M. Shimizu, T. Yamashita*[*]*, W. Iwai*

Panasonic, Japan
[*]NHK, Japan

While LED lighting is being increasingly used in television production, it is important to clarify the color rendering index of LED lighting required for UHDTV production. From subjective evaluation results, we propose adding R9 as an index in addition to Ra and recommend Ra > 90 and R9 > 80.

VHF5 - 2 18:10 **An Adaptive Color Calibration Method for LCDs in Different Display Modes**

Y. C. Su, P. L. Sun, H. C. Li, W. C. Hung

Nat. Taiwan Univ. of S&T, Taiwan

Color characteristic under different display modes are investigated and an image-based color correction method is proposed to minimize the color variation under different display modes.

VHF5 - 3
18:30

Evaluation of Color Correction Operations for 3D Scanning Images

K. L. Chan, H. Y. Hsiao, T. H. Lin, H. S. Chen
Nat. Taiwan Univ. of S&T, Taiwan

This paper uses polynomial regression for correcting the color information and luminance distortion of 3D scanned models. Evaluations of 3D luminance correction for 3D scanning image were performed in terms of color difference, luminance curve plot and contrast ratio.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:20 **Ohmi 9**

3D4/VHF6: Autostereoscopic and Head-Mounted Displays

Chair: Y. Takaki, Tokyo Univ. of A&T, Japan
Co-Chair: S. Uehara, Toshiba, Japan

3D4/
VHF6 - 1
9:00

HaptoMIRAGE: An Active-Shuttered Real Imaged Auto-Stereoscopic Display

Y. Ueda, H. Nii[*], K. Minamizawa, S. Tachi[**]
Keio Univ., Japan
[*]IIJ Innovation Inst., Japan
[**]Univ. of Tokyo, Japan

HaptoMIRAGE is an auto-stereoscopic display that does not require the viewer to wear devices like 3D glasses. it is convenient to produce content such that real objects and 3D virtual objects are combined. Furthermore, multiple users can share the 3D view from their respective viewpoints.

3D4/
VHF6 - 2
9:20

Dual Orthogonal Flat Panel Autostereoscopic Display Using Visible Gap Contraction Prism

H. Imai, N. Takanashi
NEC, Japan

We have developed a dual orthogonal flat panel autostereoscopic display using visible gap contraction prism. Since the prism contracts the visible gap region between two orthogonal panels optically, it is possible to diminish visual discomfort for viewer in observing stereoscopic images.

3D4/ VHF6 - 3 9:40 **Sense of Height and Virtual Body in Head-Mounted Display Environments**

T. Shibata, T. Inoue[*]

Tokyo Univ. of Social Welfare, Japan
[*]Kanagawa Inst. of Tech., Japan

When using a head-mounted display, we cannot see our own body. We conducted an experiment to evaluate effects of virtual body on the user's sense of height and fear of heights. The results showed that the virtual body increased the user sense of height slightly and fear of heights significantly.

3D4/ VHF6 - 4 10:00 **Development of Poor Man's 3D-AR Platform for Amateur Game Creators**

Y. Yoneda, E. Dong, T. Fujita, H. Kiriyama, K. Takemura, K. Iwasaki, R. Urushihara[*], T. Ichii

Tokyo Inst. of Tech., Japan
[*]Ochanomizu Univ., Japan

For 3D-AR by amateur creators, development of a low-cost and easy to use platform is necessary. The system should be composed of low-cost devices such as tablet-PCs and USB-cameras. However, the performance of each device is low. We'll show the way to cover the performance by combination of available sensors.
Also presented in Innovative Demonstration Session (see p. 207)

----- Break -----

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

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 10

9:00 - 9:05 **Ohmi 10**

Opening

Opening Remarks
9:00

S. Ouchi, Hitachi, Japan

9:05 - 10:30 **Ohmi 10**

PRJ1: Projection Applications

Chair: D. Cuypers, imec, Belgium
Co-Chair: H. Nakano, Barco Japan, Japan

PRJ1 - 1: 9:05 ***Invited*** **Volumetric Display Containing Multiple Two Dimensional Information Patterns**

A. Shiraki, H. Nakayama, R. Hirayama, T. Kakue, T. Shimobaba, T. Ito

Chiba Univ., Japan

We have developed an algorithm to record multiple two-dimensional information patterns in single volumetric display. In this technique, different two-dimensional information pattern is expressed by the observation position of the observer. We showed some application of this technique.

PRJ1 - 2 9:30 **Implementation of Volumetric 3D Display with Multi-Layered Shutter Screens for Enhanced the Depth Recognition**

J.-T. Kim, S.-H. Yoo, M.-K. Park, H.-R. Kim

Kyungpook Nat. Univ., Korea

We proposed the new 3D system of projection type consisting of SLM projector, polarization controller, and active shutter screens. To divide a 2D image according to depth information, optical properties of SLM projector and polarization controller are analyzed by measuring the Stokes parameter which can represent the polarization state.

PRJ1 - 3 **Boosting the Brightness of an LED Projector by**
9:50 **Adding Laser Light Source**

P. Hickl, M. N. Ngo
Barco Control Rooms, Germany

High Power LEDs are in many respects a perfect light source for projection, especially for professional applications. However the maximum reachable projector brightness is Étendue limited. This paper describes a very simple method to increase the brightness by just modifying the typical LED illumination architecture with a laser source.

PRJ1 - 4 **Low-Speckle 6 Primary Laser Digital Cinema**
10:10 **Projector**

P. Janssens, N. Coulier, W. D'Oosterlinck, G. Van Den Bergh
Barco, Belgium

Barco has developed a high-brightness laser projector platform for digital cinema ranging from 20.000 to 60.000 lm. The projectors use a free-space coupled 6 primary laser source and are optimized for speckle reduction. The platform uses a chilled liquid cooling system to maximize lifetime and to reduce operational costs.

10:30 - 10:54 **Ohmi 10**

Short Presentation PRJp1: Projection

All authors of poster papers for the PRJp1 session will give a brief 3-minute oral presentations with no discussion time in advance.

----- Lunch -----

13:40 - 15:40 **Ohmi 6**

***Poster* PRJp1: Projection**

PRJp1 - 1 **On the Discussion of the Uniformity Metrics**

C.-J. Ou, S.-E. Hong, S.-Z. Yang, Y.-Y. Chang, C.-H. Wu
Hsiuping Univ. of S&T, Taiwan

New definition of the Uniformity is required for different scenario. It is clear to see that the present definition is close to the EBU code, with easier algorithm embedded in microchip for real time inspection.

PRJp1 - 2 **Image Projection Using Random Phase-Free Hologram**

Y. Nagahama, T. Shimobaba, T. Kakue, T. Ito

Chiba Univ., Japan

Random phase is frequently used to a hologram calculation in order to widely spread an object light. However, the reconstructed image is contaminated by speckle noise. In this paper, we apply spherical wave instead of random phase to the hologram calculation, and demonstrate image projection with random phase-free amplitude hologram.

PRJp1 - 3 **Head-Up Display System Incorporated with an Optical Element Having Both Lens Shift and Convex Features**

C.-Y. Shih, S.-W. Cheng, J.-T. Hsu

Automotive Res. & Testing Ctr., Taiwan

A HUD system was developed to incorporate an optical element that has the features of lens shift and convex. In doing so, HUD system was downsized while the magnifying, long-distance image was maintained. The HUD was capable of displaying information 2.1 meters in front of driver and large image (16.1-in).

PRJp1 - 4 **Electrochromic Display Combined with Microcapsule**

J.-H. Yoon, M.-S. Kim, C.-H. Moon

Hoseo Univ., Korea

To enhance the contrast and the uniformity of the electrochromic display devices, microcapsules were introduced inside the devices. As a chemical reaction layer, WO_3 and polyaniline were injected inside the microcapsules and their coloration characteristics were investigated with the change of the operating voltage.

PRJp1 - 5L **Waveguide-Type Red-Green-Blue Laser Beam Combiners Integrated with Semiconductor Lasers**

A. Nakao, K. Tsujino, S. Yokokawa, S. Tanaka, S. Hayashiguchi, T. Katsuyama

Univ. of Fukui, Japan

We have realized a new waveguide-type red-green-blue laser beam combiner, which is integrated with semiconductor lasers. Its size is as small as 4.5 × 7.5 mm. Tapered spot size converters and curved waveguides were introduced. This laser source can be applied to compact image projectors including eyewear projectors.

PRJp1 - 6L **Polarization-Dependent Diffuser Based on Liquid-crystal Lens Array**

W.-K. Lin[,**], W.-C. Su[**], B.-S. Lin[*]*

[*]Nat. Chiao Tung Univ., Taiwan

[**]Nat. Changhua Univ. of Education, Taiwan

A polarization-dependent diffuser is fabricated by liquid-crystal micro lens array. The device is operating with a low applied voltage. In this study, the optical characteristic of the diffuser is analyzed. The device can be a screen when the incident light is diffused.

PRJp1 - 7L **A Study Liquid Crystal Lens Dimming Technology in the Non-Image Projection System**

Y.-L. Su, Y.-C. Fang, W.-T. Li
Nat. Kaohsiung First Univ. of S&T, Taiwan

The main purpose of this paper is to explore to improve the laser projector projection contrast lighting design. Used as the light source of a liquid crystal lens array local dimming system, the contrast of the projector reaches the imaging element wafer significantly improved purposes.

PRJp1 - 8L **Validation of Illuminance Measurement for Laser Display**

*S. Kubota, M. Kurashige, K. Ishida, K. Ochi**
Dai Nippon Printing, Japan
**Konica Minolta, Japan*

The effect of speckle on the measurement of illuminance was investigated by changing speckle contrast of RGB lasers and measuring illuminance directly and indirectly. Illuminance level in the both methods was almost same, which means the effect of speckle was small in the measuring conditions of this validation study.
Also presented in Innovative Demonstration Session (see p. 207)

----- Break -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:20 **Ohmi 10**

PRJ2: Projection Components and Materials

Chair: P. Janssens, Barco, Belgium
Co-Chair: T. Hayashi, OKAMOTO GLASS, Japan

PRJ2 - 1 9:00 **Circular Liquid Crystal Alignment Using the Oblique Inorganic Material Deposition Method**

D. Cuypers, J. De Smet, P. Joshi, X. Shang, H. De Smet
IMEC & Ghent Univ., Belgium

The possibility of circular liquid crystal alignment using only inorganic obliquely evaporated alignment layers is explored and used to realize proof-of-principle devices, as an alternative to the polymer based circular alignment approaches.

PRJ2 - 2 **Optical Resin for Displays**
9:20

R. Ozeki, T. Kenmochi

Kyoritsu Chem., Japan

Future technologies will rely on the utilization of optical resins. Resin technologies offer effective optical performance for devices which contributes to optical display units of the present and future for wearable devices. There are three key technologies related to optical performance; Optical Control, Coloration, and Anchor. These technologies can be made with design latitude.

PRJ2 - 3 **Ultra High Contrast Reflective HTPS Projector**
9:40 **Applied Laser Diode**

A. Haruyama, Y. Sugimoto, S. Uchiyama, M. Kawamura, T. Toyooka, H. Iisaka

Seiko Epson, Japan

We developed a new liquid crystal display (LCD) projector that employs a new reflective high-temperature poly-silicon (R-HTPS) device and laser diodes (LD) for the light source. To achieve a high contrast ratio, the devices and optical system were modified.

PRJ2 - 4L **High-Speed 8-bit Image Projector at 1,000 fps with**
10:00 **3 ms Delay**

Y. Watanabe, G. Narita, S. Tatsuno, T. Yuasa[*], K. Sumino[*], M. Ishikawa

Univ. of Tokyo, Japan
[*]Tokyo Electron Device, Japan

We report a newly developed high-speed projector operating at a frame rate of 1,000 fps and with a latency of 3 ms. This was achieved by synchronized operation of the DMD and LED and by using a specially developed image transmission module.

----- Break -----

10:40 - 12:25 **Ohmi 10**

PRJ3: Solid State Light Source

Chair: P. Hickl, Barco Control Rooms, Germany
Co-Chair: T. Fukui, Oxide, Japan

PRJ3 - 1: 10:40 ***Invited*** **Speckle Reduction by Using Transmissive ZnO Device Based on Dressed-Photon-Assisted Optical Modulation**

N. Tate, T. Kawazoe[*], S. Nakashima, W. Nomura, M. Ohtsu[,**]*

Kyushu Univ., Japan
[*]Res. Inst. of Nanophotonics, Japan
[**]Univ. of Tokyo, Japan

We demonstrated large optical modulation using zinc oxide single crystal doped with nitrogen ions, which was annealed by a dressed-photon–assisted annealing method. The device, having a thin, transmissive structure, was used as a key component of a novel speckle reduction method.

PRJ3 - 2 11:05 **Highly Reliable High Power 638 nm Broad Area Laser Diode for Display Application**

T. Yagi, K. Kuramoto, R. Wakamatsu, M. Miyashita

Mitsubishi Elec., Japan

638-nm broad area laser diode (BA-LD) with triple 60-μm stripes assembled on ϕ-9.0 mm TO emitted up to 5.5 W at 25˚C, pulse with duty of 30%. Mean time to failure of the LD under 2.5 W with duty of 30% was estimated to be 120 K hours.

PRJ3 - 3 11:25 **Optically Efficient Homogenization of Laser Illumination**

F. Shevlin

DYOPTYKA, Ireland

DYOPTYKA's innovative deformable mirror technology is shown to achieve effective and efficient intensity homogenization of laser illumination and speckle reduction in a projection display. Performance is found to be similar to an approach which uses one stationary and one moving diffuser moving diffuser but with significantly improved optical efficiency.

Also presented in Innovative Demonstration Session (see p. 207)

PRJ3 - 4 11:45 **Mixed Phosphors/Dye in Liquid for High Power Digital Projectors with Laser Excitation**

K. Li

Wavien, USA

Heat dissipation using standard phosphor wheel configuration in laser phosphor projectors limits the output to about 6,000 lumens. This paper describes a circulating liquid with a suspension of phosphor powder in an optical cell allowing the output to be extended to beyond 60,000 lumens for 3D digital cinema.

PRJ3 - 5L 12:05 **SiC magneto-optical current-transformer applicable to a polarization rotator using dressed photons**

T. Kawazoe[*], N. Tate[**], M. Ohtsu[,***]*

[*]Nanophotonics Eng. Organization, Japan
[**]Kyushu Univ., Japan
[***]Univ. of Tokyo, Japan

An magneto-optical current-transformer using SiC was demonstrated. This device was SiC homojunction diode processed by the dressed-photon-phonon annealing. The Verdet constant of the device was 600 deg/A and the Faraday rotation angle was 7800 deg/cm. Its potential as a display component is extremely high.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 14:50 **Ohmi 10**

PRJ4: Automotive Display and Lighting

Chair: F. Shevlin, DYOPTYKA, Ireland
Co-Chair: K. Ohara, Texas Instrs., Japan

PRJ4 - 1: 13:30 ***Invited*** **Study on the Effect of the Laser Headlights on the Brightness of Road Surfaces and Traffic Signs**

S. Iwamoto, Y. Tsukada[*]

Honda R&D, Japan
[*]Nat. Traffic Safety & Environment Lab., Japan

In the past few years, laser has been developed as a light source to be used in the headlamps, and its practical application has already been started. Accordingly, we conducted comparative study on how headlights with different light sources and colors affect the appearance of traffic signs and white lines.

PRJ4 - 2: 13:50 ***Invited*** **Laser/LED Headlights**

T. Waragaya, Y. Nakazato, T. Anzai

Stanley Elec., Japan

The automotive headlight which is equipped with LED currently becomes familiar. Laser based light sources are attracting attention as next-generation light sources in automotive headlights. In this paper, we introduce as the example that how the laser based headlight which we manufactured contributes to safe driving.

PRJ4 - 3: 14:10 ***Invited*** **Visualization of the Wind by the 1.5 μm Coherent Doppler LIDAR**

T. Yanagisawa, T. Sakimura, N. Kotake, S. Kameyama, T. Ando, K. Asaka, M. Furuta, H. Tanaka, T. Harada, M. Hagio, M. Enjo, Y. Kajiyama, Y. Fujii, Y. Hirano

Mitsubishi Elec., Japan

We have released coherent Doppler LIDARs (CDLs) which realize visualization of the wind. Long-range CDL (A series) can measure wind up to 30-km of radius. Compact CDL (W series) can visualize velocity and direction of the wind in real time. We introduce principle and technologies used in the CDLs.

PRJ4 - 4L 14:30 **Augmented Reality Head-Up Display: Defining Brightness Requirements**

S. Martin, J. Thompson, J. Ferri

Texas Instrs., USA

The next generation augmented reality (AR) head-up display (HUD) will fundamentally change the driver's experience, providing graphics conformed to the real-world screen. AR HUD systems have new parameters requiring significantly higher luminous flux. Additionally, sunlight thermal loading and polarization effects must also be considered for these new AR HUD systems.

----- Break -----

15:10 - 16:35 **Ohmi 10**

PRJ5: Projection Optics

Chair: J.-W. Pan, Nat. Chiao Tung Univ., Taiwan
Co-Chair: Y. Asakura, NITTOH KOGAKU, Japan

PRJ5 - 1: 15:10 ***Invited*** **Development of RGB Laser Backlit Liquid Crystal Display**

E. Niikura, N. Okimoto, S. Maeda, H. Yasui, A. Heishi, S. Yamanaka, T. Sasagawa[*]*, Y. Nishida*[**]*, Y. Kusakabe*[**]

Mitsubishi Elec., Japan
[*]*Mitsubishi Elec. Lighting, Japan*
[**]*NHK, Japan*

We have developed a laser backlit liquid crystal display with the RGB semiconductor laser diodes in the backlight light source. In this backlit system, three-color laser lights are emitted by our original light guide rods. This display has achieved 98% cover ratio of the Rec. ITU-R BT.2020.

PRJ5 - 2
15:35

Aberration Correction in Ultra Short Throw Projection Lens Using a Relay Optical System

T. Matsuo, K. Mochizuki, A. Sawamoto, M. Yoshida, K. Ooe, Y. Asakura

Nittoh Kogaku, Japan

We have developed a new optical system that uses Hybrid Relay Lens (HRL) system. The HRL system is a lens with very short focal length, which satisfies all the requirements expected for a projection lens. This new type of lens system will fulfill unsolved needs in the market.

PRJ5 - 3
15:55

Wide-Conversion Lens Design for a Pico Projector

K.-W. Zhao, C.-W. Tsao, Y.-C. Chen, K-D. Chang[*]*, J.-W. Pan*

Nat. Chiao Tung Univ., Taiwan

We propose a concept for the design of a 0.702x wide-conversion lens for a 0.30-in. Digital Micromirror Device. By attached in front of the projection lens of a Pico Projector, this wide-conversion lens is capable of enlarging the size of the original projected image at the same projection distance.

PRJ5 - 4
16:15

Optical Device Design to Realize the Visor-Type Display and Augmented Reality

C.-H. Chuang[*]*, Y.-K. Hsu*[*]*, C.-Y. Chen*[**]*, B.-S. Lin*[***]*, P.-J. Wu*[***]

[*]*Nat. Yunlin Univ. of S&T, Taiwan*
[**]*Nat. Taiwan Univ. of S&T, Taiwan*
[***]*Nat. Chiao Tung Univ., Taiwan*

In this study, we propose a wearable display with a projection device. The “optical projection device” is designed and mounted on the visor to realize augmented reality. By using the device, an upright enlarge virtual image is obtained and the distance between the eyes and the image is 14 cm.

----- Break -----

16:50 - 18:20 **Ohmi 10**

PRJ6: Wearable Applications

Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: S. Shikama, Setsunan Univ., Japan
Co-Chair: S. Ouchi, Hitachi, Japan

PRJ6 - 1: 16:50 ***Invited*** **High-Luminance See-Through Eyewear Display with Novel Volume Hologram Waveguide Technology**

S. Nakano, T. Oku, K. Akutsu, M. Kuwahara, T. Yoshida, E. Kato, K. Aiki, I. Matsumura, A. Machida, H. Mukawa

Sony, Japan

We have developed a see-through eyewear display with novel volume hologram waveguide. The waveguide has two in-coupling and one out-coupling reflection holograms. This technology enables to achieve high-luminance (1000 cd/m^2) and high-uniformity (70%) characteristics, which is indispensable for augmented reality applications in various environments.

PRJ6 - 2: 17:15 ***Invited*** **Augmented Vision for Minimally Invasive Surgery**

T. Nakaguchi

Chiba Univ., Japan

Laparoscopic surgery is one of the most important trends in modern medicine. It, however, makes the surgical procedure much difficult and risky. Since augmented reality (AR) technologies have a potential to address these problems, we will present current situation and future problem of the projector-based AR system in Medicine.

PRJ6 - 3 17:40 **A Head Mounted Display Using the Original Flexible Arm and Headband**

M. Watanabe, Y. Fukuda, M. Yagi, H. Ishizaki, M. Nakanishi[*]*, N. Hanafusa*[**]*, T. Katano*

Brother Inds, Japan
[*]Keio Univ., Japan
[**]Univ. of Tokyo Hospital, Japan

We have developed a Head Mounted Display “HMD” using the original flexible arm and headband. Users of this HMD can place the display at the free position. The feasibility test of this HMD on ultrasound guided vascular access puncture confirmed good operability.

Also presented in Innovative Demonstration Session (see p. 207)

PRJ6 - 4L **An Applied Method for Wearable Device with**
18:00 **Assortment Work in Logistics**

T. Fujiwara, T. Kosaka, T. Matsuda, Y. Nakajima, T. Sakurada[*]*, T. Ozaki*

Hitachi, Japan
[*]*Hitachi Transport Sys., Japan*

Wearable device attracts many companies. Logistics department especially expects it because getting advantage of hands-free. In this study, we adapted wearable device to assortment work in logistics and evaluated cost cut effect in comparison with current method. As the result of evaluation, cost cut effect is approximately 15%.

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Supporting Organizations:
Laser Display Technology Research Group, Optical Society of Japan
Technical Group on Information Display, ITE

"Innovative Demonstration Session" *by Oral and Poster Presenters*

Live demonstrations of emerging information display technologies

Thursday, Dec. 10, 2015
10:30 – 16:00
Ohmi 5 (2F)
Shakunage 2 (1F)
See page 205-209 for details

EXHIBITION

12:00 – 17:00 Wednesday, Dec. 9
10:00 – 18:00 Thursday, Dec. 10
10:00 – 14:00 Friday, Dec. 11

Lobby (2F)
Otsu Prince Hotel

Free admission with your registration name tag

Workshop on Electronic Paper

Wednesday, December 9

13:30 - 14:40 **Hiei**

EP1: Emerging Technologies for e-Paper

Chair: S. Maeda, Tokai Univ., Japan
Co-Chair: N. Kobayashi, Chiba Univ., Japan

EP1 - 1: 13:30 ***Invited*** **Paper Electronics for All Paper-Based Displays**

H. Koga

Osaka Univ., Japan

Cellulose nanofiber paper-based flexible electronic devices, such as transparent conductive paper, nonvolatile paper memory and paper antenna, were successfully developed. These paper electronics offered both high flexibility and device performances, opening new doors for all paper-based displays.

EP1 - 2: 13:55 ***Invited*** **New Switchable Mirror Sheet Using Gasochromic Switching Method**

K. Yoshimura, Y. Yamada

AIST, Japan

We developed an innovative gasochromic switchable mirror sheet. With this new switching method, the attached sheet can be switched between transparent and mirror state like a conventional gasochromic method using pair glass. Because the thin film structure of gasochromic is very simple and this new technique has a possibility to raise a cost revolution for switchable sheet.

EP1 - 3 14:20 **Photo-Thermo Functional Polymeric Films Showing RGB Coloration and Emission for Dual Mode Displaying Media**

K. Ogasawara, K. Nakamura , N. Kobayashi

Chiba Univ., Japan

Thermochromic reactions are widely applied to thermal rewritable media. These displaying media are usually enabling single coloration and no visibility in dark place. We combined RGB thermochromic materials with luminescent materials to construct multi-color novel dual mode displaying media which showed high visibility in both bright and dark places.

----- Break -----

15:10 - 16:35 **Hiei**

EP2: Electrochromic Displays

Chair: N.-S. Roh, Samsung Display, Korea
Co-Chair: M. Higuchi, NIMS, Japan

EP2 - 1: 15:10 ***Invited*** **Inkjet Printed Multi-Color Thin Films for High-Contrast Electrochromic Devices**

B.-H. Chen, S.-Y. Kao, C.-W. Hu[*], M. Higuchi[**], K.-C. Ho, Y.-C. Liao

Nat. Taiwan Univ., Taiwan
[*]AIST, Japan
[**]NIMS, Japan

By digitally controlling print dosages of primary electrochromic colorants, colors of the printed thin film patterns can be adjusted directly without pre-mixing or synthesizing new materials. Various color setup or patterns can also be printed by this all-solution process to manufacture single electrochromic devices with multiple colors and high contrast.

EP2 - 2 15:35 **Investigation of Mean Electrode Potential in Organic Electrochromic Device during Device Operation**

N. Ura, Y. Watanabe, K. Nakamura, N. Kobayashi

Chiba Univ., Japan

We measured the electrode potential of anode and cathode during actually-driving of electrochromic cell to reveal the load of the material receiving from the electrode. From the result, it became obvious that the electrode potentials of the anode and the cathode were automatically regulated to facilitate both electrode reaction.

EP2 - 3 15:55 **Investigation of Electrodeposition Behavior and Its Optical Characterization of Ag Deposition-Based Multicolor EC Device**

R. Onodera, A. Tsuboi, K. Nakamura, N. Kobayashi

Chiba Univ., Japan

Recently, we reported Ag deposition-based multicolor electrochromic (EC) device. The EC device can show three primary colors of cyan, magenta and yellow (CMY). To investigate the detailed optical property, the electrodeposition behavior of Ag nanoparticles and its coloration mechanisms of the device were analyzed in detail.

EP2 - 4 16:15 **Electrochemical Modulation of Emission and Coloration by Novel Functional TiO_2 Electrode Having Covalently Connected Lanthanide(II) Complexes and Viologen Derivatives**

K. Nakamura, K. Kanazawa, Y. Komiya, N. Kobayashi
Chiba Univ., Japan

A dual-mode display device which can operate in both emissive and reflective modes, having advantages of both modes, is expected as a next generation display. In this study, electrochemical switching systems, which enable simultaneous control of both emission and coloration, were investigated in order to create the novel displaying materials.

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

9:00 - 10:15 **Ohmi 3**

EP3: Electrophoretic Displays and Applications

Chair: G. Zhou, South China Normal Univ., China
Co-Chair: K. Hashimoto, E Ink Japan, Japan

EP3 - 1: 9:00 ***Invited*** **Innovation and Application of e-Paper Display**

F.-J. Ko
E Ink Holdings, Taiwan

E Ink's ePaper offers the best paper-like viewing experience. Besides the first successful adoption of ePaper for the eReader application, numerous other new and innovative product applications made possible by its advantages such as low power consumption, bi-stability, flexibility and etc. New applications will be described in this talk.

EP3 - 2: 9:25 ***Invited*** **Development of Flexible Active-Matrix Electrophoretic Displays**

K. Nomoto
Sony, Japan

We have developed flexible active-matrix electrophoretic displays. We will discuss a flexible a-Si TFT backplane based on bonding-debonding process and an ultra-flexible organic TFT with bending radius down to 2 mm. Challenge to incorporate high-resolution printing process will be also discussed for future manufacturing process.

EP3 - 3: 9:50 ***Invited*** **Future Electronic Paper in Office: Proposals Based on Actual Use of Electronic Paper Device**

H. Shibata, Y. Fukase[*], K. Hashimoto[**], Y. Kinoshita[***], H. Kobayashi, S. Nebashi[****], M. Omodani[*****], T. Takahashi[******]

Fuji Xerox, Japan
[*]ISJ, Japan
[**]E Ink Japan, Japan
[***]Toshiba Tec, Japan
[****]Seiko Epson, Japan
[*****]Tokai Univ., Japan
[******]Dai Nippon Printing, Japan

Nine participants used an A4-size electronic paper device in their work. Based on the results, we suggest that electronic paper in the office should aim at supporting activities with other devices that could compensate for defects of electronic paper. We also discuss three application domains: active reading, collaboration and note-taking.

10:15 - 10:36 **Ohmi 3**

Short Presentation EPp1: Electronic Paper

All authors of poster papers for the EPp1 session will give a brief 3-minute oral presentations with no discussion time in advance.

----- Lunch -----

13:40 - 15:40 **Ohmi 6**

Poster **EPp1: Electronic Paper**

EPp1 - 1 **Withdrawn**

EPp1 - 2 **Effects of Silver Halide Complexes on the Coloration Properties of Silver Deposition-Based Electrochromic Device**

R. Kimura, A. Tsuboi, K. Nakamura, N. Kobayashi

Chiba Univ., Japan

We have constructed Ag deposition-based electrochromic (EC) device which showed reversible changes of optical states between clear transparent and silver-mirror by driving procedure. In this research, we evaluated the effects of silver halide complexes on the coloration properties of the EC device by changing halide anion species.

EPp1 - 3L **Titanium Plate as Rewritable Imaging Media**

I. Komatsu, K. Matsunaka, S. Maeda

Tokai Univ., Japan

The method for preparing digital images on titanium plate by anodic oxidization was studied. First making a toner image on the treated transparency sheet, then transferring the toner image to titanium plate thermally. And we found that 1% HF solution could erase the image in a few minutes.

EPp1 - 4L **Rewritable Paper Utilizing Kapok Fibers Containing Chromic Material**

K. Noda, S. Kiyama, T. Makino, S. Yoshinari, S. Maeda

Tokai Univ., Japan

We have succeed to make Kapok fibers containing metal complex. Kapok fiber is natural half-transparent hollow tube whose inner and outer diameters are 18 and 20 μm respectively. We think that the Kapok fibers containing metal complex have potential to apply to the field of anti-counterfeit and rewritable paper.

EPp1 - 5L **Flexible Electrophoretic Image Display Using PEDOT/PSS Organic Transparent Electrode**

K. Aoba, H. Hyakutake, T. Kitamura[*]

Denshi Kako, Japan
[*]*Chiba Univ., Japan*

The flexible electrophoretic image display device with an organic electrically conductive layer using PEDOT/PSS printing ink by screen printing was produced. It was confirmed that the black and white image were displayed on the electrophoretic image display device with the organic conductive electrodes.

EPp1 - 6L **Memory Effect Cancelling of Twisting Ball Display via Space-Charge Polarization**

Y. Komazaki, T. Torii

Univ. of Tokyo, Japan

E-papers utilizing particle movement, such as electrophoretic displays, liquid powder displays and twisting ball displays usually have memory effect (bistability). In this study, we perform a quite simple method to cancel the memory effect of a twisting ball display by using space-charge polarization.

EPp1 - 7L **Effects of the Severity of Cataract Cloudiness on the Readability of e-Books**

K. Iwata, Y. Ishii, S. Matsunami, N. Ishio, P. R. Lege, T. Kojima[*], M. Miyao

Nagoya Univ., Japan
[*]Chubu Gakuin Univ., Japan

We carried out experiments to evaluate the readability of e-readers with different levels of cloudiness in the eyes. In the experiments, we used four devices. We conducted subjective evaluations under staged illuminance conditions. This study found a relationship between the severity of cataract cloudiness and readability of device.

EPp1 - 8L **Verification of the Minimum Character Sizes for Comfortable Reading of an e-Paper**

Y. Ishii, K. Iwata, N. Ishio, S. Matsunami, L. R. Paul, T. Kojima[*], M. Miyao

Nagoya Univ., Japan
[*]Chubu Gakuin Univ., Japan

We carried out an experiment to evaluate the readability of e-books, backlit LCD, and ordinary paper text. In the experiment, we measured the objective evaluation, and then asked them evaluate the subjective evaluation. This study found a dependency on the minimum character sizes and readability for e-paper devices.

----- Break -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Evening Get-Together with Wine

Tuesday, Dec. 8, 2015
18:00 – 20:00
Hiei (2F)
Otsu Prince Hotel
(Sponsored by Merck Ltd., Japan)
See page 12 for details

Workshop on MEMS and Emerging Technologies for Future Displays and Devices

Thursday, December 10

13:40 - 15:40 **Ohmi 6**

***Poster* MEETp1: Emerging Technologies**

MEETp1 - 1 Electrode Patterns for Optimized HB-LED Apodization Profiles

S. -Z. Yang, C.-J. Ou, S.-E. Hong, Z.-Y. Shi, Y. -Y. Lin
Hsiuping Univ. of S&T, Taiwan

Comparison for the two LED electrodes is demonstrated. Model with scattering mechanism and the optical throughput simulations for both photons and electron/hole recombination are considered simultaneous. Results indicate that LED electrode arrangements for multi-physics and optical throughput are contradict to each other. Guidelines to overcome these conflicts are discussed.

MEETp1 - 2 Surface Structures Treatment for Light Extraction of HB-Light Emitting Diode

C.-J. Ou, C.-H. Wu, Z.-Y. Shi, S.-Z. Yang, Y.-Y. Lin, M.-Z. Zhang, Y.-Y. Chang
Hsiuping Univ. of S&T, Taiwan

In that respects are high demands for increasing the light extraction of the LED, surface treatment on layer structure becomes a viable path to overwhelm the limitation due to the LED materials. We represent the geometric variations of the surface micro-structure to explore the structure equations of the LED device.

MEETp1 - 3 Investigating the Photoelectric Characteristics of the TiO_2 Composite Graphene UV Photodetector

C.-T. Wang, C.-C. Ting[*]*, S.-Y. Chu*
Nat. Cheng Kung Univ., Taiwan
[*]*Nat. Chung Cheng Univ., Taiwan*

In this paper, we controlled the thickness of the TiO_2 to enhance the performance of the graphene photodetector. We could find the responsivity and rising time were strong dependence on the thickness of the TiO_2. We well explain by the semiconductor nanoparticles adsorption and desorption oxygen molecules.

MEETp1 - 4L Water-Proof and Flexible Inverted Quantum-Dot Light Emitting Diodes with Thin-Film Encapsulation

J. Lee, H.-M. Kim, Y. Kim, E. Hwang

Kyung Hee Univ., Korea

We developed the thin-film encapsulation technique having a water-proof and flexible properties for inverted quantum-dot light emitting diodes (QLEDs). The flexibility evaluations for inverted QLED with thin-film encapsulation, such as bending and rolling tests, are reported and it was confirmed that the QLED can be operated at underwater successfully.

----- Break -----

16:00 - 16:05 **Ohmi 8**

Opening

Opening Remarks
16:00

M. Nakamoto, Shizuoka Univ., Japan

16:05 - 17:25 **Ohmi 8**

MEET1: Quantum Dots Applications

Chair: Y. Bonnassieux, Ecole Polytechnique, France
Co-Chair: F. Templier, CEA-LETI, France

MEET1 - 1: *Invited* Beyond Edge-Lit TV: Diversifying Quantum Dot Penetration into Other Display Segments
16:05

S. Coe-Sullivan

QD Vision, USA

In the PC monitor space, new and existing standards in color gamut may be the primary driver of QD market penetration.

MEET1 - 2: *Invited* Next Generation Display Technology: Quantum Dot LEDs
16:25

J. R. Manders[*], L. Qian[*], A. Titov[*], J. Hyvonen[*], K. P. Acharya[*], J. Tokarz-Scott[*], Y. Yang[*], W. Cao[*], Y. Zheng[*], J. Xue[**], P. H. Holloway[,**]*

[*]NanoPhotonica, USA
[**]Univ. of Florida, USA

Colloidal quantum dot light emitting diodes (QLEDs) are reported that exhibit external quantum efficiencies (EQE) >10% for red, green, and blue. This includes a record 21% EQE, 82 cd/A green. Devices have lifetimes of >280k hours and cover >170% NTSC 1987 and ~90% of the Rec. 2020 color spaces.

MEET1 - 3: *Invited* Outcoupling Efficiency of Electrospun Nanofiber Sheet Embedded with Quantum Rods
16:45

M. Hasegawa, Y. Hirayama, S. Dertinger

Merck, Japan

We fabricated aligned and nonaligned electrospun polymer nanofibers embedded with quantum rods using a high-speed rolling drum or a planar substrate. Both sheets showed a higher outcoupling efficiency compared with those of QRs dispersed in a polymer film even after enhancement using titanium oxide nanoparticles.

MEET1 - 4: *Invited* Inverted Quantum-Dot Light Emitting Diodes Using Solution Processed Metal-Oxide Electron Transport Layer
17:05

H.-M. Kim, J.-G. Kim, J.-E. Lee, J. Jang

Kyung Hee Univ., Korea

Inverted quantum-dot light-emitting diodes (QLEDs) are demonstrated using solution processed metal-oxide electron transport layer (ETL). The QLEDs with metal-oxide based green, yellow and red QLEDs were demonstrated with high efficiencies. The multilayer structure with surface modification for ETLs can improve the performance of QLEDs.

----- Break -----

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

10:40 - 12:00 **Ohmi 8**

MEET2: Novel Materials and Components

Chair: J. Silver, Brunel Univ. London, UK
Co-Chair: J. Jang, Kyung Hee Univ., Korea

MEET2 - 1: *Invited* Very Low Voltage Flexible N-Type Organic Field Effect Transistors
10:40

Y. Bonnassieux, S. Jung, M. Al-Bariqi[*], G. Gruntz[**], Y. Nicolas[**], T. Toupance[**], G. Horowitz

Ecole Polytechnique, France
[*]Royal Saudi Naval Forces, Saudi Arabia
[**]Univ. of Bordeaux, France

We propose an efficient approach for an n-type OFETs with the same device structure used commonly for p-type. Using TIPSTPDO-tetraCN and cross-linked PMMA, respectively as n-type OSC and dielectric, We have obtained linear regime mobility (1.8±0.2) $\times 10^{-2}$ cm^2/Vs, small spatial standard deviation of threshold voltage (~0.1 V), and operating voltage less than 3 V.

MEET2 - 2: *Invited* Carbon Nanotube Electron Beams for Medical and Display Devices
11:00

J. S. Kang, M. T. Chung, K. C. Park

Kyung Hee Univ., Korea

We introduced the novel carbon nanotube electron beam(C-beam) fabrication techniques for medical imaging and display devices. C-beam were fabricated with resist-assisted pattering (RAP) process grown carbon nanotube emitters. With the C-beam, we fabricated silicon PIN and TFT devices and the performances of display devices and X-ray tubes will be presented.

MEET2 - 3: *Invited* World's Fastest Plastic Optical Fiber and Network for 4K/8K TV
11:20

A. Inoue, Y. Koike

Keio Univ., Japan

Optical network based on world's fastest graded-index plastic optical fiber (GI POF) has been proposed and developed for the 2020 Tokyo Olympics and Paralympics. We developed the 120 Gb/s GI POF cable with ballpoint-pen connector for consumer-friendly optical interface without electromagnetic interference in upcoming 4K/8K era at home.

MEET2 - 4 Pseudo-Crystalline Silicon PIN Diode with Carbon Nanotube Electron Beam(C-Beam) Exposure Technique
11:40

M. T. Chung, J. S. Kang, H. R. Lee, J. H. Hong, K. C. Park

Kyung Hee Univ., Korea

We introduced the novel pseudo-crystalline silicon diode fabrication technique with carbon nanotube electron beam (C-beam) irradiation. With the high performance C-beam, we could crystallized pin structures and obtained enhanced the diode characteristics with higher on/off ratio. Detail on multi-layer crystallization and various display device application will be presented.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 14:50 **Ohmi 8**

MEET3: MEMS and Related Technologies

Chair: Y. Aoyagi, Ritsumeikan Univ., Japan
Co-Chair: K. C. Park, Kyung Hee Univ., Korea

MEET3 - 1: *Invited* Development and Applications of MEMS Process Tools
13:30

S. Tanaka
Tohoku Univ., Japan

This paper presents our recently-developed process tools including ALD systems, a vacuum wafer bonder, a vacuum flip chip bonder for chip-scale packaging and a remote-type hot-wire atomic hydrogen source for metal reduction and polymer etching. In addition, examples of MEMS which have been created using the above tools are introduced.

MEET3 - 2 Membrane-Type Microheater for Wavelength Selective Infrared Emitter and CO_2 Gas Sensing
13:50

H. Ishihara, K. Masuno, M. Ishii, S. Kumagai[*], M. Sasaki[*]
Yazaki, Japan
[*]Toyota Tech. Inst., Japan

A wavelength selective infrared emitter is fabricated showing the clear enhanced emission peak due to the surface plasmon polariton. The emission at the wavelength of the absorption band of CO_2 gas is enhanced. Against input power, the intensity at the peak wavelength shows the steeper increase than the background intensity.

MEET3 - 3 Enhancement and Transparent of Film Applied to the Transparent Display Device
14:10

C.-H. Chiu, Y.-H. Chen[*], W.-C. Chien[*], C.-H. Chien[*]
Chunghwa Picture Tubes, Taiwan
[*]Tatung Univ., Taiwan

The transparent display devices (TDDs) were limited by the performance of the luminance. In this study, the film is a double structure, included some micro metal oxide particles that can be scattering and refracting the light. The film can be improved the TDD at least 60% of luminance.

MEET3 - 4 **Novel Solar Window with LED Illuminating**
14:30 **Compensation for LCD Display**

C.-J. Ou, H.-J. Wang, M.-Z. Zhang, H.-C. Chen, M.-H. Tsai, J.-L. Cheng, C.-M. Lu, M. Chen[*], T. Hu[*]

Hsiuping Univ. of S&T, Taiwan
[*]LED SignS, Taiwan

Natural light system (NLS) becomes a promising resource as the next generation light source. It is of interest to see the possibilities that introduce the NLS as the source for the information display. We demonstrate an information device that installs at the Historical sites - Nuomi Bridge tour center.

----- Break -----

15:10 - 16:30 **Ohmi 8**

MEET4: Nanotechnologies for Display Applications

Chair: S. Tanaka, Tohoku Univ., Japan
Co-Chair: G. R. Fern, Brunel Univ. London, UK

MEET4 - 1: ***Invited*** **Blue and Green 10-µm Pixel Pitch GaN LED**
15:10 **Arrays with Very High Brightness**

F. Templier, J.-M. Bethoux, B. Aventurier, F. Marion, S. Tirano, M. Lacroix, M. Marra, V. Verney, L. Dupré, F. Olivier, F. Berger, W. B. Naceur, A. Sanchot, I.-C. Robin, M.-A. di Forte-Poisson[*], P. Gamarra[*], C. Lacam[*], M. Tordjman

CEA-LETI, France
[*]III-V Lab, France

High-brightness 10-µm pixel pitch GaN arrays hybridized on silicon circuit were developed and exhibit more than 4×10^6 and 2.2×10^7 cd/m² for the blue and green arrays, respectively. This technology is very promising for fabricating very high brightness microdisplays, which are necessary for many new applications.
Also presented in Innovative Demonstration Session (see p. 208)

MEET4 - 2: ***Invited*** **Fabrication of Nonlinear Photonic Crystal**
15:30 **and Its Application to UV Laser**

Y. Aoyagi[,**], N. Kurose[*], S. Inoue[**]*

[*]Ritsumeikan Univ., Japan
[**]Tokyo Inst. of Tech., Japan

A concept of nonlinear hetero-structure photonic crystal is proposed and fabrication techniques of the photonic crystal are described. The performance of the nonlinear photonic crystal and its application to generate efficiently UV laser by 2nd harmonic generation of incident laser are explained.

MEET4 - 3 **15:50** **Multifunctional LED Back-Lightings for Displaying, Illuminating and Insect Prevention**

C.-J. Ou, Y.-Y. Lin, H.-J. Wang, G.-T. Liu, Z.-Y. Shi, Y.-Y. Lin, M.-Y. Li, M.-Z. Zhang, C.-H. Wu, W.-M. Lee, C.-H. Lin

Hsiuping Univ. of S&T, Taiwan

In this article we will demonstrate a novel smart LED lightings system that can fulfill the necessity for the multifunctional requirement for a local Historical site - Nuomi Bridge tour center.

MEET4 - 4 **16:10** **OLED Micro-Display in 0.35 µm Complementary Metal-Oxide Semiconductor Technologies for Wearable Electronic Display Application**

C.-H. Chang, P.-T. Liu, T.-Y. Ting[*], J.-T. Lian[*]

Nat. Chiao Tung Univ., Taiwan
[*]Chungwa Picture Tubes, Taiwan

We will focus on the OLED driven by single crystal Si metal-oxide-semiconductor field effect transistors technology. The milestone of this project will lower the overall power consumption of circuit and achieve the goal of ultra-high resolution to realize the 3D-Display application.

----- Break -----

16:50 - 18:20 **Ohmi 8**

MEET5: Emerging Quantum Dots and Nanotechnologies

Chair: S. Coe-Sullivan, QD Vision, USA
Co-Chair: J. Manders, NanoPhotonica, USA

MEET5 - 1: ***Invited*** **16:50** **By Understanding How Light Emission Depends on Size, Morphology and Phase in Inorganic Phosphor Materials, Can We Deduce Properties to Design Efficient Nanostructures for Tomorrows Industrial Needs**

*J. Silver[*], R. Dhillon, D. den Engelsen[*], G. R. Fern[*], T. G. Ireland[*], D. Hudry[**], J. H Dickerson[**,***]*

[*]Brunel Univ. London, UK
[**]Brookhaven Nat. Lab., USA
[***]Brown Univ., USA

The light emitting properties of a wide variety of Eu^{3+} doped macro and nanostructures that differ in morphology are considered/discussed along with quantum dots (QDs) and quantum rods (QRs). Features that are important in light emission are considered along with their implications for future phosphor design.

MEET5 - 2: 17:10 ***Invited*** **Electron Microscopy of Quantum Dots for Display Applications**

G. R. Fern, J. Silver, T. G. Ireland, A. Howkins, P. Hobson, S. Coe-Sullivan[*]

Brunel Univ. London, UK
[*]QD Vision, USA

CdSe/ZnCdS core/shell Quantum dots with high quantum yield (~84%) were used in this experiment. For the first time the red filtered cathodoluminescence images are shown along with their corresponding electron energy loss spectrum map, and high angle annular dark field image of the corresponding particles is shown.

MEET5 - 3: 17:30 ***Invited*** **ITU-R BT.2020 Color in LCDs with Today's Technologies: A Comparative Analysis**

J. Thielen, J. Hillis, J. Tibbits, A. Lemon, D. Lamb, J. VanDerlofske, G. Benoit

3M, USA

We previously demonstrated the ability of current CdSe-QDs to achieve the ITU-R BT.2020's color recommendation. Here we expand our investigation to include InP-QDs and Potassium Fluorosilicate phosphor with a focus on tradeoffs with efficacy. Finally, we consider whether any can be considered perceptually indistinguishable from a true Rec. 2020 display.

MEET5 - 4L 17:50 **Structural Properties of Al Doped Zinc Oxide Nano/ Microstructures Prepared under Various pH Conditions**

T. Umakoshi, K. H. Kim, Y. Abe, M. Kawamura, T. Kiba

Kitami Inst. of Tech., Japan

Al-ZnO nano/microstructures grown on ZnO seed layers were investigated structural properties with various pH conditions adding an ammonia solution. Due to initial weak acidic condition (pH ~5.5), the randomly oriented microrods were formed. At pH ~7.1 and ~10, the nanorods and nanodisks were grown on the ZnO seed layers, respectively.

MEET5 - 5L 18:05 **Piezoelectric Characteristics of P(VDF-TrFE)/PZT Composites for Pressure Sensor**

S. Y. Han, D. Geng, J. Jang

Kyung Hee Univ., Korea

In this study, we have developed a series of high-performance P(VDF-TrFE)/PZT composites of varying PZT concentration that demonstrate great piezoelectric characteristics. The proposed composite piezoelectric material was achieved by dissolving the PZT powder in the prepared P(VDF-TrFE) solution. Finally, the piezoelectric coefficient has been evaluated through the piezocapacitor and monitored by the charge amplifier. The P(VDF-TrFE)/PZT demonstrated much high piezoelectric coefficient , 5 times higher than those of pure P(VDF-TrFE).

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Quantum Dots Sessions

PHp 10:30 – 12:30 Thursday, Dec. 10
Ohmi 6 (Poster)

MEET1 16:05 – 17:25 Thursday, Dec. 10
PH3 9:00 – 10:00 Friday, Dec. 11
MEET5 16:50 – 18:20 Friday, Dec. 11
Ohmi 8 (Oral)

RECEPTION

Wednesday, Dec. 9, 2015
18:50 – 20:50
Prince Hall (3F)
Otsu Prince Hotel
See page 12 for details

Workshop on Display Electronic Systems

Wednesday, December 9

13:30 - 15:10 **Ohmi 10**

DES1: Various Visualization Technologies
Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: Y. Oyamada, Tottori Univ., Japan
Co-Chair: T. Mitasaki, NTT, Japan

DES1 - 1: 13:30 ***Invited*** **Near-Eye Display of Light Fields**

W. Wu, I. Tosic, N. Bedard, P. Llull, K. Berkner, N. Balram
Ricoh Innovations, USA

We address processing of light field data captured using a plenoptic camera for the purpose of display on a personal near-eye display. Our technique optimizes the focal plane configuration of a multi-focal display for the captured data and produces significantly better visual quality than the uniform focal plane configuration.

DES1 - 2: 13:55 ***Invited*** **Perceptual Illusions for Multisensory Displays**

T. Amemiya
NTT, Japan

Human perceptual properties have been applied for designing multisensory display technologies. This paper overviews the sensory-illusion-based approach we have used to create a force display that elicits illusory continuous force sensation by presenting asymmetric vibrations and a self-motion display based on a cross-modal effect between visual and tactile motion.

DES1 - 3: 14:20 ***Invited*** **Duality in Computational Photography and Display**

S. Hiura
Hiroshima City Univ., Japan

Computational Photography is a new concept of imaging to offer attractive functions such as blur reduction or posterior focus adjustment by assuming the optical devices as an encoder of the light to images. In this presentation, I will introduce several basic concepts and achievements in this field.

DES1 - 4: 14:45 ***Invited*** **Augmented Reality Visualization Fusion**

Y. Oyamada

Tottori Univ., Japan

In this presentation, we introduce a new interaction in Augmented Reality applications. The interaction is to overlap/overlay multiple markers that mimics physical action such as mixing and merging several objects.

----- Break -----

15:30 - 16:55 **Ohmi 10**

DES2: Transparent Display Systems

Chair: H. Okumura, Toshiba, Japan
Co-Chair: A. Sakaigawa, Japan Display, Japan

DES2 - 1: 15:30 ***Invited*** **A Concept of Immersive Telepresence "Kirari!"**

M. Imoto, S. Uchida, E. Ashikaga, M. Wagatsuma, K. Hidaka

NTT, Japan

We have been researching "Kirari!", an immersive telepresence platform that generates ultra-high realistic sensation in transporting sporting events to the world in general in real time. Wherever its users are, they can feel as if they are experiencing the atmosphere of the sporting venue with highly realistic sensation.
Also presented in Innovative Demonstration Session (see p. 208)

DES2 - 2 15:55 **Transparent Liquid Crystal Display with Three States; Transparent State, White State and Black State**

Y. Iyama, T. Sasaki, I. Aoyama, K. Hanaoka, T. Ishihara, M. Yashiki, K. Takase, H. Miyata, H. Yoshida

Sharp, Japan

We have developed a transparent liquid crystal display (LCD) with three states: "transparent," "white (colored)" and "black." We have applied the field sequential color (FSC) method. Our transparent display has the following properties: (1) high transmittance, (2) high color purity, and (3) no blurring.
Also presented in Innovative Demonstration Session (see p. 208)

DES2 - 3 16:15 **A Novel RGBT Signal and Device for Transparent Display**

P.-L. Hsieh, H.-T. Lin

Chunghwa Picture Tubes, Taiwan

An RGBT signal and device is proposed for future transparent displays. The RGBT transparent display simultaneously operates in "black state", "white state", and "transparent state". The level and area of transparency can be controlled precisely by using the RGBT signal.

DES2 - 4 16:35 **Improving the Image Quality of Transparent PDLC Display by Using Dehazing Technique**

C.-C. Liao, C.-W. Su

Chunghwa Picture Tubes, Taiwan

We proposed an effective dehazing technology to enhance the image quality of transparent polymer-dispersed-liquid-crystal (PDLC) display. The technique consists of two main parts, one is unsharp-masking-algorithm and the other is color management function. Experimental results demonstrate that the proposed method effectively improves the image quality of the transparent PDLC display.

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

13:40 - 15:40 **Ohmi 6**

Poster **DESp1: Display Electronic Systems**

DESp1 - 1 **Development of 32-in. 8K4K LCD Driving System**

H.-L. Hu, W.-C. Peng, J.-M. Kuang, X.-L. Chen, C.-H. Wu, M.-J. Jou, L.-W. Chu, P.-S. Kuo, M. Wang, F. Zhao

Shenzhen China Star Optoelect. Tech., China

An advanced driving system for 32-in. 8K4K LCD which using GOA (Gate on array) and HSD (Half source driving) techniques has been developed. This system support DP interface input, and mini-LVDS output. Furthermore, a synchronization method was proposed to make it possible to do some special image improving processes.

DESp1 - 2 **Implementation of FHD Sub-Pixel Rendering Panel**

D.-W. Kuo, J.-S. Liao, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

CPT has proposed FHD SPR (Sub Pixel Rendering) panels which have special sub-pixel arrangement unlike conventional RGB arrangement. They have been implemented in five inches panels with FHD resolution. In this paper, we have also discussed the feature of these SPR panels, include optical evaluation and circuit architecture.

DESp1 - 3 **The Introduction of a Pixel Structure Design**

X. Xu, A. Zhang, J. Chen, Q. Qiu, X. Chen, B. Liao

Shenzhen China Star Optoelect. Tech., China

In this paper, a pixel structure design was introduced, the adjacent two sub-pixels having the same color in the adjacent two pixels sharing a date line, which can make data line reduced and aperture ratio improved.

DESp1 - 4 **Low-Power and Highly Reliable a-Si Gate Driver with DC-Type Driving Source**

P.-C. Lai, F.-H. Chen, C.-E. Wu, C.-L. Lin

Nat. Cheng Kung Univ., Taiwan

This work presents a new gate driver circuit with AC-driving scheme and DC-type driving source to improve the lifetime and the power consumption. Simulation results show that the proposed circuit still operates normally when the threshold voltage shifts to 21.5 V and the power consumption is reduced by 32%.

DESp1 - 5 **Novel PWM Circuits and Power Supply Design for LED Lightings**

C.-J. Ou, Z.-Y. Shi, S.-Z. Yang, J.-L. Cheng, T. Hu

Hsiuping Univ. of S&T, Taiwan

We will present a simple and cost effective PWM driving circuit. The system is consisting with a specialized filtering design with low cost microchip inside the LED power regulator, such that the optimum control of the LED lighting and the grey scale is reached.

DESp1 - 6L **Development of High-Speed LED Display System on FPGA**

T. Kobayashi[*], A. Tsuji[*], H. Mizushina[*], S. Suyama[*], H. Yamamoto[,**,***]*

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

We have designed and implemented high-speed LED display controller and ultrasonic distance sensor controller on FPGA. Our system drives P3-LED panels and ultrasonic distance sensor in parallel. As the result, latency from sensor input to display can be reduced to 5.8 ms.

DESp1 - 7L **A Fast-Switching Current-Pulse Driver for LED Backlight Applications**

C.-W. Lu, Y.-C. Huang[*], Y.-S. Lin[*], H.-W. Chen[**]

Nat. Tsing Hua Univ., Taiwan
[*]Nat. Chi Nan Univ., Taiwan
[**]Nat. United Univ., Taiwan

A fast-switching current-pulse driver for dimming controllers of LED backlight applications is proposed. The proposed current-pulse driver was fabricated in 0.25-μm 1P4M BCD high-voltage process. The measured rising time and falling time of the LED current are 120 ns and 12 ns, respectively, when the load is a 7-LED string.

13:40 - 15:40 **Ohmi 6**

Poster **DESp2: Image Processing for Augmented Reality**
Special Topics of Interest on Augmented Reality and Virtual Reality

DESp2 - 1L **AR Marker Available on Foldable Surfaces**

H. Sasanuma, Y. Manabe, N. Yata
Chiba Univ., Japan

This paper is focused on marker-based AR technology. Existing AR markers are almost available on only flat surface. Therefore, this paper proposes an original AR marker design and processing method that can recognize the marker on the foldable and cylindrical surface.

----- Break -----

16:00 - 17:15 **Ohmi 10**

DES3: Application for Automobiles

Chair: K. Morita, Nat. Traffic Safety & Environment Lab., Japan
Co-Chair: T. Fujine, Sharp, Japan

DES3 - 1: 16:00 ***Invited*** **Technical Evolution of Automotive Headlamps**

S. Yamamura
Koito Manufacturing, Japan

The latest automotive headlamps come with an adaptive driving beam (ADB) system for the high-beam, which selectively shades oncoming or preceding vehicles from glare based on inputs from an onboard camera. Future high-resolution ADB systems are expected to include functions such that draws letters or symbols on the road surface ahead.

DES3 - 2: 16:25 ***Invited*** **Standardization of Camera Monitor System (CMS) for Mandatory Rearview Mirrors for Road Vehicles Replacement**

H. Shinki, N. Yoshitsugu[*], E. Oba[**], M. Oka[***]
Faltec, Japan
[*]Nissan Motor, Japan
[**]Sony, Japan
[***]UD Trucks, Japan

Summarized introduction of new ISO standard ISO 16505 “Road vehicles – Ergonomic and performance aspects of Camera Monitor Systems – Requirements and test procedures” and its technical background. The study for the regal approval in regard to this system is based on this standard.

DES3 - 3: 16:50 ***Invited*** **Consideration of Brightness Contrast Ratio Which Influences Visibility of Head-Up Display**

M. Enomoto[,**], M. Sekine[*], K. Morita[*], K. Tanaka[**]*

[*]Nat. Traffic Safety & Environment Lab., Japan
[**]Univ. of Electro-Commun., Japan

Authors previously measured head-up display (HUD) visibility, brake response time and others using a driving simulator, among which HUD visibility was considered to be related to the contrast ratio between the HUD and background. In this study we measured luminance outside to verify the results obtained in the indoor experiment.

----- Break -----

18:05 - 19:10 **Ohmi 10**

DES4: Image Processing

Chair: A. Sakaigawa, Japan Display, Japan
Co-Chair: T. Fujine, Sharp, Japan

DES4 - 1 **Withdrawn**

DES4 - 2: 18:05 ***Invited*** **Finely Categorized Clothing Recognition**

K. Sudo, T. Umeda, K. Murasaki, J. Shimamura, A. Kojima

NTT, Japan

We propose two methods for recognizing fine-grained clothing categories to achieve clothing-image retrieval based on similarities covering fine-grained patterns, e.g., narrow or wide stripes and fine-grained attributes, e.g., shapes of necklines and sleeve lengths. Our method incorporates prior knowledge of attributes and the position of patterns, which improves recognition accuracy.

DES4 - 3 18:30 **Advanced RGBW OLED Display System with Novel RGB-to-RGBW and Subpixel Rendering Algorithm**

H. Li, Y.-F. Jin, S.-S. Syu, M.-J. Jou, J.-W. He, L. Li[*], R. Wang[*]

Shenzhen China Star Optoelect. Tech., China
[*]Peking Univ., China

The new RGB-to-RGBW and subpixel rendering were proposed. The former is applied to enhance luminance and decrease color-distortion, the latter is designed to scale the virtual resolution. Experimental result shows that the proposed method increases the average intensity by 23% with a color-distortion level of 0.013, meanwhile it almost identical to real RGB resolution.

DES4 - 4
18:50

Adaptive Saturation Enhancement Based on Min-Max Value and Intensity Gray-Levels Histogram Feedback

H. Li, J. L. Zhu, S.-S. Syu, M.-J. Jou

Shenzhen China Star Optoelect. Tech., China

This paper proposed one method about improving saturation of RGB image based on HSI model. We improved saturation with an adaptive exponent, and used intensity component with differential gray-levels histogram adjusting it, and designed a configurable mechanism to modify contrast and colorfulness by a controlled parameter. Experiment shows excellent performance.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Supporting Organizations:
Kansai Section, IEEE
The Society of Automotive Engineers of Japan (JSAE)
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, Information and Systems Society, IEICE(IE)
Technical Group on Information Display, ITE
Technical Group on Three-Dimensional Image Technology, ITE

Workshop on Flexible Electronics

Thursday, December 10

13:40 - 15:40 **Ohmi 6**

***Poster* FLXp1: Flexible Electronics 1**

FLXp1 - 1 **Low Temperature Silicon Nitride Thin Films for Moisture Barrier Layers by a PECVD Process**

S. J. Kim, S. H. Yong, H. J. Ahn, S. Gatineau[*]*, H. Chae*

Sungkyunkwan Univ., Korea
[*]*Air Liquide Labs., Korea*

Low temperature silicon nitride thin films were deposited by a plasma enhanced chemical vapor deposition (PECVD) process for moisture barrier layers. Inorganic thin films was fabricated in various process conditions. In this research, Water vapor transmission rate (WVTR) of below 10^{-2} g/m^2/day was achieved.

FLXp1 - 2 **Al_2O_3/ZrO_2 Thin Film Encapsulation with Spatially Resolved ALD Process**

S. H. Yong, S. J. Kim, H. Chae

Sungkyunkwan Univ., Korea

Al_2O_3 and ZrO_2 thin films were deposited on polymer substrates as moisture barrier layers by a spatially resolved ALD process. This inorganic layers was applied for OLED thin film encapsulation.

FLXp1 - 3 **Optimization of Al_2O_3/ZrO_2 Nanolaminate Structure on the Plastic Substrates for the Flexible Display**

J. H. Eun, Y. S. Paek, H. G. Kim, M. S. Kim, Y. C. Kim, S. S. Kim

Kyung Hee Univ., Korea

Al_2O_3/ZrO_2 nanolaminate was deposited on plastic substrates by low frequency plasma-enhanced atomic layer deposition (PEALD) process. In order to enhance the barrier properties of polymeric substrates, the layer structure was optimized with various process conditions.

FLXp1 - 4L **Flexible Reflective LCDs Using Stainless Steel Substrate and Optical Compensation Technology**

A. Sato, T. Ishinabe, H. Fujikake

Tohoku Univ., Japan

A flexible reflective liquid crystal display using stainless steel with heat resistance and polycarbonate substrates compensating a phase retardation of VA-mode liquid crystal was developed. We realized a good contrast ratio over 20:1. The stainless steel substrate is a promising technology to realize high-quality flexible displays with low power consumption.

FLXp1 - 5L **Fabrication of Thin Flexible Liquid Crystal Display Using Dye-Type In-Cell Polarizer**

D. Fujiwara, T. Ishinabe[*], N. Koma, H. Fujikake[*]

Polatechno, Japan
[*]Tohoku Univ., Japan

We have developed an in-cell polarizer using dye type polarizing film. This polarizing film has high heat resistances and ultraviolet light exposure, and enables to insert the polarizing film into the LC panel. We successfully achieved thin flexible TN-mode liquid crystal device with high flexibility and high contrast ratio.

FLXp1 - 6L **The effect of Mechanical Stress on the Properties and Stability of In-Ga-Zn-O Thin Film Transistors**

C. S. Kim, N. D. Trung, H.-S. Kim

Chungnam Nat. Univ., Korea

Amorphous In-Ga-Zn-O (a-IGZO) thin-film transistors (TFTs) were fabricated on polyimide/glass substrates and mechanically detached from carrier glass. The electrical properties and device stability were evaluated on both flat and bending state. The obtained bending performance and bias-stability of a-IGZO TFTs were demonstrated to be promising for the next-generation flexible display.

FLXp1 - 7L **Stable Crystallization of a-Si Film on a Flexible Substrate**

T. Ashitomi, T. Harada, K. Nakao, C. J. Koswaththage, T. Okada, T. Noguchi, N. Kawamoto[*], H. Ikenoue[**], T. Okuyama[***], A. Suwa[****], K. Noda[****]

Univ. of the Ryukyus, Japan
[*]Yamaguchi Univ., Japan
[**]Kyusyu Univ., Japan
[***]TOYOBO, Japan
[****]GIGAPHOTON, Japan

The ELA using high repetition pulse for a-Si film on flexible sheet is performed. As a result of multi-shots ELA, the crystal structure of Si film on oxide buffer layer was stably obtained in lower pulse energy density. High performance TFT on flexible sheet is expected.

13:40 - 15:40 **Ohmi 6**

***Poster* FLXp2: Flexible Electronics 2**
Special Topics of Interest on Oxide-Semiconductor TFT

FLXp2 - 1 **The Instability Change of Flexible a-IGZO TFTs under Different Mechanical Stress**

H.-J. Jeong, K.-C. Ok, H.-M. Lee, J.-S. Park
Hanyang Univ., Korea

Amorphous InGaZnO (IGZO) thin film transistors (TFTs) were made on the polyimide (PI) substrate. We evaluated transistor performance and instability depends on mechanical stress, various bending radius (10 mm, 5 mm and 2 mm) were applied to flexible substrate. The variation in the threshold voltage under NBTS was –0.58 V (without bending)/ –6.48 V (2 mm).

FLXp2 - 2L **Highly Robust Flexible Oxide TFTs Achieved by Plastic Substrate with Embedded CNT/GO Backbone**

Y.-H. Kim, J. G. Um, M. Mativenga, J. Jang
Kyung Hee Univ., Korea

We demonstrate the highly robust flexible oxide TFT fabricated on 5 μm-thick PI. Particularly, by process employed of embedding the graphene oxide and carbon nanotubes mixture into the PI substrate, it makes excellent functionality as flexible substrate that self-standing without any supporting materials and prevent from the electrostatic discharge effect.

FLXp2 - 3L **Thermal Analysis of Oxide Thin Film Transistor with Fluorinated Silicon Nitride Gate Insulator**

H. Yamazaki, Y. Ishikawa, M. N. Fujii, J. P. S. Bermundo, E. Takahashi, Y. Andoh*, Y. Uraoka*
NAIST, Japan
**Nissin Elec., Japan*

We found that amorphous In-Ga-Zn-O thin-film transistors with W=5 μm showed higher mobility than TFTs with W=90 μm, and showed a sharp mobility curve. The results of thermal analysis show local heating at the edge of the drain. We conclude that these effects are caused by mobile minus ions.

13:40 - 15:40 **Ohmi 6**

Poster FLXp3: Flexible Electronics 3
Special Topics of Interest on Printed Electronics

FLXp3 - 1 **Development of Novel Primer Material Suitable for COP Film and Ag Nano-Ink**

T. Yamate[,**], E. Mieda[*], K. Kumazawa[*], H. Suzuki[*], M. Akazome[**]*

[*]Nippon Soda, Japan
[**]Chiba Univ., Japan

We have developed a unique organic-inorganic hybrid coating agent suitable for a primer which connects Ag nano-ink to COP film. This material forms the glass-like surface on the topmost surface of the hybrid layer after UV irradiation. Therefore, Ag nano-ink can adhere strongly with glass-like surface.

FLXp3 - 2L **Flexible Glass Substrate on Roll to Roll Gravure Off-Set Printing Process**

K.-T. Kuo, S. M. Garner, J.-C. Lin, P.-L. Tseng, S.-M. Lin, M.-H. Huang, R. L. Smith, T. H. Chou[*], C. W. Hsieh[*], Y. M. Wang[*], S. Yang[*], K. G. Wang[*], H. Y. Lin[*]

Corning, USA
[*]ITRI, Taiwan

Glass enables high-quality and long-life devices compared to plastic in electronics industry. The ultra-slim flexible glass also allows for new device designs and continuous manufacturing enabled by roll-to-roll (R2R) processes. This paper describes how gravure off-set printing applied to R2R process and made functional touch sensors on ultra-slim flexible glass.

FLXp3 - 3L **Control and Improvement of Electrical Performance of Solution-Processable Organic Transistors by Spin Coating from Mixed Organic Solvents**

R. Nakamichi[*], T. Nagase[,**], T. Kobayashi[*,**], Y. Sadamitsu[***], H. Naito[*,**]*

[*]Osaka Pref. Univ., Japan
[**]The Res. Inst. for Molecular Elect. Devices, Japan
[***]Nippon Kayaku, Japan

We have developed a simple method to control and improve the electrical characteristics of solution-processable OTFTs based on dialkylbenzothienobenzothiophenes by using mixed organic solvents. Top-gate OTFTs processed by spin coating from mixed non-halogen solvents exhibit high average field-effect mobility of 8.4 $cm^2V^{-1}s^{-1}$ and low threshold voltage of −0.18 V.

----- Break -----

17:40 - 17:50 **Ohmi 8**

Opening

Opening Remarks
17:40

M. Kimura, Nagaoka Univ. of Tech., Japan

17:50 - 19:20 **Ohmi 8**

FLX1/INP4: Flexible Input Devices

Chair: T. Shiro, Teijin, Japan
Co-Chair: K. Yamazaki, Corning Japan, Japan

FLX1/INP4 - 1: 17:50 ***Invited*** **Foldable AMOLED with Integrated On-Cell Touch Sensor for Mobile Device Applications**

J. Chen, J.-C. Ho, G. Chen, M.-H. Yeh, C.-C. Lee

ITRI, Taiwan

Based on ITRI's Flexible Universal Plane (FlexUP) technology, we have recently developed a coverless on-cell touch panel with gas barrier. In this report, we overcome flexibility and interference issues with the on-cell touch panel, and successfully demonstrated a foldable AMOLED integrated with coverless on-cell touch panel at 5mm folding radius.

FLX1/INP4 - 2 **Withdrawn**

FLX1/INP4 - 5L: 18:15 ***Invited*** **Inkjet-Printed Electrodes for Stretchable Wearable System**

Y. Hong, S. Kim, T. Kim, J. Byun, B. Lee, H. Kim, S. Choi, E. Oh, S. Chung, J. Lee

Seoul Nat. Univ., Korea

For wearable, body-attachable electronic system, the strategy of combining rigid islands and stretchable interconnects is one of the best near-term solutions. In this talk, as part of our effort toward stretchable hybrid electronic system, inkjet-printed stretchable electrodes based on silver nano-particle, SWCNT, and nano composite materials is discussed.

FLX1/INP4 - 3 18:40 **Evaluation of Electrochemical Migration of ITO/Ag/ITO Structure for Touch Panel Sensor**

Y. Toshimori, T. Ueda, F. Kikuchi, H. Ishii, I. Shiono, S. Zhang

Mitsubishi Materials, Japan

The purpose of this study is to evaluate the electrochemical migration of ITO/Ag/ITO structure for Touch Panel Sensor and to prepare the data necessary to decide the evaluation standard of reliability for application of ITO/Ag/ITO to electrode materials. Our evaluation result shows the guideline of the new evaluation standard.

FLX1/ INP4 - 4 19:00 **Ultra High Resolution Copper Lithography Not Requiring Fine Mask Design Rules and Without Damaging Copper**

M. A. Hsu, C.-H. Lin, R.-C. Lian, A. Igawa[*]

Consistent Elect. Materials, Taiwan
[*]*eChem Solutions Japan, Japan*

Applying common photolithography process to copper substrate with novel formulated lithographic chemicals, extremely fine copper pattern could be obtained without using fine mask patterns and with no copper damaging. Very precise metal mesh or copper circuit can be formed onto not only Si or glass substrate but also flexible film.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

Friday, December 11

9:00 - 10:30 **Ohmi 3**

FLX2/LCT5: Flexible LCDs

Chair: H. Funahashi, Kagawa Univ., Japan
Co-Chair: H. Okada, Toyama Univ., Japan

FLX2/ LCT5 - 1: 9:00 ***Invited*** **Advanced Polymer and LC Technologies for High Quality Flexible Displays**

H. Fujikake, H. Sakai, A. Sato, E. Uchida, D. Sasaki, Y. Obonai, Y. Isomae, T. Ishinabe

Tohoku Univ., Japan

For a practical flexible liquid crystal display, fine polymer spacer walls and networks are formed in a nematic liquid crystal layer for stabilizing substrate gap. Total optical compensating design methods using plastic substrates are also presented for wide viewing angle, and flexible backlight is discussed for whole flexible display systems.

FLX2/ LCT5 - 2 9:25 **Uniform Lying Helix of Cholesteric LC Aligned by Means of Coating Method with Electric Treatment**

N. Endo, M. Kimura

Nagaoka Univ. of Tech., Japan

The feature of Uniform Lying Helix (ULH) is its fast response speed whereas the alignment process of ULH is not simple. Previously we proposed a novel fabrication process of liquid crystal display (LCD) by means of slit coater. Paying attention to the shear flow force, we applied this method to align the ULH with using electric field treatment. Optimum fabrication condition and characteristics of ULH will be demonstrated.

FLX2/ LCT5 - 3L: 9:45 ***Invited*** **Development of World's Largest 60-in. Roll Display**

M. Shigeta, M. Kawabata, K. Kobayashi, M. Teragawa
Sakai Display Prods., Japan

The 60-in. roll display with radius 500 mm has been developed. No alignment defect due to the displacement of the panel appears for UV2A mode, and excellent optical performance is confirmed.
As the roll display has the perspective features and texture gradient, the three dimensional sensation is enhanced by the physiological effects.

FLX2/ LCT5 - 4L 10:10 **Novel Alignment-Process-Free Flexible VA-LCDs with highly-Stable LC Alignment**

M. Yamamoto, K. Asanuma, Y. Iimura
Tokyo Univ. of A&T, Japan

We investigate fabrication processes of high-performance flexible VA-LCDs. It is shown that using special-shaped pole spacers and a PSS method gives multi-domain pixel structure with highly-stable LC alignment. A fabricated flexible VA-LCD is highly resistive against external stresses such as bend deformation.

----- Break -----

10:40 - 12:00 **Ohmi 2**

OLED5/FLX3: Flexible OLED and OTFT

Chair: Y. Sakai, Mitsubishi Chem. S&T Res. Ctr., Japan
Co-Chair: T. Kamata, AIST, Japan

OLED5/ FLX3 - 1: 10:40 ***Invited*** **Flexible OLED Fabricated with Fully R2R Process and Their Evaluation Technology**

Y. Mitamura, T. Minakata, A. Sugimoto, M. Tanamura, Y. Ohzu, A. Suzuki, N. Ibaraki, H. Tomiyasu
Chem. Materials Evaluation & Res. Base, Japan

Flexible organic light-emitting diodes (OLEDs) on continuous plastic film have been successfully fabricated with full roll-to-roll (R2R) processes and exhibit good stability and high performance comparable to OLEDs on glass. Degradation due to penetration of moisture have been studied qualitatively and respectively.

OLED5/ FLX3 - 2 11:00 **Accurate Evaluation of Water Vapor Transmission for Flexible OLEDs**

A. Suzuki, A. Uehigashi
Chem. Materials Evaluation & Res. Base, Japan

An evaluation technique for determining the water vapor transmission rate (WVTR) has been developed using our reference films with multiple pinholes created strategically. The WVTR was reliably obtained at a level of 10^{-5} g/m^2/day. The films can be widely applied to accurately calibrate several WVTR measurement systems.

OLED5/ FLX3 - 3 **Withdrawn**

OLED5/ FLX3 - 5L 11:20 **Solution-Processed, Air-Stable N-Type Organic Single Crystal Microribbon Transistors**

C.-Y. Tan, P.-Y. Tseng, C.-W. Wang, C.-Y. Hung, C.-W. Tsai, G.-W. Hsieh

Nat. Chiao Tung Univ., Taiwan

We used halogen-substituted perylene diimide derivatives to form self-assembled microribbons for organic field effect transistors. Devices based on a network of microribbons have showed typical n-channel field effect behaviors with average ON/OFF current ratio $>10^3$ and revealed remarkable stability under ambient air over 90 days.

OLED5/ FLX3 - 4 11:40 **Solution Processed P-Type Top-Gate Small-Molecular Organic TFT**

H.-C. Hsiao, Z.-X. Jiang, S. Su, H.-Y. Xu, M. Zeng, B. Sun, C.-Y. Lee, H. Zhou[*]*, S. Zhang*[*]

China Star Optoelect. Tech., China

[*]*Peking Univ., China*

A p-type organic thin film transistor (OTFT) technology on plastic substrates was developed, in which, a small molecular organic semiconductor (OSC) material was used as channel layer. The fabricated p-OTFT at processed temperature below 120˚C shows a high hole mobility of 3.4 cm^2/Vs and an excellent performance stability under gate electrical stress.

Author Interviews and Demonstrations
12:00 – 12:40, Ohmi 6

----- Lunch -----

13:30 - 14:40 **Ohmi 2**

FLX4: Flexible Printed Electronics
Special Topics of Interest on Printed Electronics

Chair: T. Sekitani, Osaka Univ., Japan
Co-Chair: M. Ito, Toppan Printing, Japan

FLX4 - 1: 13:30 ***Invited*** **Exploring Low-Dimensional Charge Transport Phenomena in Solution-Processed Metal Oxide Superlattice Transistors**

Y.-H. Lin, K. Zhao[*]*, R. Li*[**]*, A. Amassian*[*]*, T. D. Anthopoulos*

Imperial College London, UK

**King Abdullah Univ. of S&T, Saudi Arabia*

***Cornell Univ., USA*

We report on metal oxide superlattice systems grown from solution and their use in high electron mobility transistors. On the basis of temperature-dependent electron transport measurements and carrier distribution evaluation, we argue that the enhanced performance arises from the presence of 2-dimensional electron gas-like systems formed at the oxide-oxide heterointerfaces.

FLX4 - 2: 13:55 ***Invited*** **Fluorophilicity as Selection Criterion of Solvents for Printed Organic Electronics**

Y. Kuwana, T. Abe, N. Shirota, T. Sakurada, M. Obi

Asahi Glass, Japan

We investigated the deterioration of carrier mobility of organic thin film transistors after immersing into various solvents containing fluorine. The deterioration was correlated with the fluorophilicity, the partition ratio between solvents containing fluorine and without fluorine. The fluorophilicity will be a useful parameter for screening the process solvent.

FLX4 - 3 14:20 **Highly Stable Transparent Conductive Coatings on Ultra-Thin Glass for Flexible Devices**

M. Junghaehnel, S. Weller, T. Gebel[*], W. Skorupa[**], T. Schumann[**]

Fraunhofer, Germany
[*]DTF Tech., Germany
[**]Helmholtz-Zentrum Dresden-Rossendorf, Germany

Ultra-slim flexible glass is an emerging flexible substrate material for flexible displays, devices or lighting. 100 μm thick flexible glasses with a maximum dimension of 250 × 300 mm^2 were deposited with ITO and IZO at room temperature. The films were refined by in-line flash lamp annealing in the millisecond time range.

----- Break -----

15:10 - 16:45 **Ohmi 2**

FLX5: Flexible Displays and Devices

Chair: H. Maeda, Dai Nippon Printing
Co-Chair: K. Uemura, Nippon Steel & Sumitomo Metal, Japan

FLX5 - 1: 15:10 ***Invited*** **Designing Flexible and Stretchable Circuits and Displays**

J. Genoe[,**], K. Myny[*], F. De Roose[*,**], S. Steudel[*], J.-L. van der Steen[***], G. H Gelinck[***], P. Heremans[*,**,***]*

[*]imec, Belgium
[**]Katholieke Univ. Leuven, Belgium
[***]Holst Ctr., the Netherlands

Technologies on flexible and stretchable foils suffer from intrinsic parameter variations. A detailed analysis of these variations enables designers to predict the soft yield for different topologies of flexible circuits. This methodology has been applied to designs of organic and oxide NFC tags, microprocessors and integrated linedrivers for displays.

FLX5 - 2 **Withdrawn**

FLX5 - 5L: 15:35 ***Invited*** **Plastic Liquid Crystal Displays Enabled by Organic Transistor Technology**

J. Harding, M. Banach

FlexEnable, UK

The use of a low-temperature Organic TFT process opens the door to include new classes of materials in active matrix backplanes. The authors show an IPS-LCD on plastic made possible through the adoption of low-birefringence TAC substrates and a stress-free demount mechanism.

FLX5 - 3: 16:00 ***Invited*** **High-Mobility Short-Channel Organic Transistors with Photolithography-Patterned Top Electrodes**

T. Uemura, T. Sekitani

Osaka Univ., Japan

We report novel fabrication processes for high-mobility organic transistors with photolithography-patterned top electrodes. In the top-contact transistors, small contact resistance of ~50 Ωcm was realized by a proper annealing process. As a result, high mobility ~4.5 cm^2/Vs and high on/off ratio ~10^9 were achieved in 5-μm channel-length transistors.

FLX5 - 4 16:25 **Fabrication of Low Reflectivity Metal Grid Transparent Electrode on Flexible Plastic Substrate by Adopting Self-Patterned Black Polymer**

J.-C. Choi, J.-S. Park, H.-R. Kim

Kyungpook Nat. Univ., Korea

We fabricated metal grid transparent electrode on flexible plastic substrate with low reflectivity by adopting self-patterned black polymer layer under the electrode pattern. In order to make metal grid electrode pattern, doctor blade method was introduced. Furthermore, selective etching process was used to form self-patterned black polymer.

----- Break -----

Author Interviews and Demonstrations
18:10 – 18:50, Ohmi 6

Supporting Organizations:
Technical Committee on Electronic Information Displays, Electronics Society, IEICE
Technical Group on Information Display, ITE

Workshop on Touch Panels and Input Technologies

Wednesday, December 9

13:30 - 13:35 **Ohmi 8**

Opening

Opening Remarks
13:30

N. Hashimoto, Citizen Holdings, Japan

13:35 - 14:55 **Ohmi 8**

INP1: Interactive Technologies

Chair: K. Imoto, Toshiba, Japan
Co-Chair: H. Haga, NLT Techs., Japan

INP1 - 1
13:35

Integrated Solutions of Electromagnetic Touch Sensor

F. Lu, C.-M. Liu, Y.-K. Lin*, S.-L. Jin, Q.-J. Yao, H.-S. Wu*, Y. Wu, T.-Y. Wu, C.-M. Liu*, J. Ma*

Shanghai Tianma Micro-Elect., China
**KYE Systems, Taiwan*

Novel solutions of integrated electromagnetic touch sensors were proposed. Electrodes in a mutual capacitive touch panel were utilized to receive electromagnetic touch signals simultaneously. In-cell electromagnetic touch sensors and the accompanying parasite capacitance effect were also studied theoretically and experimentally.

INP1 - 2
13:55

A Novel Technologies of High Resolution Touch on Cell (ToC) LCD with Passive Pen Function

S.-Y. Wu, Y.-L. Ho, Y.-C. Chen, H.-H. Chen, H.-M. Su, W.-Z. Zeng

Chunghwa Picture Tubes, Taiwan

CPT has successfully developed the low cost and high resolution with advanced touch on cell (ToC) display. The 8-in. high resolution (1600 × 2560, 377 ppi) with touch on cell (ToC) display that can support 2 mm passive pen writing.

INP1 - 3: 14:15 ***Invited*** **Design Everything by Yourself**

T. Igarashi

Univ. of Tokyo, Japan

We envision that computer tools that help people to design things by themselves can enrich their lives. To that end, we develop innovative interaction techniques for end users to (1) create rich graphics (2) design their own real-world, everyday objects, and (3) design the behavior of their personal robots.

INP1 - 4L 14:40 **Pen Based User Interface for Handwritten Document Handling**

K. Imoto

Toshiba, Japan

To allow users to perform natural input operations without the need for a keyboard or mouse, the handwritten notes apps that consist of handwriting retrieval and handwritten graphics formatting have been developed. We provide a brief introduction to managing facilities for handwritten documents and discuss about pen interface.

----- Break -----

15:10 - 16:40 **Ohmi 8**

INP2: Touch Panel

Chair: J. Taylor, Sharp Labs. of Europe, UK
Co-Chair: D. Ito, Japan Display, Japan

INP2 - 1: 15:10 ***Invited*** **Improved Signal Processing for Capacitive Touch Panel with Conductive and Non-conductive Object Distinction**

J. Taylor, C. Brown, A. Kay, D. Gallardo, S. Maguire, Y. Sugita[*]*, K. Kida*[*]

Sharp Labs. of Europe, UK
[*]*Sharp, Japan*

We present novel algorithms for the detection, classification and tracking of conductive and non-conductive probes in the vicinity of a mutual-capacitance touch panel with enhanced electrode pattern.
Also presented in Innovative Demonstration Session (see p. 208)

INP2 - 2 15:35 **3D Shaped Touch Panel with Transparent Carbon Nanotube Electrodes**

R. Hattori, O. Watanabe[*]*, S. Takada*[*]

Kyushu Univ., Japan
[*]*Toray Inds., Japan*

A three-dimensional transparent touch panel was formed by thermally molding a transparent plastic film/board with a carbon nanotube (CNT) layer that acted as a touch-sensing electrode patterned by laser ablation. A self-capacitive touch-sensing method with a low side current was employed, which enabled multitouch, hover touch, and glove touch.

INP2 - 3 15:55 **High Integration Touch in Cell Module**

W.-J. Yang, C.-Y. Hsu, C.-C. Chang, Y.-C. Li, H.-H. Chen, H.-M. Su, W.-T. Tseng

Chunghwa Picture Tubes, Taiwan

Chunghwa picture tubes, Ltd. has been successfully developed 5.5-in. HD FFS mode a-Si display with a novel development which was embedded type capacitive touch In-cell was driven by the TDDI IC. In this structure that has high integration, more cost-effective and compact size.

INP2 - 4: 16:15 ***Invited*** **Newly Developed 5.5-in. WQHD Display with Hybrid In-Cell Capacitive Touch Technology**

D. Ito, T. Suzuki, K. Noguchi, Y. Nakajima

Japan Display, Japan

This paper is a presentation of the 5.5-in. WQHD (1440×2560) IPS-mode LTPS display with a newly developed hybrid In-cell capacitive touch technology, and introducing the technology trend of In-cell touch panel.

Author Interviews and Demonstrations
16:30 – 17:10, Ohmi 6

Thursday, December 10

9:00 - 10:45 **Ohmi 8**

INP3: AR and Interactive Systems
Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: M. Sato, MIT Media Lab, USA
Co-Chair: N. Hashimoto, Citizen Holdings, Japan

INP3 - 1: 9:00 ***Invited*** **Development of a TV System Augmented Outside the TV Screen**

H. Kawakita[,**], M. Uehara[*], T. Nakagawa[*], M. Sato[**]*

[*]NHK, Japan
[**]Tokyo Inst. of Tech., Japan

We advocated "Augmented TV" that gives an appearance of connecting the onscreen world, captured by the TV camera, to the real world in front of the TV screen. To realize the goal, we have developed AR system for TV video images, which is characterized by smoothness of the connecting representation.
Also presented in Innovative Demonstration Session (see p. 208)

INP3 - 2: 9:25 ***Invited*** **Disappearing Touchscreens: Making the World Interactive without Instrumenting It**

M. Sato[*,**]

[*]*MIT Media Lab, USA*
[**]*Univ. of Tokyo, Japan*

Interaction with physical objects and information in the real world is becoming increasingly important. However, conventional methods require adding physically complex touch sensors or tags. In this paper, we discuss several approaches to make the world more interactive without any need for these technical implementations.

INP3 - 3: 9:50 ***Invited*** **Haptic Technologies for Surface Interaction**

H. Kajimoto

Univ. of Electro-Commun., Japan

As the touch panel does not have physical cues such as bumps and edges of a keyboard, applying haptic (tactile) display technology to the touch panel was studied intensively. This talk introduce current trends of haptic interface for surface interaction, as well as our recent studies on electro-tactile displays.

INP3 - 4L 10:15 **Demonstration of Interactive 3D Display Using Holographic Screen and Consumer-Use 4K Projector**

T. Nakamura, S. Sakurai, S. Igarashi, M. Yamaguchi

Tokyo Inst. of Tech., Japan

We previously proposed an interactive 3D display, which is based on a transparent holographic screen and a projector-camera system. In this report, we demonstrate the interactive 3D display with improved 3D image quality using a holographic screen and a consumer-use 4K projector whose pixel count is 4096×2160.

INP3 - 5L 10:30 **Character Recognition System Using Cellular Neural Network Suitable for Integration on Electronic Displays –Development of Simulator and Evaluation of Operation–**

T. Kameda[*], *M. Kimura*[*,**], *Y. Nakashima*[*]

[*]*NAIST, Japan*
[**]*Ryukoku Univ., Japan*

We are developing cellular neural networks that might be suitable for integration on electronic displays. In order to decide best architecture of the neural networks, we developed a character recognition simulator. We confirmed that the neural networks can learn multiple characters.
Also presented in Innovative Demonstration Session (see p. 208)

----- Lunch -----

13:40 - 15:40 **Ohmi 6**

***Poster* INPp1: Touch Panel**

INPp1 - 1 **Oxidation Resistant Cu-Ni-Mn Cap Layer for Bezel Interconnection in the Film Touch Panels**

Y. Shida, H. Goto, H. Okuno, M. Kanamaru*, T. Kugimiya*

Kobe Steel, Japan
**Kobelco Res. Inst., Japan*

We have developed a Cu-Ni-Mn cap layer which is superior in anti-oxidation properties and etching processability. The reflectance change amount of the Cu interconnections with the Cu-Ni-Mn cap layer after annealing in air was suppressed by 6% or less.

INPp1 - 2 **Withdrawn**

INPp1 - 3L **Three-Dimensional Finger and Hand Gesture Interactive Displays**

H.-K. Liu, H.-I Ning, Y.-C. Fan

Nat. Taipei Univ. of Tech., Taiwan

In this article, we proposed a three-dimensional finger and hand gesture interactive displays. We use stereo camera to capture stereo image. And it calculate disparity map and depth map for supplying user a real-time interface based on hand gesture and finger action.

----- Break -----

17:50 - 19:20 **Ohmi 8**

FLX1/INP4: Flexible Input Devices

Chair: T. Shiro, Teijin, Japan
Co-Chair: K. Yamazaki, Corning Japan, Japan

FLX1/ INP4 - 1: 17:50 ***Invited* Foldable AMOLED with Integrated On-Cell Touch Sensor for Mobile Device Applications**

J. Chen, J.-C. Ho, G. Chen, M.-H. Yeh, C.-C. Lee

ITRI, Taiwan

Based on ITRI's Flexible Universal Plane (FlexUP) technology, we have recently developed a coverless on-cell touch panel with gas barrier. In this report, we overcome flexibility and interference issues with the on-cell touch panel, and successfully demonstrated a foldable AMOLED integrated with coverless on-cell touch panel at 5 mm folding radius.

FLX1/ INP4 - 2 **Withdrawn**

FLX1/ INP4 - 5L: 18:15 ***Invited*** **Inkjet-Printed Electrodes for Stretchable Wearable System**

Y. Hong, S. Kim, T. Kim, J. Byun, B. Lee, H. Kim, S. Choi, E. Oh, S. Chung, J. Lee

Seoul Nat. Univ., Korea

For wearable, body-attachable electronic system, the strategy of combining rigid islands and stretchable interconnects is one of the best near-term solutions. In this talk, as part of our effort toward stretchable hybrid electronic system, inkjet-printed stretchable electrodes based on silver nano-particle, SWCNT, and nano composite materials is discussed.

FLX1/ INP4 - 3 18:40 **Evaluation of Electrochemical Migration of ITO/Ag/ ITO Structure for Touch Panel Sensor**

Y. Toshimori, T. Ueda, F. Kikuchi, H. Ishii, I. Shiono, S. Zhang

Mitsubishi Materials, Japan

The purpose of this study is to evaluate the electrochemical migration of ITO/Ag/ITO structure for Touch Panel Sensor and to prepare the data necessary to decide the evaluation standard of reliability for application of ITO/Ag/ITO to electrode materials. Our evaluation result shows the guideline of the new evaluation standard.

FLX1/ INP4 - 4 19:00 **Ultra High Resolution Copper Lithography Not Requiring Fine Mask Design Rules and Without Damaging Copper**

*M. A. Hsu, C.-H. Lin, R.-C. Lian, A. Igawa**

Consistent Elect. Materials, Taiwan
**eChem Solutions Japan, Japan*

Applying common photolithography process to copper substrate with novel formulated lithographic chemicals, extremely fine copper pattern could be obtained without using fine mask patterns and with no copper damaging. Very precise metal mesh or copper circuit can be formed onto not only Si or glass substrate but also flexible film.

Author Interviews and Demonstrations
19:00 – 19:40, Ohmi 6

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 10

10:30 - 16:00 **Ohmi 5 and Shakunage 2**

Innovative Demonstration Session

LCT1 - 3 **High Resolution Display Solution with LTPS Technology**

C. P. Xiang, Z. D. Zhang, H. Wu, Y. Z. Ma, B. P. Liu, B. Z. Liu, L. Wen, X. F. Zhou, B. P. Shen, J. Y. Li, Z. H. Zeng

XiamenTianma Microelect., China

LCTp6 - 6L **2D-3D Switchable Auto-Stereoscopic Multi-View 3D Mobile Display Using Polarization Dependent Reactive Mesogen Lens Array Film**

M.-K. Park, K.-B. Son, M. Kim, H.-R. Kim

Kyungpook Nat. Univ., Korea

FMC2 - 4L **Prototyping of LED Color Generator for Imaging Systems with Wide Gamut**

H. Suzuki, H. Urabe[*], M. Katoh[**], Y. Shimodaira[*]

Nobuo Elect., Japan

[*]Shizuoka Univ., Japan

[**]Papalab, Japan.

FMC5 - 2 **Aerial Three-Dimensional Display Based on Retro-Reflective Optical Imaging**

D. Miyazaki, Y. Maeda[*], S. Onoda, Y. Tokubo, S. Murakami, R. Tamaki, T. Mukai

Osaka City Univ., Japan
[*]Parity Innovations, Japan

PH1 - 1 **High Directional LED Lighting for Forming Pattern, HOLOLIGHT: Its Business Developments and Prospects**

T. Ikeda

Pi Photonics, Japan

PH1 - 4L **White LEDs Using Sharp β-sialon:Eu Phosphor and K_2SiF_6:Mn Phosphor for Wide-Color Gamut Display Application**

K. Yoshimura, H. Fukunaga, M. Izumi, M. Masuda, T. Uemura, K. Takahashi[*], R.-J. Xie[*], N. Hirosaki[*]

Sharp, Japan

[*]NIMS, Japan

3D1 - 1 **Occlusion Processing in Computer Holography - With a Focus on Switch-Back Technique -**

K. Matsushima

Kansai Univ., Japan

3D2/ LCT3 - 4 **Wide Viewing Angle Autostereoscopic 3D Display with Eye-Tracking System**

Y. Hyodo, S. Oka, T. Koito, H. Sugiyama, Y. Maede, T. Ochiai, T. Takahashi, S. Komura

Japan Display, Japan

3D4/ VHF6 - 4 **Development of Poor Man's 3D-AR Platform for Amateur Game Creators**

Y. Yoneda, E. Dong, T. Fujita, H. Kiriyama, K. Takemura, K. Iwasaki, R. Urushihara[*], T. Ichii

Tokyo Inst. of Tech., Japan

[*]Ochanomizu Univ., Japan

3D5 - 4 **Floating Image Display Based on a Dihedral Corner Reflector Array**

Y. Maeda

Parity Innovations, Japan

3D6 - 2 **Aerial Imaging by Retro-Reflection with Transparent Retro-Reflector (AIRR with TRR)**

Y. Tokuda[,**], K. Onuki[*], M. Takahashi[*], S. Onose[*], T. Okamoto[*], M. Hirose[**], H. Yamamoto[*,***]*

[*]Utsunomiya Univ., Japan

[**]Univ. of Tokyo, Japan

[***]CREST, Japan

3D6 - 3 **Superimposed 3D Display Viewable from 360 Degrees**

H. Kato, T. Yendo

Nagaoka Univ. of Tech., Japan

3D6 - 4 **A Method to Make 360 Degree Contents for Realistic 3D Image Display Using Direct Light Scanning**

X. Luo, H. Horimai[*], X. Tan

Beijing Inst. of Tech., China

[*]3Dragons, Japan

3Dp1 - 8 **Wide Vertical Viewing Zone in Arc DFD (Depth-Fused 3D) Display**

K. Yoshioka, S. Nishiyama, H. Mizushina, S. Suyama

Tokushima Univ., Japan

3Dp1 - 10 **An Autostereoscopic Display Combining Parallax Barrier and Volumetric Images Using Non-Negative Edge Filter**

B. Yu, H. Kakeya

Univ. of Tsukuba, Japan

VHFp1 - 6 **Development and Application of Hyperspectral Two-Dimension Display**

M. Saika, K. Yoshida, T. Satoh, M. Yamada, K. Uchikawa[*]

Topcon, Japan

[*]Tokyo Inst. of Tech., Japan

PRJ3 - 3 **Optically Efficient Homogenization of Laser Illumination**

F. Shevlin

DYOPTYKA, Ireland

PRJ6 - 3 **A Head Mounted Display Using the Original Flexible Arm and Headband**

M. Watanabe, Y. Fukuda, M. Yagi, H. Ishizaki, M. Nakanishi[*], N. Hanafusa[**], T. Katano

Brother Inds, Japan

[*]Keio Univ., Japan

[**]Univ. of Tokyo Hospital, Japan

PRJp1 - 8L **Validation of Illuminance Measurement for Laser Display**

S. Kubota, M. Kurashige, K. Ishida, K. Ochi[*]

Dai Nippon Printing, Japan

[*]Konica Minolta, Japan

MEET4 - 1 **Blue and Green 10-µm Pixel Pitch GaN LED Arrays with Very High Brightness**

F. Templier, J.-M. Bethoux, B. Aventurier, F. Marion, S. Tirano, M. Lacroix, M. Marra, V. Verney, L. Dupré, F. Olivier, F. Berger, W. B. Naceur, A. Sanchot, I.-C. Robin, M.-A. di Forte-Poisson[*], P. Gamarra[*], C. Lacam[*], M. Tordjman

CEA-LETI, France

[*]III-V Lab, France

DES2 - 1 **A Concept of Immersive Telepresence "Kirari!"**

M. Imoto, S. Uchida, E. Ashikaga, M. Wagatsuma, K. Hidaka

NTT, Japan

DES2 - 2 **Transparent Liquid Crystal Display with Three States; Transparent State, White State and Black State**

Y. Iyama, T. Sasaki, I. Aoyama, K. Hanaoka, T. Ishihara, M. Yashiki, K. Takase, H. Miyata, H. Yoshida

Sharp, Japan

INP2 - 1 **Improved Signal Processing for Capacitive Touch Panel with Conductive and Non-conductive Object Distinction**

J. Taylor, C. Brown, A. Kay, D. Gallardo, S. Maguire, Y. Sugita[*], K. Kida[*]

Sharp Labs. of Europe, UK

[*]Sharp, Japan

INP3 - 1 **Development of a TV System Augmented Outside the TV Screen**

H. Kawakita[,**], M. Uehara[*], T. Nakagawa[*], M. Sato[**]*

[*]NHK, Japan

[**]Tokyo Inst. of Tech., Japan

INP3 - 5L **Character Recognition System Using Cellular Neural Network Suitable for Integration on Electronic Displays –Development of Simulator and Evaluation of Operation–**

T. Kameda[*], M. Kimura[,**], Y. Nakashima[*]*

[*]NAIST, Japan

[**]Ryukoku Univ., Japan

Quantum Dots Sessions

PHp 10:30 – 12:30 Thursday, Dec. 10
Ohmi 6 (Poster)

MEET1 16:05 – 17:25 Thursday, Dec. 10
PH3 9:00 – 10:00 Friday, Dec. 11
MEET5 16:50 – 18:20 Friday, Dec. 11
Ohmi 8 (Oral)

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12:00 – 17:00 Wednesday, Dec. 9
10:00 – 18:00 Thursday, Dec. 10
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TOKYO ELECTRON LIMITED

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EIZO Corporation
JAPAN BROADCASTING CORPORATION
JNC Corporation
Merck Ltd. Japan
NLT Technologies, Ltd.
Toshiba Corporation
ULVAC, Inc.

EXHIBITORS: COMPANIES (as of November 10, 2015)
Hamamatsu Agency for Innovation/Nobuo Electronics Inc.
KONICA MINOLTA, INC.
NAGASE & CO., LTD.
Nippon Electric Glass Co., Ltd.
OXIDE Corporation
SHINTECH, Inc.
Silvaco Japan Co., Ltd.
Toray Research Center, Inc.
Tosoh Corporation
TOYO Corporation
VITEC GLOBAL ELECTRONICS CO., LTD.
YUASA SYSTEM Co., Ltd.

EXHIBITORS: UNIVERSITIES (as of November 10, 2015)
Fujieda Lab., Ritsumeikan Univ.
Hattori Lab., KASTEC·IGSES, Kyushu Univ.
Nakamoto Lab., Shizuoka Univ.
Maeda Lab., Tokai Univ.
Mutsu Matsu Lab./Ryukoku Extension Center, Ryukoku Univ.
Noguchi Lab., Univ. of the Ryukyus
Suyama Lab., Tokushima Univ.
Yamamoto Lab., Utsunomiya Univ.

Evening Get-Together with Wine

Tuesday, Dec. 8, 2015
18:00 – 20:00
Hiei (2F)
Otsu Prince Hotel
(Sponsored by Merck Ltd., Japan)
See page 12 for details

Special Address

Lighting the Earth by LEDs

Hiroshi Amano
2014 Nobel Laureate
Nagoya Univ., Japan

17:20 – 18:20 Wednesday, Dec. 9
Ohmi 1 (2F)

RECEPTION

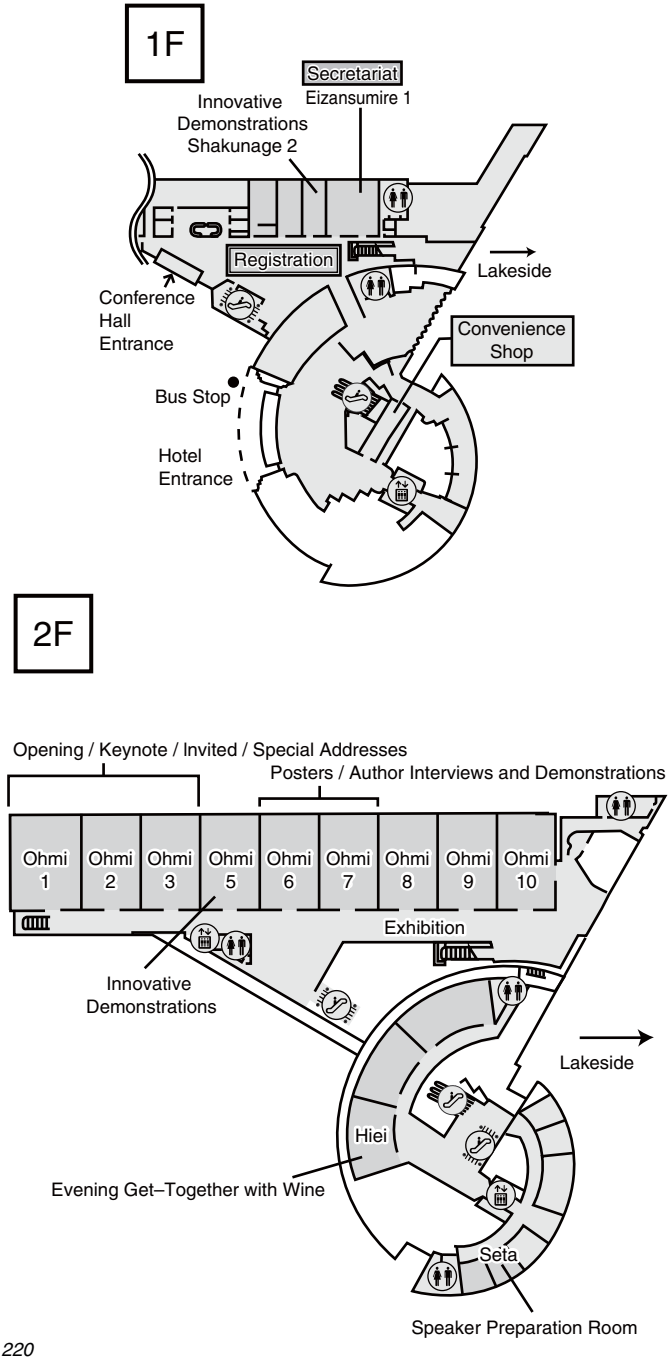
Wednesday, Dec. 9, 2015
18:50 – 20:50
Prince Hall (3F)
Otsu Prince Hotel
See page 12 for details

"Innovative Demonstration Session" *by Oral and Poster Presenters*

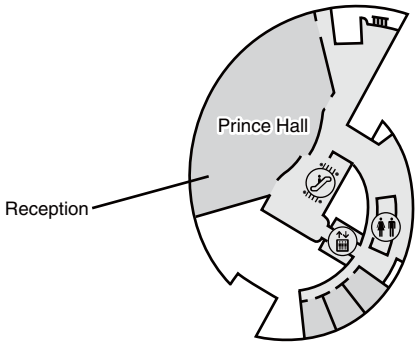
Live demonstrations of emerging information display technologies

Thursday, Dec. 10, 2015
10:30 – 16:00
Ohmi 5 (2F)
Shakunage 2 (1F)
See page 205-209 for details

FLOOR MAP


1F
Secretariat
Eizansumire 1
Innovative
Demonstrations
Shakunage 2
Registration
Lakeside
Conference
Hall
Entrance
Convenience
Shop
Bus Stop
Hotel
Entrance
2F
Opening / Keynote / Invited / Special Addresses
Posters / Author Interviews and Demonstrations
Ohmi 1
Ohmi 2
Ohmi 3
Ohmi 5
Ohmi 6
Ohmi 7
Ohmi 8
Ohmi 9
Ohmi 10
Exhibition
Innovative
Demonstrations
Lakeside
Hiei
Evening Get–Together with Wine
Seta
Speaker Preparation Room

3F



IDW Best Paper Award

IDW Outstanding Poster Paper Award

These awards will go to the most outstanding papers selected from those presented at IDW ’15.
The 2015 award winners will be announced on the IDW website: http://www.idw.or.jp/award.html

SID Display Week 2016

May 22 – 27, 2016

Moscone Convention Center

San Francisco, CA, USA

IDW/AD ’16

The 23rd International Display Workshops in conjunction with Asia Display 2016

Dec. 7 – 9, 2016

Fukuoka Convention Center
Fukuoka, Japan

http://www.idw.or.jp

MEMO

MEMO

IDW '15 Workshop Timetable

Date	1F Lobby	2F Ohmi 1	Ohmi 2	Ohmi 3	Ohmi 5	Ohmi 6	Ohmi 7	Ohmi 8	Ohmi 9	Ohmi 10	Hiei	Lobby
Tue., Dec. 8	Registration 17:00 - 20:00										Evening Get-Together 18:00 - 20:00	
Wednesday, December 9	Registration 8:00 - 18:00	Opening, Keynote & Invited Addresses 9:30 - 11:50										
		Lunch										Exhibition 12:00 - 17:00
		OLED1 13:30 - 14:45					VHF1 13:30 - 14:55	INP1 13:30 - 14:55	LCT1 13:30 - 14:55	DES1 13:30 - 15:10	EP1 13:30 - 14:40	
		Break										
		OLED2 15:10 - 16:45					VHF2 15:10 - 16:25	INP2 15:10 - 16:40	LCT2 15:10 - 16:10	DES2 15:30 - 16:55	EP2 15:10 - 16:35	
						Author Interviews & Demonstrations 16:30 - 17:10						
		Special Address 17:20 - 18:20										
		Reception at the Prince Hall (3F) 18:50 - 20:50										
Thursday, December 10	Registration 8:00 - 18:00	OLED3 9:00 - 10:15	PH1 9:00 - 10:25	EP3† 9:00 - 10:36				INP3 9:00 - 10:45	3D1 9:00 - 10:20	PRJ1† 9:00 - 10:54	VHF3 9:00 - 10:35	Exhibition 10:00 - 18:00
		Break										
					Innovative Demonstration Session 10:30 - 16:00	Poster LCTp1-3,FMCp,PHp,OLEDp,3Dp 10:30 - 12:30						
		Lunch										
					Further Innovative Demonstration Session held in Shakunage 2	Poster LCTp4-6,AMDp,VHFp,PRJp, EPp,MEETp,DESp,FLXp,INPp 13:40 - 15:40						
		Break				Break						
		AMD1 16:00 - 17:25	PH2 16:00 - 17:10	FMC1 16:00 - 17:15				MEET1 16:00 - 17:25	3D2/LCT3 16:00 - 17:25	DES3 16:00 - 17:15	VHF4 16:00 - 17:25	
		Break										
		AMD2 17:40 - 19:10	LCT4 17:40 - 18:40	FMC2 17:40 - 18:55				FLX1/INP4 17:40 - 19:20	3D3 17:40 - 19:00	DES4 18:05 - 19:10	VHF5 17:40 - 18:50	
						Author Interviews & Demonstrations 19:00 - 19:40						
Friday, December 11	Registration 8:00 - 13:00	AMD3 9:00 - 10:30	OLED4 9:00 - 10:00	FLX2/LCT5 9:00 - 10:30	FMC3 9:00 - 10:00			PH3 9:00 - 10:00	3D4/VHF6 9:00 - 10:20	PRJ2 9:00 - 10:20		Exhibition 10:00 - 14:00
		Break										
		AMD4 10:40 - 11:55	OLED5/FLX3 10:40 - 12:00	FED1 10:40 - 12:25	FMC4 10:40 - 11:40			MEET2 10:40 - 12:00	3D5 10:40 - 12:00	PRJ3 10:40 - 12:25		
						Author Interviews & Demonstrations 12:00 - 12:40						
		Lunch										
		AMD5 13:30 - 15:00	FLX4 13:30 - 14:40	FED2 13:30 - 15:10	LCT6 13:30 - 15:00			MEET3 13:30 - 14:50	3D6 13:30 - 14:50	PRJ4 13:30 - 14:50		
		Break										
		AMD6 15:10 - 16:35	FLX5 15:10 - 16:45	FED3 15:20 - 16:40	LCT7 15:10 - 16:30			MEET4 15:10 - 16:30	FMC5 15:10 - 16:10	PRJ5 15:10 - 16:35		
		Break										
		AMD7 16:50 - 18:25						MEET5 16:50 - 18:20		PRJ6 16:50 - 18:20		
						Author Interviews & Demonstrations 18:10 - 18:50						

†Including Short Presentations

IDW '15 Special Topics of Interest Navigator

	Fri, Dec. 11 PM	Fri, Dec. 11 AM	Thu, Dec. 10 PM	Thu, Dec. 10 AM	Wed, Dec. 9 PM
Oxide-Semiconductor TFT	AMD6: Oxide TFT: Solution Processes 15:10 - 16:35	AMD5: Oxide TFT: Applications 13:30 - 15:00	AMD2: High Resolution Displays Using LTPS & Oxide TFTs 17:40 - 19:10		
Ohmi 1		AMD4: TFT Fabrication Technologies 10:40 - 11:55	AMD1: Oxide TFT: Crystalline Oxide 16:00 - 17:25		
		AMD3: Oxide TFT: Reliability 9:00 - 10:30			
Ohmi 6			AMDp1,FLXp2 Poster 13:40 - 15:40		
			DESp2 Poster 13:40 - 15:40		
Augmented Reality and Virtual Reality				INP3: AR & Interactive Systems 9:00 - 10:45	
Ohmi 8					
Ohmi 9	FMC5: Augmented Reality & Virtual Reality 15:10 - 16:10	3D5: 3D/Hyper Realistic Display Systems 10:40 - 12:00	3D4/VHF6: Autostereoscopic & Head-Mounted Displays 9:00 - 10:20		
Ohmi 10	PRJ6: Wearable Applications 16:50 - 18:20				DES1: Various Visualization Technologies 13:30 - 15:10
Lighting Technologies					OLED2: OLED for Lighting Application 15:10 - 16:45
Ohmi 1					
Ohmi 2				PH1: Phosphors for Lighting Application 9:00 - 10:25	
Ohmi 6				PHp2: Poster 10:30 - 12:30	
Printed Electronics		FLX4: Flexible Printed Electronics 13:30 - 14:40		OLED4: Advanced OLED Technologies II 9:00 - 10:00	
Ohmi 2					
Ohmi 6			FLXp3: Poster 13:40 - 15:40		

IDW '15 Session Navigator

	Wednesday, December 9			Thursday, December 10						Friday, December 11						
	PM		16:30-17:10	AM		PM			19:00-19:40	AM		12:00-12:40	PM			18:10-18:50
3D / Hyper-Realistic Displays				Ohmi 9	Ohmi 6	Ohmi 9			Ohmi 6	Ohmi 9		Ohmi 6	Ohmi 9			Ohmi 6
				Holography	Posters		Autostereoscopic 3D Displays*	Wavefront/Light Field Recording & Rendering	A.I.	Autostereoscopic & Head-Mounted Displays*	3D/Hyper-Realistic Display Systems	A.I.	Floating & Omnidirectional Display Systems			A.I.
Active-Matrix Displays						Ohmi 6	Ohmi 1		Ohmi 6	Ohmi 1		Ohmi 6	Ohmi 1			Ohmi 6
						Poster	Oxide TFT: Crystalline Oxide	High Resolution Displays Using LTPS & Oxide TFTs	A.I.	Oxide TFT: Reliability	TFT Fabrication Technologies	A.I.	Oxide TFT: Applications	Oxide TFT: Solution Processes	Advanced Si Technologies	A.I.
Display Electronic Systems	Ohmi 10		Ohmi 6			Ohmi 6	Ohmi 10		Ohmi 6							
	Various Visualization Technologies	Transparent Display Systems	A.I.			Posters	Application for Automobiles	Image Processing	A.I.							
Emissive Technologies				Ohmi 2	Ohmi 6		Ohmi 2	Ohmi 3	Ohmi 6	Ohmi 8	Ohmi 3	Ohmi 6	Ohmi 3			Ohmi 6
				Phosphors for Lighting Application	Posters		Phosphor for General	Display Optics & Information Technologies	A.I.	Phosphor Application	Advanced Technologies & FE Mechanism	A.I.	FEA Fabrication Process & Novel Materials	Flexible Light Source Using Plasma Technologies		A.I.
Emerging Technologies & Novel Applications						Ohmi 6	Ohmi 8		Ohmi 6		Ohmi 8	Ohmi 6		Ohmi 8		Ohmi 6
						Posters	Quantum Dots Applications		A.I.		Novel Materials & Components	A.I.		Nanotechnologies for Display Applications	Emerging Quantum Dots & Nanotechnologies	A.I.
e-Paper	Hiei		Ohmi 6	Ohmi 3		Ohmi 6			Ohmi 6							
	Emerging Technologies for e-Paper	Electrochromic Displays	A.I.	Electrophoretic Displays & Applications		Posters			A.I.							
Flexible Electronics						Ohmi 6		Ohmi 8	Ohmi 6	Ohmi 3	Ohmi 2	Ohmi 6	Ohmi 2			Ohmi 6
						Posters		Flexible Input Devices*	A.I.	Flexible LCDs*	Flexible OLED & OTFT*	A.I.	Flexible Printed Electronics	Flexible Displays & Devices		A.I.
Interactive Technologies	Ohmi 8		Ohmi 6	Ohmi 8		Ohmi 6		Ohmi 8	Ohmi 6							
	Interactive Technologies	Touch Panel	A.I.	AR & Interactive Systems		Posters		Flexible Input Devices*	A.I.							
Human Factor	Ohmi 7		Ohmi 6	Hiei		Ohmi 6	Hiei		Ohmi 6							
	Display Metrology	Display Image Quality	A.I.	Human Factors		Posters	Color & Vision	Color Rendering	A.I.							
Liquid-Crystal Technologies	Ohmi 9		Ohmi 6		Ohmi 6	Ohmi 6	Ohmi 9	Ohmi 2	Ohmi 6	Ohmi 3		Ohmi 6	Ohmi 5			Ohmi 6
	Fascinating High Resolution Panel Technologies	Advanced LC Materials	A.I.		Posters	Posters	Autostereoscopic 3D Displays	New Fast Response LCDs	A.I.	Flexible LCDs*		A.I.	IPS/FFS Display Modes	Innovative Technology for Surface/Interface Control		A.I.
Manufacturing, Process & Equipment					Ohmi 6					Ohmi 5		Ohmi 6				
					Posters					Manufacturing Technologies		A.I.				
Materials & Components					Ohmi 6		Ohmi 3		Ohmi 6		Ohmi 5	Ohmi 6		Ohmi 9		Ohmi 6
					Posters		Materials & Components	Display Optics & Information Technologies	A.I.		Film Technologies	A.I.		Augmented Reality and Virtual Reality		A.I.
							Ohmi 2		Ohmi 6	Ohmi 8		Ohmi 6				
							Phosphor for General		A.I.	Phosphor Application		A.I.				
MEMS													Ohmi 8			Ohmi 6
													MEMS & Related Technologies			A.I.
Organic Light-Emitting Displays & Organic Devices	Ohmi 1		Ohmi 6	Ohmi 1	Ohmi 6				Ohmi 6	Ohmi 2		Ohmi 6				
	Advanced OLED Technologies I	OLED for Lighting Application	A.I.	OLED Materials	Posters				A.I.	Advanced OLED Technologies II	Flexible OLED & OTFT*	A.I.				
Projection & Large Area Displays				Ohmi 10		Ohmi 6			Ohmi 6	Ohmi 10		Ohmi 6	Ohmi 10			Ohmi 6
				Projection Applications		Posters			A.I.	Projection Components & Materials	Solid State Light Source	A.I.	Automotive Display & Lighting	Projection Optics	Wearable Applications	A.I.

A.I. Author Interviews & Demonstrations
* Joint Session

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IDW ’15
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