Special Topics of Interest on

- Oxide TFT
- Augmented Reality and Virtual Reality
- Lighting Technologies

Workshops on

- LC Science and Technologies (LCT)
- Active Matrix Displays (AMD)
- FPD Manufacturing, Materials and Components (FMC)
- Plasma Displays (PDP)
- EL Displays and Phosphors (PH)
- Field Emission Display and CRT (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 Displays (FLX)
- Touch Panels and Input Technologies (INP)
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The 20th International Display Workshops will be held as IDW ’13 for encouraging aggressive research and development of display technologies throughout the world and especially in the Asian region. IDW ’13 focuses on the following three special topics, which are extremely timely, as well as fifteen active workshops.

**Special Topics of Interest on**
- Oxide TFT
- Augmented Reality and Virtual Reality
- Lighting Technologies

**Workshops on**
- LC Science and Technologies
- Active Matrix Displays
- FPD Manufacturing, Materials and Components
- Plasma Displays
- EL Displays and Phosphors
- Field Emission Display and CRT
- 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 Displays
- Touch Panels and Input Technologies

The three-day conference will feature 504 papers, including three keynote addresses, 115 invited papers and 164 oral presentations, and 222 poster presentations, including 97 late-news papers. Following plenary session of Keynote and the 20th Anniversary addresses in the Wednesday morning, presentations will begin and continue in 8 parallel oral sessions through Friday. Poster sessions and author interviews with demonstrations will enable participants to discuss topics in detail. IDW ’13 will also present “IDW Best Paper Award” and “IDW Outstanding Poster Paper Award” based on paper originality and technical significance to information displays. Exhibits by universities and display industry-related businesses will also be featured from Wednesday to Friday in parallel with workshops. IDW ’13 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 TFT**
Oxide TFTs have a long history going back for almost a half century, but they have been intensively investigated only since the first demonstration of amorphous oxide semiconductor TFTs in 2004, and have now become one of the hottest topics in backplane technologies for active-matrix FPDs. Although we were glad to see and touch the first commercial LCD products using the oxide TFTs in 2012 and the following OLED televisions this year, there still remain many technical issues for further evolution toward better performance, high resolution, robust reliability, low fabrication temperature, and broader applications. In IDW ’13, the latest achievements involved in the brand-new challenges of these issues will be found in the papers marked Special Topics “Oxide TFT” in workshops for FMC and AMD. Neither should you miss the brilliant invited talks given by world-leading researchers in oxide TFTs nor the contributed presentations with outstanding results.
Special Topics of Interest on Augmented Reality and Virtual Reality

In recent years, augmented reality (AR) and virtual reality (VR) applications have been making substantial progress with high-performance display devices and sensors including cameras with tracking capabilities. In a special session held under the Projection and Large-Area Displays and Their Components Workshop, discussion will be focused on HMD and projection-mapping as new applications of projection technology. In the sessions of the Workshop on Display Electronic Systems (DES), medical systems, perception-based displays, blue light matters, and perceptual comparison between binocular and monocular observation are presented as research that focuses on human perception in VR/AR. Moreover, viewpoint-estimation and digital archiving methods are presented as essential sensing technologies for VR/AR applications. Regarding the AR&VR topics related to the Touch Panels and Input Technologies Workshop, Prof. Inami from Keio Univ. reviews several applications of enhanced human I/O based on modern biological understanding of sensation, emerging electronic devices, and agile computational methods. These include transparent cockpits, stop-motion goggles, galvanic vestibular stimulation and reality jockeys. A new hands-free videophone based on Eye-glass with multiple fish-eye cameras, which attracted great attention at last year's CEATEC, will be demonstrated. A novel tablet-based interface provides a quick and accurate method to manipulate remotely distributed AR objects, for example, in urban planning. The sessions are organized by the 3D, VHF, PRJ, DES and INP workshops.

Special Topics of Interest on Lighting Technologies

This 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.

Workshop on LC Science and Technologies (LCT)

This workshop covers topics from fundamental studies to recent developments in LCD technologies and LC materials. In this 20th anniversary year “What's the next display?” is planned with keynote and invited talks from the viewpoints of the company. In the regular session, new LCD technologies, such as blue phase LCDs, 3D-LCDs, polymer stabilized LCDs and photo-alignment LCDs are extensively discussed. Novel semiconductor LCs and special novel LCD evaluation techniques are also discussed.

Workshop on Active Matrix Displays (AMD)

The AMD workshop has devoted itself to the exchange of scientific and technological knowledge for FPD applications, covering the various technologies of Si-TFT, oxide TFT, organic TFT, OLED, integrated sensors, flexible devices and novel applications. AMD is recognized as one of the largest workshops at IDW. Recent paper presentations tend to focus on oxide TFTs, which may be expected to play a role in the applications for higher-definition LCD, next-generation OLED and flexible displays. We highlight the oxide TFT as a special topic of interest (STI), as we did last year. We devote four sessions to the oxide TFT STI, and three sessions to AMD alone, which cover a wide area from device/process to applications. The presentations also show promise for the achievement of green and sustainable technologies.

Workshop on FPD Manufacturing, Materials and Components (FMC)

The FMC workshop covers the recent developments and achievements in the field of flat panel display technologies in manufacturing, materials, measurements and components. Two special 20th anniversary sessions
named “Past, Present and Future” are planned, with the top experts in their fields lined up to speak on this theme. The sessions devoted to special topics of interests, lighting and oxide TFT, show recent trends. The joint sessions with the FLX workshop include hot topics. More than 30 oral presentations including 10 invited papers and more than 20 poster papers will be held, showing the progress of the display field.

**Workshop on Plasma Displays (PDP)**
The PDP workshop will present the latest large screen device technologies and advanced applications. For the advanced plasma display technologies, elegant protective layers with a significant improvement of luminous efficiency, and graphene coated electrode materials with a reduction of material cost of device will be introduced. Novel large screen panel fabrication technologies for new film-type plasma tube arrays display were exhibited at I-Zone in SID Display Week 2013, where they won the Best Prototype Award. In our session, this new technology will be presented by Shinoda Plasma Co., Ltd. Also, reproduction of a three dimensional 22.2 multichannel sound system with built-in type loudspeaker array for large screen Super Hi-Vision PDP will be introduced.

**Workshop on EL Displays and Phosphors (PH)**
This workshop presents the latest achievements on devices and phosphors for emissive displays, general lighting and liquid-crystal backlighting. Invited talks will present emerging technologies such as wide color gamut LCD, new phosphor applications, new materials for white LED lighting and emissive displays. Development tools such as computational chemistry and structure analysis of phosphor materials will be also presented.

**Workshop on Field Emission Display and CRT (FED)**
Field emission display (FED) is a vacuum device similar to the cathode ray tube (CRT) and is one of the most promising flat panel displays because of several features such as high picture quality, low power consumption and fast response time. This workshop covers the entire field of CRT and field emission display technologies. Recent progress in image sensors and displays with field emitter arrays are presented. New devices, such as microcolumns with field emitters and photocathodes with plasmonic antennas are also presented. Furthermore, fabrication processes, field emission characteristics and various field emitter materials, such as carbon materials, hafnium nitride and nanocrystalline silicon, are also discussed.

**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. OLED technologies based on new full-color realizing methods are reported on, as well as technologies from micro display viewers to large size TV applications. Material and device architecture for higher quantum efficiencies, supporting these device technologies are also presented. In addition, OLED lighting, flexible OLED and semiconductor material for one of the optimal backplane technologies with OLEDs are also discussed.

**Workshop on 3D/Hyper-Realistic Displays and Systems (3D)**
This workshop focuses on recent progress in 3D, hyper-realistic display systems and related visual sciences. It covers acquisition, processing, 2D/3D conversion, two-view display, multi-view display, holography, new optical components, crosstalk, measurement, perception, standardization and so on for 3D/ hyper-reality display technologies. Invited talks in this workshop include topics from the forefront of 3D imaging technologies and recent research into advanced display systems such as multi-view
display and holography.

**Workshop on Applied Vision and Human Factors (VHF)**
The VHF workshop covers all topics on vision, human factors and image quality relating to information display. The oral and poster sessions include lively discussions on the latest topics ranging from fundamental theories to applications. This year, in addition to four VHF oral sessions on Improving Visual Experience, Visual Perception, Color, and Display Parameters and Human Performance, we have a joint session with the DES (Display Electronic Systems) workshop on the theme of AR (Augmented Reality), plus a joint session with the 3D workshop. Both of these promise groundbreaking interdisciplinary discussions, in addition to our regular VHF poster session (and a VHF-AR poster) which enables participants to quiz presenters in detail. Four distinguished invited talks will be given in the oral sessions, concerning the latest topics in user preferences for display luminance, wide-gamut system colorimetry for UHDTV, perception of surface quality, and observer metamerism effects.

**Workshop on Projection and Large-Area Displays and Their Components (PRJ)**
The PRJ workshop covers projection technologies, devices and related applications. This year, discussions will be focused on miniature optical system technologies for head-mounted displays and head-up displays such as optical design, solid-state light source, augmented reality and sensing. Leading edge technologies of holographic optics and projection mapping also will be discussed. There will be 22 presentations including five invited presentations in total (17 oral and 5 poster presentations).

**Workshop on Electronic Paper (EP)**
This workshop focuses on current topics in electronic paper including rewritable paper and flexible displays. Developments of e-Paper technologies are now eagerly demanded for emerging applications of e-Books, e-Notebooks, electronic shelf labels, and signage etc. Various novel technologies such as electrophoretic, electrochromic, liquid crystal, and twisting ball displays will be reported on. There will also be reports on challenging new approaches in e-Paper technologies. Systems, devices, materials, human factors, evaluations and applications in this field are expected to be eagerly discussed.

**Workshop on MEMS and Emerging Technologies for Future Displays and Devices (MEET)**
The 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 horizons of display and imaging technologies into cutting-edge technologies. Research areas such as materials, basic physics and fabrication process 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 in this field are invited from top research institutions around the world. Invited speakers are from Univ. of Cambridge, MIT (QD Vision), École Polytechnique, CEA-LETI, Kyung Hee Univ., Seoul Nat. Univ., Sungkyunkwan Univ., SAIT, ETRI, Univ. of Tokyo and Tohoku Univ. Together with excellent contributed papers, this workshop invites 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, cooperative operations between display components such as cells and backlights, sensors, and applications to augmented reality (AR). This year, we will have 26 papers including 14 invited talks and 4 poster presentations.
The top topic is “blue light,” about which there are important concerns such as its potential damage to human eyes and circadian rhythm aberration. This is an indispensable talk for display researchers. In addition, the sessions related to the driving/low-power technologies for LCD/OLED and vehicle display technologies will be planned. We will also highlight AR technology as a Special Topics of Interest (STI) session.

**Workshop on Flexible Displays (FLX)**

Recently, flexible display technologies are receiving much attention, and they are spread over a wide range of fields from materials science to practical applications. The hottest sessions cover all aspects of flexible device/material technologies including OLED, TFT fabrication, substrate, printing/roll-to-roll processes and evaluation.

**Workshop on Touch Panels and Input Technologies (INP)**

The INP workshop covers all aspects of input technologies on materials, device production, device structure and systems. We expect that INP will open up brand new fields by fusing the input and display technologies. In addition to the recent developments in touch panel technologies, new user interface technologies such as Eye-glass type devices and the most advanced 3D/2D image sensor technologies and systems are featured in this year’s session.

**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 ‘13. The award winners will be announced on the IDW website and given a plaque after the conference.

**The 20th Anniversary of IDW**

This year will mark the 20th anniversary of International Display Workshops (IDW ‘13). In commemoration of the anniversary, we will have the 20th anniversary address which will be given by Professor Shunsuke Kobayashi of Tokyo University of Science Yamaguchi. Professor Kobayashi, who is the pioneer of displays and also one of the founders of IDW, will look back on the history of IDW.

**Exhibition**

The IDW ‘13 Exhibition, which will be held from December 4 through December 6, 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 (1F, Lobby).

- December 4: 12:40 – 18:00
- December 5: 10:00 – 18:00
- December 6: 10:00 – 14:00
GENERAL INFORMATION

SPONSORSHIP
IDW ’13 is sponsored by the Institute of Image Information and Tele-vision Engineers (ITE) and the Society for Information Display (SID).

CONFERENCE SITE
Sapporo Convention Center
1-1-1 Higashi-Sapporo 6-jo, Shiroishi-ku,
Sapporo, 003-0006
Phone: +81-11-817-1010 Fax: +81-11-820-4300

ON-SITE SECRETARIAT
Telephone and fax machines for IDW ’13 use will be temporarily set up in the secretariat room (Room 104) at the Sapporo Convention Center (December 3-6). Phone/Fax: +81-11-837-7011

RECEPTION
A buffet style reception will be held on December 4 from 18:30 to 20:30 at the Conference Hall (1F) in the Sapporo Convention Center. 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 3 from 18:00 to 20:00 at Restaurant Sora (1F) in the conference site. 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 your registration at the conference site.

Registration Fees
The registration fee for IDW ’13 includes admission to the conference and a CD-ROM of the proceedings. Detailed information will be announced on the website.

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<td>Individual Member</td>
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*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 ’13 committee.

***Photocopy of student ID is required.

Please note that the payment of reduced registration fee is accepted until November 1. The full fee will be charged for payments made on and after November 2. Also note that the number of reception tickets to register on site is limited.

Proceedings Data at the Conference Site
We will provide the data on USB flash drives for copying near the registration desk. This data can also be accessed from the web-server via the wireless network only in the Free Wi-Fi Area at the conference site.

For additional proceedings (CD-ROM)
- At the conference site ¥8,000
- Airmail after the conference ¥15,000
- Domestic mail after the conference ¥10,000
Payment
Three ways are provided for registration.

(1) e-Registration
Access the following URL.
http://www.idw.ne.jp/regist.html
e-Registration will be accepted until November 22, 2013.

(2) Mail or Fax Registration
Complete the registration form (download from the website) and send it to the secretariat together with all necessary payments no later than November 22, 2013.

IDW ’13 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.ne.jp

The registration fee should be paid by one of the following methods.
1. Credit Card (VISA, MasterCard, AMEX, JCB or Diners)
2. Bank Transfer to:
   Bank: Bank of Tokyo-Mitsubishi UFJ
   (Swift Code: BOTKJPJT)
   Branch: Ichigaya Branch (Branch No. 14)
   Account No.: 1474095 (Ordinary Account)
   Account: IDW
   Please attach a copy of the bank receipt with the registration form to avoid any confusion. Please note that the remittance charges 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 3 (Tue.) 17:00 – 20:00
December 4 (Wed.) 8:00 – 18:00
December 5 (Thu.) 8:00 – 18:00
December 6 (Fri.) 8:00 – 13:00

The on-site registration fee will be payable by:
1. Cash (JAPANESE YEN only)
2. Credit Card (VISA, MasterCard, AMEX or JCB)
Bank transfer, bank checks, or personal/traveler’s checks are not accepted.

Cancellation Policy
Until November 1, cancellation is accepted by writing to IDW ’13 Secretariat to get refunds for registration and reception. For cancellations received on and after November 2 or no-shows, refunds will not be made. However, after IDW ’13 closes, a CD-ROM of the proceedings will be sent to the registrants who have paid the registration fees. If it becomes difficult to hold IDW ’13 due to the outbreak of infectious diseases and other unavoidable factors, we will substitute the IDW with the mail delivery of the IDW ’13 proceedings at a later date to all those who have registered and completed payment.

INQUIRIES
IDW ’13 Secretariat
C/o Bilingual Group Ltd.
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Phone: +81-3-3263-1345 Fax: +81-3-3263-1264
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ACADEMIC SUPPORTING ORGANIZATIONS (ASO)

- The Chemical Society of Japan
- The Electrochemical Society of Japan
- The Illuminating Engineering Institute of Japan
- The Imaging Society of Japan
- 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 Japanese Liquid Crystal Society
- The Japan Society of Applied Physics
- The Society of Polymer Science, Japan
- The Virtual Reality Society of Japan

Funds

- The Asahi Glass Foundation
- Hokkaido Tourism Organization
- The Murata Science Foundation
- National Institute of Information and Communications Technology/ NICT
- Sapporo Convention Bureau
- The Tateisi Science and Technology Foundation

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

SID Display Week 2014

June 1 – 6, 2014
San Diego Convention Center
San Diego, California, U.S.A.
TRAVEL INFORMATION

ACCOMMODATIONS
JTB Hokkaido Corp. will handle arrangements for your hotel reservations.

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

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

JTB Hokkaido Corp.
Corporate Sales Division, Sapporo, IDW ’13 Desk

Phone: +81-11-221-4800 Fax: +81-11-222-5102
Office Hours: 9:30-17:30 (Weekdays only)
E-mail: jtb_spktaikai@hkd.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.ne.jp/visa.html

CLIMATE
The average temperature in Sapporo during the conference should be around 2°C (36°F) in the daytime and -4°C (25°F) at night. From early December onward, the ground is often covered with snow. Please carefully choose what clothing and footwear you bring with you.

EXHIBITION

12:40 – 18:00 Wednesday, Dec. 4, 2013
10:00 – 18:00 Thursday, Dec. 5, 2013
10:00 – 14:00 Friday, Dec. 6, 2013
Lobby, 1F
Sapporo Convention Center
Sapporo City
Sapporo, the capital of Hokkaido, is the fifth largest city in Japan and is primarily known as the host city for the 1972 Winter Olympics. The development of Hokkaido was started on a large scale about 150 years ago, when Sapporo was enlarged according to the advice of foreign specialists. Sapporo was built based on a rectangular street grid system. Today the city is well known for its ramen (a special kind of noodles in soup), beer, and the annual snow festival held in February. Sapporo’s winter has plenty of snow, and attracts outdoor lovers including skiers and snowboarders.

Places of Interest
Odori Park
Odori Park divides the city center into north and south. It stretches for about 1.5 km, covering 12 blocks, and the grounds around the TV tower located there provide an oasis for people living and working in the surrounding office district. In every corner of the park, you will find attractions, monuments, art work (including pieces by the famous Isamu Noguchi), play-areas, fountains, and of course the beauty of the seasonal flowers and trees. The park is home to 4,700 trees of 92 species such as lilacs, elms, Japanese zelkovas, azaleas and cherry trees. Many events are held here throughout the year including the world-famous Snow Festival.

Jozankei Onsen (Spa)
A 75-minute bus tour from JR Sapporo station takes you to one of the largest hot springs in Japan, Jozankei. The history of Jozankei dates back to 1866, when Mizumi Jozan, an ascetic monk, discovered the hot springs and opened a healing spa on the upper Toyohira River. The hot spring waters that bubble out of the ground at Jozankei spa resort contain sodium chloride, which is colorless, transparent, and mildly salty. These are common qualities of the water in Japanese spas.
http://jozankei.jp/en/

Susukino
Susukino is the largest nightlife district in the northern part of Japan. There are said to be some 4,500 bars and restaurants, including Ramen Yokocho, a famous alley of noodle shops. Today it’s a bustling nightlife district that gets more crowded with each passing hour of the evening, but where women can enjoy a drink without having to worry at all about their safety. Recently, hot spring hotels with saunas have become popular.

Further information
Sapporo Official Travel Guide
http://www.welcome.city.sapporo.jp/english/
Sapporo Tourism Association
http://www.sta.or.jp/english/
ACCESS TO SAPPORO CONVENTION CENTER

Nagoya Chubu Centrair Int’l Airport (NGO)
100 min. Flight

Kansai Int’l Airport (KIX)
110 min. Flight

Narita Int’l Airport (NRT)
100 min. Flight

Beijing, Shanghai, Hong Kong, Seoul, Pusan, Inchon, Taipei, Bangkok, etc.

Haneda Airport (HND)
90 min. Flight

Sapporo New Chitose Airport (CTS)
JR Chitose Line Rapid 28 min.

Shin Sapporo Station
¥850 from the airport
8 min.

Sapporo Station
¥1,040 from the airport
1 min.

Odori Station
Subway Nanboku Line
6 min.

Higashi Sapporo Station
T 12
¥280 from Shin Sapporo Sta.
¥240 from Sapporo Sta.
10 min. on Foot

SAPPORO CONVENTION CENTER
(as of November 1, 2013)
Plenary Sessions

Wednesday, December 4

9:30 - 9:50 Conference Hall

Opening

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

Opening Remarks
9:30

Y. Iimura, General Chair, IDW
Y.-S. Kim, Representative of SID
T. Kuroda, Representative of ITE
K. Ishikawa, Program Chair, IDW

9:50 - 11:50 Conference Hall

Keynote Addresses

Co-Chairs:
K. Ishikawa, Program Chair, IDW
M. Kimura, Program Secretary, IDW

Keynote Address - 1 The Future of Mobile Displays
9:50

Y. Takubo
Japan Display, Japan

Recently, mobile devices such as smartphones are leading R&D activities for LCDs. A number of new technologies have been developed to satisfy tough requirements for mobile use. LTPS has become the main backplane technology for high pixel density. Tablet PCs are following the same trend. Developments in frontplane LCD technologies have been accelerated to improve visual performance and power efficiency to support high pixel density trends.

Keynote Address - 2 Research and Development for Future Display
10:30

S.-Y. Yoon
LG Display, Korea

With developing liquid crystal display technology, display market moved to active matrix liquid crystal display. With increasing demand for added values, the ultra-high definition was expended on the market, and flexible and/or transparent displays have been discussed. In this presentation, we will discuss technology directions of current and next generation display.
Metamaterials are artificially structured materials which realize optical constants (refractive index, permittivity, permeability, etc.) not obtained in natural materials. Metamaterials are composed of subwavelength units called meta-atoms. In this paper, recent development of metamaterials ranging from microwave to visible regions is reviewed with the emphasis on those in the THz region.

----- Break (11:50 - 12:00) -----

12:00 – 12:30 Conference Hall

The 20th Anniversary Address

Co-Chairs: Y. Iimura, General Chair, IDW
K. Azuma, Executive Chair, IDW

12:00 The Dawn of IDW and Its Growth over the Past 20 Years: The Tremendous Evolution in Information Displays
S. Kobayashi
Tokyo Univ. of Sci. Yamaguchi, Japan
Novel oxide TFT gate driver circuits using bias offset method has been investigated. The inverters in the circuit provide offset voltages to prevent operation failure due to charge leakage. Measurement was done on the gate driver circuits integrated in FHD panel and the effect is analyzed.

A 32-in. HD LCD-TV by using a-IGZO TFT which was fabricated at Gen 4.5 glass substrate with IGZO (1:1:1) AC sputtering system for TFT-LCD. TFT with an a-IGZO channel layer exhibited good subthreshold swing (S.S), Ion/Ioff ratio, threshold voltage and mobility of 0.15 V/decade, 2\*10^{-8}, 0.08 V and 19.01 cm²/Vs, respectively.

In this study, a supercritical fluid (SCF) technology is proposed to enhance the electrical performance and reliability of a-AZTO TFTs. The SCF provides liquid-like solvency and gas-like diffusivity, giving it transport capacity to take the H₂O molecules into films and terminate the traps in films by the oxidization.
This work presents a gate driver circuit using indium-gallium-zinc oxide (a-IGZO) thin-film transistors (TFTs). The proposed circuit suppresses the threshold voltage shifts and completely turns off the a-IGZO TFTs having negative threshold voltage. Simulation reveals the proposed gate driver circuit can stably operate with a-IGZO TFT having negative threshold voltage.

Threshold voltage shift ($\Delta V_{th}$) characteristics of amorphous InGaZnO thin-film transistors under positive gate bias stress are investigated and the monitoring $\Delta V_{th}$ from constant current induced drain voltage is proposed. The extracted $\Delta V_{th}$ characteristics are then analyzed using the stretched exponential model and the characteristics of the subgap density of states.

We report successful fabrication of the BCE-type TFTs with Mo/Al/Mo electrodes using etchant resistive new oxide semiconductor thin films. It is found that the additional annealing process is really effective to restore the TFT surface damage after the BCE process. The TFTs exhibit a high stress stability under the LNBTS.

We have investigated the top gate IGZO thin film transistors with polymer gate insulators. Multiple approaches were adopted for improving device performance. Electron mobility was upgraded almost $10^3$ times for stacking IGZO layers. The device characteristics showed a mobility 0.05 cm$^2$/Vs and an on/off current ratio over $10^3$. 

Wednesday December 4

AMDp1 - 4 New a-IGZO TFT Gate Driver Circuit with AC-Driven Pull-Down Circuit
Nat. Cheng Kung Univ., Taiwan

AMDp1 - 5 In-Situ Threshold Voltage Shift Monitoring of Amorphous InGaZnO Thin-Film Transistors
J. H. Kang, E. N. Cho, I. Yun
Yonsei Univ., Korea

AMDp1 - 6 High Reliability of Back Channel Etch-Type TFTs Using New Oxide Semiconducting Material
M. Ochi, S. Morita, Y. Takanashi, H. Tao, H. Goto, T. Kugimiya, M. Kanamaru
Kobe Steel, Japan
*Kobelco Res. Inst., Japan

AMDp1 - 7 The Study on Sol-Gel IGZO Thin Film Transistors with Top Polymer Gate Insulators
Y. W. Wang, M. S. Lai, C. Y. Huang, W.-C. Su
Nat. Changhua Univ. of Education, Taiwan

Wednesday December 4
The article studied the relation between oxide TFT (IGZO) process and reliability of product. From experiments, the appropriate conditions were adopted in the process improvement. The recommended conditions of IGZO process, such as higher IGZO anneal temperature, ESL anneal temperature and PVX deposition temperature, were provided in this paper.

Self-aligned top-gate a-IGZO TFT with homogenous source/drain and channel is fabricated. The low resistance of source/drain regions is achieved using a N₂ plasma treatment. After the N₂ plasma treatment, the resistivity of IGZO film experiences a sharp decrease. A simple and cost-effective self-aligned top-gate TFT technology is thus demonstrated.

We investigated the impact of the power deposition in etch-stopper layer (ES layer) and high temperature annealing in the active layer and ES layers, respectively for stability of Oxide-TFT. For stability test, the devices during active layer annealing under positive and negative bias stress, respectively, exhibited weak shift.

High-mobility IGZO TFTs were demonstrated at 360°C with an IGZO channel and AlOₓ gate dielectric stack that was deposited by ozone-assisted solution-based atmospheric pressure (AP) process. The mobility of the AP-processed IGZO TFT significantly improved to 12.3 cm²/Vs which is comparable to the value obtained from vacuum processed IGZO TFTs.
This paper presents an AMOLED pixel circuit which uses a "source-follower" to sense $V_{TH}$, enabling a precise compensation even if the initial $V_{TH}$ value is negative. In addition, the circuit can compensate for performance variations of both TFTs and OLED.

This work presents a new pixel circuit design adopting amorphous indium-gallium-zinc-oxide (a-IGZO) thin-film transistors (TFTs) that compensates for the threshold voltage shift of the driving TFT and ameliorates the luminance drop of OLED for active-matrix organic light-emitting diode (AMOLED) display.

Amorphous oxide semiconductor, represented by a-IGZO, is now used in current FPDs. On the other hand, a-IGZO TFTs require thermal annealing at 300-400°C for better uniformity and stability. Here, we discuss structural relaxation, defect annihilation and creation by thermal annealing in relation to hydrogen and oxygen effects.
The results of etching formulations for wet chemical, damage free IGZO TFT processing are presented. Selective etching of the source/drain metal can be increased substantially by using SACHEM’s proprietary formulations. The use of an etch stop layer to protect the IGZO channel is therefore not required, allowing for cost effective TFT processing.

We have investigated the microwave-detected photoconductivity responses from the amorphous In-Ga-Zn-O (a-IGZO) thin films. The peak values and the lifetime extracted by the reflectivity signals were correlated with TFT performances. It is concluded that the microwave photoconductivity decay (μ-PCD) is a promising method for in-line process monitoring for the IGZO-TFTs fabrication.

We have developed a solution-processed Photosensitive Passivation Layer (PPL) for an oxide TFT. We have also developed a manufacturing process for oxide TFT that is suitable for the PPL process. By controlling the oxygen concentration in the oxide semiconductor, we have achieved an oxide TFT with the PPL.
Highly conductive ruthenium metal thin films and ruthenium oxide ones were prepared by a solution process at low temperature (e.g., $6.9 \times 10^{-5}$ $\Omega$cm at 300 $^\circ$C for Ru). Their structure and electric properties depend on the annealing conditions. The process allowed us to fabricate ruthenium electrodes on flexible substrates.

A flexible AMOLED on PEN (Polyethylene-Napthalate) substrate, with an anodic amorphous Al$_2$O$_3$ as gate insulator, is presented. Through the anodic oxidation, the high quality gate insulator was deposited at room temperature, which ensured good characteristics in the TFTs. The maximum processing temperature during the fabrication was controlled below 180$^\circ$C.
Threshold voltage shifts of amorphous In-Ga-Zn-Oxide (a-InGaZnO) TFTs on plastic substrates against bias-temperature stress were reduced below 0.03 V. We have developed a 10.2-in. WUXGA flexible AM-OLED display driven by a-InGaZnO TFTs fabricated on a transparent polyimide film. We demonstrated an interactive prototype flexible-display system integrated with a bend-input function.

Low temperature a-IGZO TFTs were fabricated successfully on plastic substrates at 220°C. The flexible reliability of a-IGZO TFTs is investigated. For a-IGZO TFTs application in flexible display, it suffers not only electrical stress but also mechanical stress. It is found that both of them would affect the electrical characteristic of a-IGZO TFTs.

For the first time, we report a novel application of IGZO transformation to conductor, as an electrically programmable non-volatile memory. The transformation is performed by Joule heating of the channel. A very wide read window and excellent retention are demonstrated. This memory is fully compatible with standard IGZO TFT process.

Microscopic structures of a-In-Ga-Zn-O was studied using S/TEM. To avoid crystallization, samples were measured without any thinning and processing, and low electron-beam voltage/current were employed. It was confirmed that all the a-IGZO films were amorphous irrespective of hydrogen content. Instead, crystallization was observed when the probe electron dose was increased.
Oxide TFT

13:30 - 14:55 Main Hall B

AMD3: Oxide TFT: Reliability (1)

Chair: B. D. Ahn, Samsung Display, Korea
Co-Chair: H. Hamada, Kinki Univ., Japan

AMD3 - 1: Invited Photo-Bias Instability of Metal Oxide Thin Film Transistors for Next Generation Active Matrix Display
J. K. Jeong, J. H. Song
Inha Univ., Korea

Degradation mechanisms of oxide TFTs under the negative bias illumination stress were discussed including the trapping of photo-created hole carriers, the ionization of oxygen vacancy defect and the ambient atmosphere interaction. Based on the proposed mechanisms, the routes to improve the photo-stability of oxide TFTs were proposed.

AMD3 - 2: Influence of Charge Trapping on Hysteresis in InGaZnO Thin-Film Transistors under Negative Bias and Illumination Stress
M. P. Hung, D. Wang, J. Jiang, M. Furuta
Kochi Univ. of Tech., Japan

Double-sweeping mode and positive gate pulse mode were used to investigate the origin of NBIS induced hysteresis in InGaZnO thin-film transistors (IGZO TFTs). The electrons trapping in an ES bulk, holes trapping in a GI, and defect generation in channel were dominant mechanism of instability of IGZO TFT under NBIS.

AMD3 - 3: The Negative-Bias-Illumination-Stress with Channel Length Dependence in a-IGZO TFTs
J. G. Um, S. H. Park, J. U. Han, J. Jang
Kyung Hee Univ., Korea

We investigated the negative-bias-illumination-stress (NBIS) according to channel length modulation in amorphous indium gallium zinc oxide (a-IGZO) thin-film transistors (TFTs). In this result, we obviously found that in the case of longer channel TFT, the $\Delta V_{TH}$ had shown very smaller shift than shorter channel length TFT.

AMD3 - 4: Photo-Response Elimination of Amorphous InGaZnO Thin Film Transistors by Introducing a Mo-doped-ZnO Passivation Layer
Y.-C. Tsai, M.-Y. Tsai, L.-F. Teng, P.-T. Liu, H.-P. D. Shieh
Nat. Chiao Tung Univ., Taiwan

A Mo-doped ZnO (MZO) with a bandgap $\sim 3.3$ eV is adopted to eliminate the wavelength-dependent photo-responses in a-IGZO TFTs. The MZO passivated a-IGZO TFTs presents $\Delta V_{in}$ less than 1 V under NBIS while the wavelength varied from 360 nm to 620 nm, whereas the unpassivated a-IGZO TFTs exhibits $\Delta V_{in}$ around -10 V.

----- Break -----
AMD4: Oxide TFT: Reliability (2)

Chair: J. K. Jeong, Inha Univ., Korea
Co-Chair: H. Kumomi, Tokyo Inst. of Tech., Japan

AMD4 - 1: Invited Stability of Oxide TFTs
15:10  J. Jang, M. Mativenga, J. G. Um, M. D. H. Chowdhury
Kyung Hee Univ., Korea

This paper reviews the electrical instabilities of oxide TFTs under various stress conditions such as PBS, NBS, NBIS, PBTS, and high-current-stress (HCS). Degradation mechanisms explaining experimental results are provided. Stability improvement methods, both process-related and device structure-related, are proposed and evidence supporting their feasibility is provided.

AMD4 - 2: Invited Enhancement of a-IGZO Oxide TFT
15:35  Performance by Novel Method Including Ultraviolet and Thermal Annealing
B. D. Ahn*, Y. J. Tak* **, H. J. Kim**
*Samsung Display, Korea
**Yonsei Univ., Korea

We proposed the novel method for enhancement of a-IGZO oxide TFT performance by ultraviolet and thermal annealing (UVA) treatment and compared its properties to that of a conventional thermal annealing. Our UVA-treated TFT had a higher field-effect mobility and positive bias-stress stability than those of conventional thermal annealing.

AMD4 - 3  Effect of Back Channel on the Characteristics of Solution-Derived Amorphous InZnO Thin-Film Transistors
16:00  Y. Osada, Y. Ishikawa, L. Lu, Y. Uraoka
Nara Inst. of S&T, Japan

We investigated the channel layer thickness dependence on the performance of amorphous InZnO thin-film transistor fabricated by spin-coating process. Decreasing the channel layer thickness improved the on-current and the field effect mobility, significantly. These phenomena can be explained by the back channel effect.

AMD4 - 4  Fabrication and Electrical Properties of Highly Stable Amorphous InGaZnO Thin-Film Transistors
16:20  P.-L. Chen, C.-L. Chiang, Y.-L. Chou, S. Li, Y.-F. Liu, Q. Shang
Shenzhen China Star Optoelect. Tech., China

We have improved the storage stability, gate bias stress stability, and thermal stability of a-IGZO TFTs by tuning the ESL quality. The a-IGZO TFTs with the high-quality ESL exhibit excellent electric properties and stabilities. A 120 Hz 32-in. UHD resolution TV panel has been developed by using the a-IGZO TFTs.
Thursday December 5

16:50 - 18:10 Main Hall B

AMD5: Oxide TFT: Modeling & Devices

Chair: J. Jang, Kyung Hee Univ., Korea
Co-Chair: K. Takatori, NLT Techs., Japan

AMD5 - 1: Invited Modeling of Transparent Amorphous Oxide Semiconductor Thin-Film Transistor
16:50
K. Abe, H. Kumomi, T. Kamiya, H. Hosono
Tokyo Inst. of Tech., Japan

We review operation models for transparent amorphous oxide semiconductor thin-film transistors (TAOS TFTs). After introducing previous model, a model considering a carrier-density-dependent mobility and subgap states of TAOS is explained. It reproduces the TFT characteristics over a wide temperature range, and is applied to extract annealing effect of subgap states.

AMD5 - 2
17:15
Solution-Processed Metal Oxide TFTs for AMOLED Applications
AU Optronics, Taiwan

Oxide TFT driving OLED was so popular due to its high mobility and perfect stability and uniformity. With solution manufacture, it is capable to replace the vacuum system and achieve the mask-less process. In this paper, we introduced the solution type metal oxide manufacture for 4-in. OLED.

AMD5 - 3
17:35
A High Mobility Metal Oxide Thin Film Transistor with Solution Coating Process
Evonik Inds., Germany

We fabricate solution-processed metal oxide TFTs with Evonik-developed metal oxide based semiconductor and passivation. The solution material/coating technology can be easily scaled up to larger substrate size without influencing device homogeneity and performance. With high mobility of 20 cm²/Vs, solution-processed TFT is capable for AMOLED driving, high resolution and other high-end applications.
The thermal annealing effect of amorphous InGaZnO (a-IGZO) semiconductor layer sandwiched between top and bottom SiO₂ layers is investigated. We illustrate the dynamics of inter-diffusion of constituent atoms, especially oxygen, at the IGZO/SiO₂ interfaces for different annealing temperatures and correlate them with TFT device characteristics.

Author Interviews and Demonstrations
18:30 – 19:10

Friday, December 6

9:00 - 12:00 Main Hall C
Poster FMCp: FPD Manufacturing, Materials & Components

FMCp - 15  Effect of Anneal Temperature on Local Structures of In-Ga-Zn-O Films Evaluated by X-ray Absorption Fine Structure Analysis
Kobelco Res. Inst., Japan
Kobe Steel, Japan
"JASRI, Japan

X-ray absorption fine structure analysis was applied to evaluate the effect of anneal temperature on local structure of In-Ga-Zn-O films. It was found that the coordination numbers of oxygen around In and Zn atoms increased with increasing anneal temperature. In contrast, that around Ga atoms varied only slightly with temperature.

FMCp - 16  Withdrawn

FMCp - 24L  Characterization of SiO₂/In-Ga-Zn-O Interface by Hard X-ray Photoelectron Spectroscopy and X-ray Reflectometry
I. Hirosawa, Y. Taniguchi, Y.-T. Cui, H. Oji
"JASRI, Japan
"SPring-8 Service, Japan

Non-destructive investigation on interface structures between SiO₂ and oxide semiconductor In-Ga-Zn-O (IGZO) was performed by X-ray reflectometry and hard X-ray photoelectron spectroscopy (HAXPES), and suggested that chemical reactions forming silicide occurred between SiO₂ and IGZO. HAXPES signals of silicide depended on SiO₂ deposition condition.

----- Lunch -----
### FLX6: Flexible Oxide TFT

**FLX6 - 1L**
**13:30**
**High Performance Top-Gate Oxide TFT on Plastic Substrate for Flexible OLED Displays**


*LG Display, Korea*

Effect of the underlying buffer layer on device performance of self-aligned top-gate oxide TFTs on plastic substrate was investigated. The device performance was affected dramatically by various buffer deposition conditions. We also successfully developed self-aligned top-gate oxide TFTs on plastic substrate using optimized buffer deposition conditions.

**FLX6 - 2L**
**13:45**
**Evaluation of Two Flexible Substrate Technologies by Low Temperature (200°C) IGZO TFT Process**


*Tianma Micro-Elect. Group, China
"Shanghai Univ., China*

IGZO TFT array was fabricated on a Ployimide (PI) flexible substrate at 200°C. Two methods of laminating the PI substrate on carrier glass plate have been examined. This paper demonstrated and analyzed the TFT device performances in terms of the two different lamination methods.

**FLX6 - 3L**
**14:00**
**Low-Temperature IGZO TFT Backplane and Its Application in Flexible AMOLED Displays on Ultrathin Polymer Films**


*Holst Ctr., the Netherlands
"imec, Belgium
**Panasonic, Japan
***Victrex Polymer Solutions, UK*

We present a low-temperature metal oxide transistor backplane technology using PECVD dielectrics. We show successful integration of the backplane in flexible 200 ppi AMOLED displays on ultrathin polymer films. The displays are encapsulated with a thin-film barrier and the total stack thickness is less than 150 µm.
Special Topics of Interest on Augmented Reality and Virtual Reality

Wednesday, December 4

13:40 - 16:40 Main Hall C
Poster VHFp1: Applied Vision and Human Factors (AR)

VHFp1 - 1 A Cognitive Model for Fast Recognition in Images Displayed by Automotive Augmented Interface Systems
H. Hasegawa, S. Yano, S. Okabayashi, T. Wake*
Meijo Univ., Japan
*Kanagawa Univ., Japan

We have proposed and verified a new cognitive model, called “Mental Expansion”, to explain the superiority of automotive Augmented Reality Interface Systems (ARIS) incorporating AR technologies, over other automotive display systems based on visual optical experiments.

14:00 - 15:00 Mid-sized Hall B
PRJ1: Projection AR

Chair: D. Cuypers, imec, Belgium
Co-Chair: S. Shikama, Setsunan Univ., Japan

PRJ1 - 1: Invited Wearable Communication Device Leads the Future of Optical Technology
14:00
M. Takaso, K. Suzuki, T. Iguchi
Telepathy, USA

The evolution of computing has been occurring in changes in the actual display and how the user can interface with and communicate. Telepathy has been targeting to be the first wearable communication device, and optics out of all the technologies supporting Telepathy, will make it possible to be the one.

PRJ1 - 2: Invited Projector-Based Augmented Reality in Medicine
14:20
T. Nakaguchi
Chiba Univ., Japan

Although laparoscopic surgery has substantial merits for patients, it makes the surgical procedure much difficult and gives large burden on physicians. Since 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.
Projection mapping is getting a big boom around the world. And most big mapping events use over 20,000 lumen, Xenon lamp based Christie projectors. Automatic color management tools, warping and blending functions, and product reliability, etc. are assessed by well-known mapping designers. Describe the current projection mapping technology and projector features for projection mapping.

----- Break -----
We propose a cartoon-character costume. The costume equips a web camera and display panel. The system of the costume is able to change facial expressions and looks freely. The actor wearing the costume is able to play more than one role in the costume of one body.

Author Interviews and Demonstrations
17:20 – 18:00

Thursday, December 5

9:00 - 10:15 Mid-sized Hall B

3D1: Practical 3D Systems

Chair: J.-Y. Son, Konyang Univ., Korea
Co-Chair: S. Yano, Shimane Univ., Japan

3D1 - 1: Invited 3DTV Broadcasting Technologies, Trials, and Standardization Effort in Korea
9:00
J. Kim, S. Cho, S.-H. Kim, J. S. Choi
ETRI, Korea

In this paper, recent efforts on development of various 3DTV broadcasting technologies, field trials and standardization from Korea will be presented. Some technical details of different schemes are explained, followed by current status and future prospect.

3D1 - 2 A Service Compatible 3DTV Broadcasting System Based on MPEG-2 and HEVC
9:20
ETRI, Korea

We propose a service-compatible 3DTV system which consists of 3DTV encoder using MPEG-2 and HEVC, auto-synchronizing 3DTV multiplexer and 3DTV receiver. We verify in this paper that the proposed 3DTV system guarantees higher video qualities of HDTV as well as 3DTV than those of the current 3DTV system using AVC/H.264.

3D1 - 3 Stereoscopic Display System with Integrated Motion Parallax
9:40
M. F. Flynn, J. C. Tu
zSpace, USA

We present a description of a time sequential stereoscopic display which separates the images using a segmented polarization switch and passive eyewear. Additionally, integrated tracking cameras and an SDK on the host PC allow us to implement motion parallax in real time.
This paper discusses the integration of the inpainting algorithm with the virtualized-reality indoor modeler. Embedding of the texture and structure preservable inpainting method with the virtualized-reality indoor modeler makes the whole system interactive and intuitive.

No clinical procedure is performed without computational support in modern hospitals. The Augmented Reality (AR) is expected as the silver bullet for the problems happens among computerized clinics. This lecture surveys on-going medical AR trials and forecasts how AR changes our social medical system in the near future.

In cross-modal interactions, our perception through one sense is changed by stimuli simultaneously received through other senses. By utilizing this, we can provide people to multi-modal experience with limited sensory feedbacks. In this paper, I introduce examples of perception-based displays augment our experience by using cross-modal interactions and augmented reality.
Invited  Blue Light Matters: The Eye Is a Camera and a Clock!

K. Tsubota
Keio Univ., Japan

Energy-efficient blue LED lights and visual display terminals proliferate nowadays. Two concerns of blue light are potential retinal damage leading to age-related macular degeneration and circadian rhythm disruption from exposure at night. Appropriate intervention for eye protection is necessary for the long-term healthy incorporation of blue light into modern society.

Effectiveness of Freehand Modeling by BlueGrotto for CSCW in VR Space

T. Oyoshi, Y. Miwa, N. Shichijo, S. Saga
Muroran Inst. of Tech., Japan

This paper discusses the effectiveness of the implementation of the freehand modeling interface of BlueGrotto in CSCW systems using immersive VR environments. A demonstration shows that the interface naturally reinforces the mutual communications among the users without making them take the trouble to use additional communications tools.

All authors of poster papers for the DESp session will give a brief, 3-minute oral presentation with no discussion time in advance.

Position and Direction Estimation System of User’s Viewpoint for Wide Indoor Environment

M. Kanbara
Nara Inst. of S&T, Japan

This paper introduces real-time viewpoint estimation system with invisible markers for wide indoor area. The system can estimate the position and direction of user's viewpoint precisely by affixing wallpapers containing printed invisible markers on ceilings. This system can be applied to augmented reality, view depended display or human robot interaction.
We conducted two experiments to compare binocular and monocular observations when an Augmented Reality image was presented during a useful field of view (UFOV) task. We found the detection of a luminance change in the peripheral field of view was more difficult under binocular AR observation than under monocular observation.

This paper summarizes our research project, e-Heritage, to digitize cultural heritage assets over the world. We also propose cyber archaeology that provides new findings based on the digital analysis on those data. e-Heritage data is uploaded to cloud as well as archeological findings for a comprehensive visualization system.

We propose an eyeglass-based videophone. The developed glasses have fish-eye cameras to capture the wearer’s face and background, and the images are fused to generate a self-portrait image. The system also has a HMD displaying the intended party and enables a video call without holding camera and display devices.
OLEDp1 - 14 OLED Deposition System Using Plane-Source Evaporation Techniques


ITRI, Taiwan

The equipment with plane-type evaporation source for thin film evaporation is proposed. The parallel direct simulation Monte Carlo (DSMC) method is also developed for obtaining large-area uniformity for various organic materials on substrate. The system maintains film thickness non-uniformity of less than ±5% and provides high material utilization of over 70%.

OLEDp1 - 15 High Color Rendition White Organic Light-Emitting Diodes with Excimer and Fluorescent Emitter for Lighting Application

Y. Jiang, Z. Xie*, W.-Y. Wong*, H.-S. Kwok

Hong Kong Univ. of S&T, Hong Kong
Hong Kong Baptist Univ., Hong Kong

A novel Pt based triplet emitter with broadband yellow-red emission, was employed in the fabrication of WOLEDs. This broadband emission was a result of the combined effect of monomer and excimer emission of the Pt compound. By mixing with BCZVBi, a high CRI of 95.6 WOLED was demonstrated.

OLEDp1 - 16 Electroluminescence Improvement of Quantum Dots Light Emitting Diodes through Organic Hole Transport Layer Optimization

M. D. Ho, D. Kim, N. Kim, H. Chae

Sungkyunkwan Univ., Korea

In this research, we investigated improvement of electroluminescence (EL) performance of QD-LED through a composition of organic hole transport materials (polymer and small molecules). Furthermore, the effects of thermal annealing of hole transport layer on the morphology and EL performance of QD-LED were also demonstrated.
Thursday, December 5

9:00 - 12:00 Main Hall C

Poster PHp: Phosphors


N. Fujita, M. Iwao, S. Fujita, M. Ohji
Nippon Elec. Glass, Japan

Phosphor-glass composites, in which phosphors are dispersed, have been developed. The phosphor-glass composites are expected as the excellent wavelength conversion material for high power solid-state lighting, which have high-humidity resistance, long lifetime and extremely small deviation in emission color.

PHp - 16 Double-Layered CuInS$_2$/ZnS Quantum Dot-Polymer Plate-Based High-Color Rendering White Light-Emitting Diode

Hongik Univ., Korea

A free-standing double-layered composite plate, consisting of highly bright orange and greenish-yellow CuInS$_2$ quantum dots (QDs) embedded in polymeric matrix, is combined with a blue light-emitting diode (LED). The QD plate-LED exhibits a high color rendering index of 81 and high luminous efficacy of 71.2 lm/W at 20 mA.

PHp - 17 Silica-Embedded Quantum Dot-Based White LED and Effect of Silica on Device Stability Behavior

Hongik Univ., Korea

Blue-to-yellow light-convertible CuInS$_2$/ZnS quantum dots (QDs) are synthesized and then embedded into silica phase via a microemulsion. Bare and silica-embedded QDs are combined, respectively, with a blue LED for white QD-LED fabrication. These two white QD-LEDs are identically subjected to the continuous operation and compared with respect to device stability.

PHp - 18 Withdrawn

PHp - 19 A Study on Thermal Characteristics for High Power LEDs

S. Park, Y. Kim, G. Kim
Samsung Display, Korea

High-power LED was developed with 17 flip-chips performing 1,500 lumens. A mechanism of heat generation was analyzed and proposed for designing multi-chip LEDs to overcome limitation of 250 degree Celsius on a window in the LED for the application of backlight units.
For improve quantum dots (QDs) thermal stability, we synthesized quantum dot embedded silica (QDES). Moreover applying QDES a white LED (WLED) was fabricated using QDES in thin polymer film. Using remote type packaging system, by stacking yellow phosphor in glass plate and QDES film we implemented WLED with high CRI.

**OLED5: OLED for Lighting Applications**

**16:50 - 18:15 Conference Hall**

Chair: Y. Kijima, Sony, Japan  
Co-Chair: T. Ikuta, JNC Petrochem., Japan

**OLED5 - 1: Invited Recent Progress of OLED Performance for Lighting Application**

16:50  
K. Furukawa, K. Kato, T. Iwasaki  
Konica Minolta, Japan

To compete with LED in general lighting fields, one of the important and insufficient requirements for OLED lighting is the luminous efficacy. Recent progress of OLED performance, especially in phosphorescent materials and light out-coupling technology, will be discussed. In addition the alternative electrode technology to ITO will be touched on.

**OLED5 - 2 Out-Coupling Enhancement of OLEDs with Diffractive Micro Lens Film**

17:15  
Y. Kurita, H. Koshitouge, K. Mizuhara, D. Okuno, T. Tokimitsu  
Mitsubishi Rayon, Japan

A diffractive micro lens alley (MLA) film enhances emission from organic light-emitting diodes (OLEDs). The film had MLA molded on diffraction grating. The film showed superior improvement of out-coupling efficiency, luminous intensity and chromatic stability. The simulation results explained the advances of these films.
We developed a transmissive one-side-emission OLED panel with solid encapsulation and peripheral grid electrode to enhance the transmittance of the whole panel. The transmittance of solid encapsulation was 1.2 times higher than that of cavity encapsulation. As a result, we achieved the high transmittance of ~65% for the whole panel.

**PH3 - 1: Invited New Blue Light Excitable Red-Emitting Phosphate Phosphor**

*K. Toda, S.-W. Kim, T. Ishigaki, T. Hasegawa, K. Uematsu, M. Sato*

Niigata Univ., Japan

A novel red-emitting olivine-structure type phosphor NaMgPO$_4$:Eu$^{2+}$ was synthesized for the first time by the melt synthesis technique. The NaMgPO$_4$:Eu$^{2+}$ phosphor shows red emission band centered at 628 nm under blue light excitation. The internal quantum efficiency of this phosphor at the excitation wavelength of 450 nm was 81%.

**PH3 - 2 Synthesis and Luminescence Characterizations of New Thiosilicates Phosphors for LED Lighting**

*S.-P. Lee, T.-M. Chen, C.-H. Huang*, T. S. Chan**

Nat. Chiao Tung Univ., Taiwan

*TTRI, Taiwan*

**Nat. Synchrotron Radiation Res. Ctr., Taiwan*

Unprecedented M(La$_{1-x}$Ce$_x$)$_2$Si$_2$S$_8$ (M = Ca, Sr, Ba) phosphors were investigated and evaluated for potential application in white-light LEDs. The Ce$^{3+}$-activated thiosilicates can be excited by near-UV to blue light and show green broadband emissions. Recent progress on their luminescence and applications are discussed.
Comparison of ACELs Formed on Copper, Silver and Gold Back Electrodes


Brunel Univ., UK
*Intrinsiq Materials, UK
**Johnson-Matthey, UK
***Printed Elect., UK

AC electroluminescent display panels were prepared by first ink-jet printing electrode structures (either copper, silver or gold) onto substrates, then screen printing first a single binder layer (containing both the ACEL phosphor powder and the barium titanate ferroelectric particles) before finally overprinting with a transparent conducting electrode.

9:00 - 12:00 Main Hall C

Poster FMCp: FPD Manufacturing, Materials & Components

FMCp - 18 Designing of Side Emitting Lens for Slim Direct LED Back Light Unit

S. Park, J. Seo, G. Kim
Samsung Display, Korea

The light extraction efficiency of side emitting lens was simulated. The amount of light reaching the bottom and side detectors of LUXEON was 52.62%. We developed a new design lens with an extraction efficiency of 81.13%, thereby improving the performance by 154% compared to that of LUXEON.

FMCp - 19 Fiber Optic Illuminator Using Recycling Light Technology for Signage Applications

K. Li
Wavien, USA

A single color and a multi-color fiber optic illumination system using single white LED and RGBW LEDs respectively, powered by Wavien’s Recycling Light Technology (RLT) systems will be described. The multi-color system will open up many applications where this capability is not available using neon tubes or linear LED arrays.

FMCp - 20 Efficient LED Hard Edge Spot Light Using Recycling Light Technology

K. Li
Wavien, USA

A hard-edge LED spot light for PAR and MR lamps using Wavien RLT technology are described. These TruSpot LED spot light also accept GOBO image slides so that it can be used to project advertising images. The RLT technology allows up to 280% improvement in brightness over standard optical configurations.
FMCp - 21  The Design of High Efficiency Light-Guide Plate with Multi Step Wedge Structure
Y. W. Chang
AU Optronics, Taiwan

We successfully release a multi steps wedge design which is better than AUO published in 2012. According to our research, we divide the wedge structure into two parts due to different functions. We do improve the wedge structure to be processed more easily, better performance and more stable.

FMCp - 22  Surface Diffusing System LCDs with Small Viewing Angle Dependence of Contrast Ratio and Color Shift
N. Munemura, D. Sekine, A. Tagaya, Y. Koike
Keio Univ., Japan

We fabricated the scattering film to realize wide luminance angular distribution liquid crystal display with surface diffusing system based on the novel multiple light scattering simulation. With this scattering film, we demonstrated the surface diffusing system liquid crystal display with small viewing angle dependence of contrast ratio and color shift.

FMCp - 23  Thin Seamless LED Flat Lighting Panel Using Highly Scattered Optical Transmission Polymer
K. Mochizuki, K. Sakurai, T. Iwamoto, K. Oosumi, Y. Shinohara, A. Tagaya*, Y. Koike*
Nitto Kogaku, Japan
*Keio Univ., Japan

We have developed a thin seamless LED flat lighting panel (Seamless Panel) using a highly scattered optical transmission polymer. The Seamless Panels can be connected without showing seams on the lighting surface. The Seamless Panel gives more flexibility to design various illumination systems.

FMC8: Lighting Technologies
Chair: K. Käläntär, Global Optical Solutions, Japan
Co-Chair: Y. Yang, Japan Display, Japan

FMC8 - 1  Quantum Dot Enhancement of Color for LCD Systems
13:30  J. V. Derlofske, G. Benoit, A. Lathrop, D. Lamb
3M, USA

Quantum dot technology promises to significantly extend the color gamut of liquid crystal displays (LCDs). Used in a film format, quantum dots can produce large color gamuts (>96% NTSC) with high efficiency. This paper discusses how quantum dots are incorporated into an LCD system and the factors that dictate performance.
### Monday, December 6

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**Author Interviews and Demonstrations**

16:40 – 17:20
Workshop on LC Science and Technologies

Wednesday, December 4

14:00 - 15:00 Mid-sized Hall A

LCT1: Keynote & Special Session (1)

Chair: H. Okada, Univ. of Toyama, Japan
Co-Chair: M. Ozaki, Osaka Univ., Japan

LCT1 - 1: Invited TFT-LCD Manufacturing Technology; Current Status and Future Prospects
14:00
Y. Ukai
Ukai Display Device Inst., Japan

Current status and future prospects in the thin-film-transistor liquid crystal display (TFT-LCD) manufacturing technology are reviewed. Amorphous Si (a-Si), low temperature poly-Si (LTPS) and metal oxide TFT-LCDs are discussed in this paper. Future trends in TFT-LCD manufacturing technologies are described in terms of green manufacturing and in-cell integration technologies.

LCT1 - 2: Invited IGZO Technology for the Innovative LCD
14:35
Sharp, Japan
*Semiconductor Energy Lab., Japan
**Advanced Film Device, Japan

We developed the IGZO technology for the innovative LCD panels. IGZO-TFT can realize lower power consumption and higher touch panel performance than a-Si TFT. IGZO technology has been successfully applied to our Gen 8 factory. We developed high performance LCDs with IGZO technology from mobile devices to large sized monitors.

----- Break -----
LCT2: Special Session (2)

Chair: Y. Ukai, Ukai Display Device Inst., Japan
Co-Chair: T. Ishinabe, Tohoku Univ., Japan

LCT2 - 1: Invited Recent LC Material’s Development and Its Challenge toward Future
15:40 K. Tarumi
Merck KGaA, Germany

Liquid Crystal Display (LCD) development is a big success story that begun by note PC application in 1990s and has been followed by monitor and TV application. This development story is reviewed by LC materials development of TN, IPS/FFS, VA and PS-VA.

LCT2 - 2: Invited Past, Present, and Future of FFS-LCD
16:05 S. H. Lee, I. W. Jang, D. H. Kim
Chonbuk Nat. Univ., Korea

Fringe-field switching (FFS) mode becomes a symbol of high performance LCD technology. The talk discusses how the technology was developed and how it was evolved to present and what will be future of the FFS mode in terms of performance and technologies.

LCT2 - 3L: Invited High Performance IPS Technology Suitable for High Resolution LCDs
16:30 K. Ono, H. Matsukawa
Panasonic Liquid Crystal Display, Japan

Transmittance of an IPS panel has been drastically evolved by introducing a new pixel structure having a shielding transparent common electrode. Furthermore, picture quality has been improved by developing a low scattering LC material and photo alignment technology.

Author Interviews and Demonstrations
17:20 – 18:00

Evening Get-Together with Wine
Tuesday, December 3, 2013
18:00 – 20:00
at Restaurant Sora (1F), Sapporo Convention Center
(Sponsored by Merck Ltd., Japan)
See page 12 for details
We have developed a “novel super fast response (SFR) mode with ultra-wide temperature range.” SFR shows super fast response by forcibly controlling the alignment of LC molecules. We will explain the reason why the response of the SFR mode is much faster than the conventional mode.

We have developed a new driving scheme and bidirectional field switching (BFS) LC mode for fast nematic LC switching. The advantage of the BFS mode is submillisecond response time achieved both for LC switching-on and switching-off processes. That was achieved by excluding the field-off viscous-elastic relaxation stage of LC molecules.

A reflective field sequential color display with electrically suppressed helix ferroelectric liquid crystal is proposed. The ultra fast response time enables this display cell to drive at very fast frequency with low electric field. This reflective display cell can be used in projection displays and micro displays.

A viewing angle control technology based on a 3-electrode FFS mode design is proposed. In narrow viewing mode, it provides a privacy protection function with the special driving scheme. To further enhance the privacy protection performance, the unbalanced domain design concept is proposed and verified by simulation.
### LCT4: LC Materials

**Chair:** K. Tarumi, Merck KGaA, Germany  
**Co-Chair:** S. Komura, Japan Display, Japan

**LCT4 - 1**  
**Temperature-Independent Hole Mobility in an Ordered Smectic Phase of Phenylterthiophene Derivative and a Columnar Phase of Perylene Tetracarboxylic Bisimide Derivatives**  
**M. Funahashi, Y. Funatsu, T. Ishii, A. Sonoda**  
*Kagawa Univ., Japan  
*AIST, Japan*

In this study, the hole transport characteristic in the ordered smectic phase of a 2-phenylterthiophene derivative is compared to the electron transport property in an ordered columnar phase of perylene tetracarboxylic bisimide derivative bearing disiloxane chains. The carrier transport mechanisms are different between the smectic and columnar phases.

**LCT4 - 2**  
**A New Patterning Technology with Polymerizable LCs**  
*FUJIFILM, Japan*

We have developed a new film patterned retarder of vertically aligned polymerizable discotic materials (VPDM) for passive 3D-LCDs. The direction of VPDM slow-axis can be switched from perpendicular to parallel to the rubbing direction by a single non-polarized UV exposure onto alignment layer containing a photo-reactive additive.

**LCT4 - 3**  
**Comparison of Surface Characteristics on Rubbed Polyimide by Rubbing Condition with NEXAFS**  
*LG Display, Korea  
Pohang Accelerator Lab., Korea*

We studied the surface characteristics of polyimide (PI) under various rubbing condition using near-edge X-ray absorption fine structure (NEXAFS) and difference speedy measurement by polarization conversion (difference-SMP) methods. As increasing the contact impression, the molecular tilt angle $\alpha$ and anisotropy decreased linearly. The stage speed dependency was not apparent.
LCT4 - 4  Study of Polymer Bump Morphology in PS-VA LCD
11:40

X. Ma, X. Zhong, H. J. Huang, K.-C. Lee
Shenzhen China Star Optoelect. Tech., China

Several factors which influence bump morphologies in PS-VA LCD were studied. Results show that bump morphologies are strongly dependent on RM type, cell gap and UV condition. LC host can also influence the bump morphologies, which means all these factors should be taken care carefully to get good optical performance.

----- Lunch ----- 

Author Interviews and Demonstrations
18:30 – 19:10

14:50 - 17:50 Main Hall C

Poster LCTp1: LC Alignment

LCTp1 - 1  Alignment and Alignment Transition of BC Nematics

O. Elamain, G. Hegde*, L. Komitov
Univ. of Gothenburg, Sweden
*Univ. Malaysia Pahang, Malaysia

Polyimide material for vertical alignment was found to promote only planar alignment of a bent core nematic and of its mixtures with calamitic (with rod like molecules) nematic. Temperature driven transition from planar to vertical alignment was found in the mixtures at higher concentrations of the calamitic nematic than 20wt%.

LCTp1 - 2  LC Alignment on Zinc Oxide Nanostructure Surfaces

M.-Z. Chen, W.-S. Chen, S.-H. Yang, Y.-F. Chung, S.-C. Jeng
Nat. Chiao Tung Univ., Taiwan

ZnO is an inorganic material and it can provide more reliable alignment than conventional polyimide alignment layers especially used in LC projection displays. In this work, nanostructure surfaces of the ZnO nanowire arrays on the ITO glass substrate were fabricated and the vertically-aligned property was observed.

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RECEPTION

Wednesday, December 4, 2013
18:30 – 20:30
Conference Hall (1F)
Sapporo Convention Center
See page 12 for details
Using liquid crystalline (LC) dendrimers, a vertical alignment mode drive operated without using polyimide alignment layer. Various LC cells using different LC dendrimers and substrates were prepared to explore effects of the dendrimers and substrates on the cell properties. Electro-optical behavior was confirmed for the cells with polymer substrates.

**LCTp1 - 4 The Establishment of UV Curing Polymerization Model for Polymer-Stabilized Vertical Alignment LCDs**

Y. Song, F. Zhao, C.-C. Hsieh, C.-Y. Chiu

Shenzhen China Star Optoelect. Tech., China

We established a semi quantitative polymerization model for PS-VA analysis. The UV irritating conditions such as wavelength and exposure time are combined to a variable quantity named as effective UV dosage. It reveals the mechanism of polymerization process and directly link to response time of LC.

**LCTp1 - 5 Withdrawn**

**LCTp1 - 6 Monte Carlo Simulation for Molecular Orientation in Mixture of LC and Dendrimers Using Hard Repulsive Model Molecules**


Yamagata Univ., Japan

*LG Display, Korea

**LCTp1 - 7 Cylindrical LC Lens by Photoalignment with Spatially Variable Pretilt Angle**


Hong Kong Univ. of S&T, Hong Kong

In present article, cylindrical LC lens is made with photoalignment material with controllable pretilt angle. The pretilt angles of the photoalignment material can be controlled continuously from planar to vertical alignment with increasing of UV exposure. The LC lens is made with spatially variable exposure energy on the alignment layer.
LCTp1 - 9  Enhancement of an Azimuthal Anchoring Energy in a Photo-Alignment Layer by Stacking Planar Alignment Layer

Hanyang Univ., Korea

We propose a method to enhance an azimuthal anchoring energy by stacking photo-alignment layer onto a planar alignment layer. The exposure of LPUV to the stacked alignment layers gave rise to the strong azimuthal anchoring energy. As a result, we achieved the fast response time characteristics in the FFS mode.

LCTp1 - 10  Photo-Addressable Bistable LCD

Nat. Sun Yat-Sen Univ., Taiwan

A photo-addressable bistable reflective display which is based on an azo dye-doped liquid crystal has been proposed and demonstrated. Bistable bright and dark states can be achieved by switching between the 45° twisted nematic and photo-induced isotropic states via photoisomerization effect.

LCTp1 - 11  Study of Electro-Optical Properties of LC/Reactive Mesogen Coated LCD Fabricated by Slit Coater

Nagaoka Univ. of Tech., Japan
*Toray Eng., Japan

We recently proposed a slit coater method for printable liquid crystal (LC) devices. In this study, we will present the effect of the ultraviolet (UV) exposure dosage on the electro-optical (EO) properties, the pretilt angle, and the azimuthal anchoring energy of LC sample cells fabricated by the slit coater method.

LCTp1 - 12L  Electro-Optical Properties of Unconventional Subphases Between Ferroelectric and Antiferroelectric LC

K. Isobe, K. Ishikawa
Tokyo Inst. of Tech., Japan

Electro-optical properties of unconventional subphases emerging between ferroelectric SmC∗ and antiferroelectric SmC∗ are studied. These subphases change their structures continuously depending on temperature and are expected to show anomalous electro-optical responses. The details of their response with their structures are discussed.
We observed the very fast response (both the rise and decay time were about 200 $\mu$s) using homeotropic cell applying the voltage along the LC molecular long axis under the oblique incident light. We confirmed the cause of this phenomenon was due to the LC molecules at the alignment surface.

14:50 - 17:50 Main Hall C

Poster LCTp2: Evaluation

LCTp2 - 1 Image Sticking Characteristic of Additive Blended LCD
LG Display, Korea

We have found out that the LC material is one of the main factors related to image sticking. We applied an additive blended with the LC to lower the level of image sticking. The additive blended LC showed outstanding performance in the image sticking test under stable electro-optic conditions.

LCTp2 - 2 Azimuthal Anchoring Energy of NLC on the Alignment Film Formed by Time Division Electro-Spray Deposition Method
Y. Kudoh, Y. Uchida, T. Takahashi
Kogakuin Univ., Japan

The ESD method is one of the film forming methods. The pre-tilt angle was controlled by using the improved ESD method has been proposed by our previous report. In this report, the azimuthal surface anchoring energy for the nematic LC on the film formed by that method was measured.

LCTp2 - 3 Improving Color Mix of High PPI LCD
Y. Feng, J. Lim, J. Zhang, N. Jiang, B. Shi
BOE Optoelect. Tech., China

Color mix is a serious problem in high ppi (pixel per inch) TFT-LCD product (include a-Si and LTPS). In this paper, we optimize structure and material characteristic by calculation and simulation to improve quality of LCD. Then color mix is better.
The Flexoelectric Effect Influence of Image Sticking in FFS Mode LCD

K.-T. Huang, Y.-W. Hung, R.-X. Fang, Y.-T. Chao, T. Lee, C. Lee, S.-C. Lin, C.-H. Yu
HannStar Display, Taiwan

Image Sticking is one of critical issue in TFT-LCD. In this paper, we discuss the influence of image sticking due to flexoelectric effect of LC in Fringe-Field Switch (FFS) mode LCD. Image sticking level will be serious if the flexoelectric effect is not be concerned in usual LCD module driving method.

Optical Evaluation of Two Type Omniwide Film

Y. K. Li, D. L. Fu, X. Huang
Infovision Optoelect., China

We have evaluated two types Omniwide film on a TN LCD module. Both of the two types O-film can improve Gray-Scale-Inversion degree from 14° to 85°, and of course the O-film will have an effect on other optical properties, such as transmittance, contrast ratio, view angle, NTSC, chromaticity etc.

Methods to Improve Contrast Ratio of LCD Under Low Temperature

F. Lin, X. Huang, Y.-J. Tang, S. Li, J.-D. Liao
Infovision Optoelect., China

We fabricated a 3.47-in. cell and applied several methods to improve the contrast ratio at low temperature. CR attenuation ratio is 37.6% with faster response LC monomer. If we increase Vgh or Vdata, CR attenuation will be 21.0%. Lessen the charging frequency from 60 Hz to 50 Hz, CR decreases about 26.9%.

The Reason of COG Mura in TFT-LCD to Explore

BOE Optoelec. Tech., China

COG Mura take place at the edge of glass where IC bonded on. The main cause is that glass warp when IC bonded on panel which make light from BLU transmit out. Panel deformation make cell gap and twist angle change little which is not the main reason.

DC Effect to VT Data of the ADS Mode

X. Xi, X. Zhou, C. Xie, J. You
BOE Tech. Group, China

To improve the image sticking of the ADS (Advanced Dimensional Switch) mode, we studied the DC bias effect to V-T (Voltage-Transmittance) and we found the optimal method to balance of positive and negative voltage in pixel.
LCTp2 - 9L  Analysis of Vertical Crosstalk Phenomenon in Fringe Field Switching Liquid Crystal Display

AU Optronics, Taiwan

In this paper, we show that the vertical crosstalk of FFS has strong azimuthal dependence in the oblique view. By DIMOS.2D simulation, we find that the phenomenon is due to the tilt deformation of LC director. Moreover, we demonstrate that the negative dielectric anisotropy LCs can sufficiently suppress this issue.

14:50 - 17:50  Main Hall C
Poster  LCTp3: Display Mode

LCTp3 - 1  Optical Compensation of Fringe Field Switching Display with Negative Dielectric Anisotropy LCs

Infovision Optoelect., China

A zero-retardation film compensated the negative FFS mode is proposed to widen viewing angle, lower light leakage at dark state and color difference. And the simulation and experimental results indicated that using the zero-retardation compensation film can reach almost the same perfect compensation effect with ±B plates.

LCTp3 - 2  An Analytical Model for 3-Electrode FFS Mode LCD

AU Optronics, Taiwan

We propose an analytical model for 3-electrode FFS mode in viewing angle switchable LCD. In this paper, the compensated pixel-electrode voltage from the proposed analytic model can effectively reduce the on-axis light leakage to improve the image quality.

LCTp3 - 3  Optimize Cell Parameters Design of IPS

B. Bai, S. N. Zhang, Z. H. Li, P. Liao
Infovision Optoelect., China

IPS display mode with its excellent image quality become a TFT-LCD ideal display technology. Response time, contrast ratio and color shift are very important factors to judge image quality. We analyzed these factors which influence image quality by simulated with Techwiz LCD software. Get the optima values of cell parameters.
LCTp3 - 4 High Aperture VA-LCD with CGL Pixel Design  
S.-H. Lo, B. Han, S.-S. Huang, M.-H. Shih, C.-H. Chen  
Shenzhen China Star Optoelect. Tech., China

We purpose a VA LCD with CGL (Central Gate Line) pixel. The cell transmittance is improved. In result, triple gate CGL pixel with gate double side driving by gate driver circuit on array is more economic, and the aperture become more efficient and realize BM less structure.

LCTp3 - 5 A Novel Transparent Color LCD Using Azobenzene Dye Layer  
Dong-A Univ., Korea  
*LG Display, Korea

We proposed a guest-host type transparent liquid crystal (LC) display using a dichroic dye color filter (DDCF) with single layer. This device with dark, color and transparent mode can show good optical performance. As measured results, we confirmed the excellent light efficiency and high contrast ratio (~357:1) in transparent mode.

LCTp3 - 6 Advanced Full Color Cholesteric LCD in a Single-Layered Configuration by Pixel Isolation  
K. S. Shim, S. I. Jo, J. H. Han, J.-H. Kim, C.-J. Yu  
Hanyang Univ., Korea

We demonstrate a full color cholesteric liquid crystal display (ChLCD) with uniform color performance in a single-layered configuration through the pixel isolation. Each pixel was formed by the photo-polymerization at different temperatures. From avoiding the inter-pixel diffusion of monomers, we achieved the full color ChLCD with the well-defined pixels.

LCTp3 - 7 Electro-Optical Characteristics of Metastable TN-LCDs with Different Pretilt Angles  
M. Akimoto, M. Sannomiya, K. Takatoh, S. Kobayashi  
Tokyo Univ. of Sci. Yamaguchi, Japan

We study pretilt angle dependence of electro-optical characteristics of various metastable TN-LCDs, mainly focusing on the RTN-LCDs. We found that there are both upper and lower bounds on pretilt angle for operative RTN-LCDs. When giving more lowered pretilt angles, we obtain a metastable STN-LCD which shows unconventional electro-optical characteristics.
LCTp3 - 8L Pixel Structure Optimized to Improve Black Line of Fringe Field Switching LCD
B. Shi, F. Yang, J. Lim, J. Zhang, Y. Feng
Chengdu BOE Optoelect. Tech., China

For Fringe Field Switching (FFS) LCD mode, Black line appears easily, especially at the pixel’s short side, which leads to low transmittance. In this paper, we optimize pixel structure in several ways. Last, black line improve and the transmittance increase.

LCTp3 - 9L Optical Compensation Using Uniaxial Films with Normal Dispersion for a Wide-Viewing-Angle IPS LCD
Pusan Nat. Univ., Korea
*Chonbuk Nat. Univ., Korea

We propose an achromatic optical compensation method using uniaxial films to eliminate the off-axis light leakage at the dark state in an IPS LCD. Three uniaxial films with different dispersion characteristics are used so that they can compensate each other to achieve achromatic effective phase retardation at off-axis.

LCTp3 - 10L Fast In-Plane Switching of Negative Liquid Crystals by Crossed Patterned Electrodes
Pusan Nat. Univ., Korea
*Samsung Display, Korea

We demonstrate fast in-plane switching of negative liquid crystals by using crossed patterned electrodes. During the turn-off process, a strong in-plane electric field is applied to the top substrates for a short period of time, by which we obtained experimentally faster turn-off switching than that of conventional IPS mode.

LCTp3 - 11L Optical Compensation of Flexible Plastic-Based LCD for Wide Viewing Angle
T. Ishinabe, A. Sato, H. Fujikake
Tohoku Univ., Japan

Optical compensation of flexible plastic-based LCD was achieved for wide viewing angle. We theoretically confirmed that viewing angle range of flexible LCD can be improved by the optical compensation considering the optical anisotropy of plastic substrates and realized a good contrast ratio of 650:1 and wide viewing angle of 160˚C.
We investigated the origins of viewing angle issues in the single-domain fringe-field-switching (FFS) liquid crystal (LC) mode. To solve the asymmetric viewing properties, the polystyrene (PS) is used as LC alignment layer which has zero pretilt. The anchoring stability could be effectively improved by the polymerized reactive mesogen layer (RM).

We propose a planar polymeric liquid crystal lens with a low cell-gap (~4.6 µm) for a 2D/3D switchable auto-stereoscopic display. This lens allows fast 2D/3D switching and low voltage due to a low cell gap. We verified the electro-optical characteristics of the proposed LC lens by fabricating each layer.

The fast switchable Fresnel zone lens with relatively high efficiency and easy fabrication procedure was studied in this article. As compared with ordinary Fresnel zone plate (FZP), our proposed Fresnel zone lens (see FIG. 1) had double light intensity at the focal point, thus possessed double efficiency of ordinary FZP.

Liquid crystal (LC) device “q-plate” (QP) based on axially symmetric photo-alignment was investigated in this work. The electro-tunable QP device could be modulated to control the shape and polarization of the linearly polarized Gaussian laser beam propagating through it. The simulation results were consistent with the experimental findings.
LCTp4 - 4 Electro-Optic Modulator Based on Nano/Micro-Sized Polymer-Dispersed LC for TFT Array Inspections

J.-Y. Hwang, Y.-N. Hwang, K.-S. Park, J.-H. Kim, C.-J. Yu
Hanyang Univ., Korea

We report a highly sensitive electro-optic modulator with low driving voltage based on the nano/micro-sized polymer-dispersed liquid crystal for TFT array inspector. The light modulator with low dielectric and high birefringence liquid crystals exhibited high defect detection sensitivity and low driving voltage at 20 µm air gap.

LCTp4 - 5 Multi-Level Optical Switch of Diffractive Light from a BCT Photonic Crystal Based on an Azo Component-Doped HPDLC

M.-S. Li, A. Y.-G. Fuh, J.-H. Liu, S.-T. Wu
Nat. Cheng Kung Univ., Taiwan

Multi-level optical switches of diffractive light from a body-centered tetragonal photonic crystal are demonstrated. The sample is fabricated on azo-dye doped polymer-dispersed liquid crystals based two-beam interference with multiple exposures. Bichromatic pumping beams are used to change the refractive index modulation and the intensity of diffractive light.

LCTp4 - 6 Optical Aberration Correction by Polymer Dispersed LC Film

Nat. Changhua Univ. of Education, Taiwan
Nat. Sun Yat-Sen Univ., Taiwan
Nat. Cheng Kung Univ., Taiwan
Cheng Shiu Univ., Taiwan

A distortion aberration (DA) correction device is fabricated with polymer dispersed liquid crystal (PDLC) film placed at the intermediate image plane of the optical system. The DA correction by PDLC film is attributed to the redirection of the off-axis propagated chief ray towards the principal point of the optical system.

LCTp4 - 7 Fabrication of 180-Fold Helix Spiral Phase Plate Based on PDLC

S.-T. Wu, M. S. Li, Y. G. Fuh, Y. H. Huang, C. H. Yan
Nat. Cheng Kung Univ., Taiwan

High-fold-helix spiral phase plates (SPPs) based on polymer-dispersed liquid crystals (PDLCs) are fabricated. The beam profiles of the helical modes emerging from the PDLC SPPs are measured using a laser beam profiler. The beam radius of the principal maximum is linearly proportional to the $\ell$ of the plate.

LCTp4 - 8 Withdrawn
A novel imaging method with a new ChLCD panel structure without patterning electrode is demonstrated. A photo mask instead of electrode pattern was used for creating a more conductive pattern to drive an image on the ChLCD. This discovery creates opportunities for signage and X-ray imaging applications, etc.

A 27-in. TN-LCD applied for monitor was developed. However, an issue named “RA bright spot” happened after reliability test. In this paper, the characteristics of the spot were analyzed. We found the spot disappeared after changing the storage capacitor electrode connected to common electrode signal instead of VDDA signal.

A method including the processes of extraction, blending and purification was developed to recycle the LC from waste LCD panel. The feasibility was evaluated based on the product yield, display performance and reliability test of the 100 pieces of LCD panels filled with the reformulated LC mixture.

We demonstrate a fast switchable Fresnel zone lens based on ferroelectric liquid crystals and multiple planar alignment domains by means of photo-alignment. Two switchable modes, FOCUS/OFF and FOCUS/DEFOCUS, of the FLCFZL have been constructed. The proposed diffracting element provides fast response time, high diffraction efficiency and simple fabrication.
The study reports that isothermal phase transition and induced by photoisomerization of azobenzene liquid crystals (azo-LCs) from trans- to cis-isomers results in the dissolution of poly(N-vinylcarbazole) (PVK) into azo-LCs. All-optically controllable and highly efficient scattering mode light modulators based on PVK films and its re-form mechanism were demonstrated.

We propose an optical switch using dye-doped chiral nematic liquid crystals. The proposed device is switchable between the transparent and black states. We expect that the proposed device can increase the visibility of a transparent OLED display by positioning it at the rear side of a transparent OLED display.

Reverse mode liquid crystal cells using reactive mesogen have been proposed. A cell thickness dependence on an electro optical property is studied in the cell with different materials and UV exposure conditions. The optical property in a scattering state is different from that of typical normal mode cell.

We have proposed a reverse mode liquid crystal LC cell with hybrid orientation for a daylight control window. The cell is transparent at any incident angle in the off-state. The transmittance depends on the incident angle in the on-state and sunlight around noon can be strongly scattered.
We present a top-down aligned reactive mesogen (RM) layer for polarization-dependent lenticular lens array in 2D/3D switchable displays. Due to the geometric alignment effect of the nano-groove of the imprinting mold, the RM layer can be well-aligned on the concave-shaped polymer layer.

In this study, we fabricate a liquid crystal grating which can operate in the terahertz frequency region by using microrubbing process. Fundamental diffraction property was investigated by using optically pumped gas laser system which can generate cw THz waves with an enough power for precise measurements.

Blue phase liquid crystal has attracted the researchers' interest in the recent years for a new mode of liquid crystal display application. In this study, we present an effect of surface alignment on the stability and electro-optical properties of blue phase liquid crystal by using various alignment films.
LCTp5 - 4  Analysis of Polymer Stabilized Blue Phase Network Structure for Understanding of LC Alignment  
M. Kwak, K. Kim, S. An, Y. Yi, S. Choi, N. Kim, B. Kim, D. Kang, Y. Choi, S. Jeon  
LG Display, Korea  
Polymer network (PN) structures of PSBP was analysed with LC removed by hexane cleansing. With different LC and monomer from previous reports, the PN resulted in was a solid layer, rather than a grid network. That means BP was not stabilized by PN. This phenomenon was interpreted as a MS effect.

LCTp5 - 5  Withdrawn

LCTp5 - 6  A Single Step Method for Characterizing Blue Phase LCs at Various Temperatures  
P. Joshi*,**, J. D. Smet*,, X. Shang*,**, D. Cuypers*,**, G. V. Steenberge*,**, S. V. Vlierberghe*,**, P. Dubrue1*,**  
*Gent Univ., Belgium  
**imec, Belgium

Characterization of blue phase liquid crystals (BPLC) at different temperatures is an interesting but time consuming research activity. We present a quick and efficient one step method to record the polarization optical micrograph (POM) depicting texture of BPLC at various temperatures simultaneously and also support our case with COMSOL simulations.

LCTp5 - 7L  Effect of Polyaniline Functionalized Graphene Doping on Blue Phase Liquid Crystal  
Shanghai Jiao Tong Univ., China  
*China Star Optoelect. Tech., China

The effect of polyaniline functionalized graphene nanosheets (G-PANI) on electro-optical properties of polymer-stabilized blue phase liquid crystals (PS-BPLCs) has been studied. The Kerr constant of PS-BPLC doped with 0.05wt% of G-PANI is increased by ~55% compared with that of PS-BPLC. Meanwhile, response time and hysteresis of PS-BPLC are not affected.

LCTp5 - 8L  Cholesteric Blue Phases from a Mixture of Rod-Like Liquid Crystal and Photoresponsive Bent-Core Mesogen  
M.-J. Gim, K.-W. Park, S.-T. Hur, S.-W. Choi  
Kyung Hee Univ., Korea

Photoinduced BP had a tendency to be easily destroyed by electric field, a factor that may be a critical obstacle for electro-optical (EO) applications. In contrast, the intrinsic cubic BP was more stable in applied electric fields and exhibited an EO performance that could be defined by the Kerr effect.
LCT5: Display Mode (2)

Chair: S. Ishihara, Osaka Inst. of Tech., Japan
Co-Chair: K. Miyachi, Sharp, Japan

LCT5 - 1  Field-Induced Optically Isotropic State in Bent Core Nematic LCs: Proof of Their Optical Biaxiality
9:00  O. Elamain, G. Hegde*, F. C. Katalin**, L. Komitov
Univ. of Gothenburg, Sweden
*Univ. Malaysia Pahang, Malaysia
**Hungarian Ac. of Sci., Hungary

The field-induced optically isotropic state in the bent core nematic liquid crystals is considered to be an unambiguous proof of their field-induced optical biaxiality. Their electro-optical behavior is explained by a simple model in which the molecular bend shape plays a vital role.

LCT5 - 2  The Improvement for TN-LCD Response Time by Partial Polymer Matrix Formation in the Vicinity of LC Alignment Layer Surfaces
9:20  K. Takatoh, T. Ide, A. Harima, M. Akimoto
Tokyo Univ. of Sci. Yamaguchi, Japan

UV irradiation to LC monomer in TN-LCDs at temperature higher than the clearing point, the formation of polymer layer possessing alignment ability was confirmed. By selecting appropriate temperature, partial polymer matrix in the vicinity of alignment layer could be formed. It realized fast decay time and relatively low driving voltage.

LCT5 - 3  New Electrically-Controllable LC Depolarizers Using Amorphous-Alignment Structure
9:40  Y. Nagatsuka, Y. Iimura
Tokyo Univ. of A&T, Japan

We have developed a new type of an electrically-controllable LC depolarizer which is a sandwich-type cell with amorphous alignment structure. Incident linearly-polarized lights to the device are converted to spatially-dependent polarized lights acting as apparently random polarized lights. We prove that the LC depolarizer is useful for eliminating polarization-dependent effects.
In this paper, we have proposed a new cholesteric liquid crystal (ChLC) that can achieve lower operating voltage and good contrast ratio. In addition, we have successively developed the 11.4-in. transparent display with bistable mode.

----- Break -----

In this paper, we successfully demonstrate the photo-alignment panel without image sticking phenomenon. The image sticking phenomenon results from impurities and ions existing in the panel. Such a problem can be detected by flicker measurement and solved by Polymer Stabilization Alignment Liquid Crystal (PSALC).

A novel optical method was introduced to optimize gamma voltages of low grey levels. It helps to reduce the residual DC effectively and improve the image sticking performance of VA type LCD.

This paper discusses the e-field interference among vertically aligned in-plane-switching mode. The results show that the e-field between the in-plane-switching electrode pair will interfere with that of the adjacent pair when the spacing difference between them is too large. Hence, similar-pitches pairs should be arranged as neighbors to avoid interference.
AUO announced the first high optical performance LCD called Peak Performance LCD (P.P. LCD) compatible with OLED optical performance. P.P. LCD has wide viewing angle (FWHM > 90 degree) and wide color gamut (Adobe RGB coverage > 95%). This novel design has great optical performance under most user conditions.

The novel microstructure film has been developed to improve drastically the viewing angle characteristics of the LCD. The novel LCD doesn’t blur in the frontal image, and has realized the more excellent visibility under a bright ambient light than the LCD using the conventional diffusing film.

--- Lunch ---

We have studied a new photo-alignment material that has liquid crystalline properties. By using a self-alignment nature of the material, a low dosage of exposed UV light produces significant surface anchoring. This material is applied to fabricating IPS samples, and the image sticking and the voltage-holding ratio are investigated.

Implementation of photoalignment for Patterned Retarder requires exposure conditions with defined distribution of polarization direction. We applied novel Patterned Rubbing Alignment Technique to fabricate patterned twister mask structure that provides linear polarization direction modulation. Being not photosensitive such polarization mask allows multi-domain azo-dye photoalignment in one mask process.
Continuous or discontinuous transition from vertical to planar alignment was found in nematic cells, containing polyimide alignment layer exposed to linear polarized UV light, depending on the layer prior treatment. Without any treatment the polyimide film is promoting vertical alignment. Simple model is suggested to explain these alignment transitions.

Author Interviews and Demonstrations
16:40 – 17:20

The 20th Anniversary Session

“Past, Present and Future of Display Technology”
by FMC Workshop
Wednesday, December 4, 2013
14:00 – 17:00 (FMC1 & FMC2)
Main Hall A, 1F
See page 87-89 for details

–The 20th Anniversary– Keynote & Special Session

“What’s the Next Display?”
by LCT Workshop
A future manufacturing technologies and newly developed LCD panels will be presented.
Wednesday, December 4, 2013
14:00 – 16:30 (LCT1 & LCT2)
Mid-sized Hall A, 1F
See page 47-48 for details
Workshop on Active Matrix Displays

Wednesday, December 4

13:40 - 16:40 Main Hall C

Poster AMDp1: Oxide TFT

Special Topics of Interest on Oxide TFT

AMDp1 - 1 Investigation on the Oxide TFT Gate Driver Circuits Using Bias Offset Method
LG Display, Korea

Novel oxide TFT gate driver circuits using bias offset method has been investigated. The inverters in the circuit provide offset voltages to prevent operation failure due to charge leakage. Measurement was done on the gate driver circuits integrated in FHD panel and the effect is analyzed.

AMDp1 - 2 A 32-in. HD LCD-TV Display Driven by Amorphous IGZO TFTs
Shenzhen China Star Optoelect. Tech., China
*TCL Corporate Res., China

A 32-in. HD (1366 x 768) LCD-TV by using a-IGZO TFT which was fabricated at Gen 4.5 glass substrate with IGZO (1:1:1) AC sputtering system for TFT-LCD. TFT with an a-IGZO channel layer exhibited good subthreshold swing (S.S), Ion/Ioff ratio, threshold voltage and mobility of 0.15 V/decade, 2 × 10^8, 0.08 V and 19.01 cm^2/Vs, respectively.

AMDp1 - 3 Electrical Performance Enhancement of a-AZTO by a Low Temperature Treatment
P.-T. Liu, C.-S. Fuh, L.-F. Teng, Y.-S. Fan, C.-H. Chang
Nat. Chiao Tung Univ., Taiwan

In this study, a supercritical fluid (SCF) technology is proposed to enhance the electrical performance and reliability of a-AZTO TFTs. The SCF provides liquid-like solvency and gas-like diffusivity, giving it transport capacity to take the H_2O molecules into films and terminate the traps in films by the oxidization.
This work presents a gate driver circuit using indium-gallium-zinc oxide (a-IGZO) thin-film transistors (TFTs). The proposed circuit suppresses the threshold voltage shifts and completely turns off the a-IGZO TFTs having negative threshold voltage. Simulation reveals the proposed gate driver circuit can stably operate with a-IGZO TFT having negative threshold voltage.

Threshold voltage shift ($\Delta V_{th}$) characteristics of amorphous InGaZnO thin-film transistors under positive gate bias stress are investigated and the monitoring $\Delta V_{th}$ from constant current induced drain voltage is proposed. The extracted $\Delta V_{th}$ characteristics are then analyzed using the stretched exponential model and the characteristics of the subgap density of states.

We report successful fabrication of the BCE-type TFTs with Mo/Al/Mo electrodes using etchant resistive new oxide semiconductor thin films. It is found that the additional annealing process is really effective to restore the TFT surface damage after the BCE process. The TFTs exhibit a high stress stability under the LNBTS.

We have investigated the top gate IGZO thin film transistors with polymer gate insulators. Multiple approaches were adopted for improving device performance. Electron mobility was upgraded almost $10^3$ times for stacking IGZO layers. The device characteristics showed a mobility 0.05 cm$^2$/Vs and an on/off current ratio over $10^3$. 

Wednesday December 4

AMdp1 - 4 New a-IGZO TFT Gate Driver Circuit with AC-Driven Pull-Down Circuit

Nat. Cheng Kung Univ., Taiwan

AMdp1 - 5 In-Situ Threshold Voltage Shift Monitoring of Amorphous InGaZnO Thin-Film Transistors

J. H. Kang, E. N. Cho, I. Yun
Yonsei Univ., Korea

AMdp1 - 6 High Reliability of Back Channel Etch-Type TFTs Using New Oxide Semiconducting Material

M. Ochi, S. Morita, Y. Takanashi, H. Tao, H. Goto, T. Kugimiya, M. Kanamaru* 
Kobe Steel, Japan
*Kobelco Res. Inst., Japan

AMdp1 - 7 The Study on Sol-Gel IGZO Thin Film Transistors with Top Polymer Gate Insulators

Y. W. Wang, M. S. Lai, C. Y. Huang, W.-C. Su
Nat. Changhua Univ. of Education, Taiwan
The article studied the relation between oxide TFT (IGZO) process and reliability of product. From experiments, the appropriate conditions were adopted in the process improvement. The recommended conditions of IGZO process, such as higher IGZO anneal temperature, ESL anneal temperature and PVX deposition temperature, were provided in this paper.

Self-aligned top-gate a-IGZO TFT with homogenous source/drain and channel is fabricated. The low resistance of source/drain regions is achieved using a N2 plasma treatment. After the N2 plasma treatment, the resistivity of IGZO film experiences a sharp decrease. A simple and cost-effective self-aligned top-gate TFT technology is thus demonstrated.

We investigated the impact of the power deposition in etch-stopper layer (ES layer) and high temperature annealing in the active layer and ES layers, respectively for stability of Oxide-TFT. For stability test, the devices during active layer active annealing under positive and negative bias stress, respectively, exhibited weak shift.

High-mobility IGZO TFTs were demonstrated at 360°C with an IGZO channel and AlOx gate dielectric stack that was deposited by ozone-assisted solution-based atmospheric pressure (AP) process. The mobility of the AP-processed IGZO TFT significantly improved to 12.3 cm²/Vs which is comparable to the value obtained from vacuum processed IGZO TFTs.
We have proposed a temperature sensor using a poly-Si TFT and 1T1C circuit. Particularly in this presentation, by controlling the gate bias, it becomes possible to detect the temperature more correctly. We think that it is promising to integrate this temperature sensor in some applications using TFTs.

We are evaluating operational amplifiers using poly-Si TFTs. Particularly in this presentation, we report characteristic comparison between multiple output stage numbers. It is found that the gain is larger as the output stage number increases, but the offset voltage still exists even if the output stage number changes.

We introduce $\Delta V_{th}$ empirical formula derived from prolonged BTS test of various driving condition for predicting malfunction and lifetime of product using amorphous silicon technology. In the result, we verified the fact that match well between the values which was simulated using SPICE circuit simulator and on-going reliability test values.

A novel pixel structure with 12-domain was developed to improve oblique image quality including color shift and smoothness of gamma for polymer stabilized vertical alignment (PSVA) display. Furthermore, as other commercial 8-domain pixel types, it has similar optical luminance and without any extra driver ICs due to utilize 1G-1D driving.
This paper shows that LDD with width of 2 μm has wide DR-range. LDDs with width of 0, 3 or 4 μm have small DR-range or have too low on current value and cannot be used as driving TFTs. Wide DR-range is obtained with doping concentration of less than 1x10^{13} / cm^2.

In this paper, we propose a cascaded type level shifter using LTPS-TFT. By simulation results, the output voltage swing of a two-stage cascaded type level shifter is about 9.4 V. In addition, the output voltage of a high-voltage generator using the level shifters is about 9.5 V.

In this work, we presented a novel hydrogenated amorphous silicon thin-film transistor (a-Si:H TFT) integrated gate driver circuit which comprises a level shift unit and has the ability of generating multi-level gate output waveforms. The circuit maintains excellent driving capability with relatively lower power consumption.

This paper presents an AMOLED pixel circuit which uses a “source-follower” to sense V_{TH}, enabling a precise compensation even if the initial V_{TH} value is negative. In addition, the circuit can compensate for performance variations of both TFTs and OLED.
We investigated the formation of SiO₂ thin films on polycrystalline silicon thin films by CO₂ laser irradiation of perhydropolysilazane. We succeeded in the formation of SiO₂ containing few OH groups and having uniform composition in the thickness direction. We considered the effect of CO₂ laser irradiation was related to bond vibration.

**AMDp2 - 10L** Effect of H₂ Annealing after BLDA for Low-Cost Poly Si TFT  
K. Sugihara, K. Shimoda, T. Okada, T. Noguchi  
Univ. of the Ryukyus, Japan

Poly Si TFT was successfully fabricated using BLDA. All the process was conducted using sputtering and vacuum evaporation without CVD and was limited below 400°C. After hydrogenation, TFT characteristics improved drastically. High performance TFT using BLDA is expected on plastic and on flexible sheet with low cost.

**AMDp2 - 11L** Lateral Large-Grained CLC Low-Temperature Poly-Si TFTs with Sputtered High-k Gate Dielectric  
T. Meguro, A. Hara  
Tohoku Gakuin Univ., Japan

We combined high-k gate dielectric with CLC poly-Si TFT and achieved high performance with s.s.=240 mV/dec and field-effect mobility of 140 cm²/Vs without hysteresis in transfer characteristic and C-V curve. This result demonstrates feasibility of high-k CLC LT poly-Si TFTs.

**AMDp2 - 12L** Self-Aligned Metal Double-Gate Ni-SPC LT Poly-Si TFTs on Glass Substrate  
T. Meguro, A. Hara  
Tohoku Gakuin Univ., Japan

Self-aligned metal double-gate Ni-SPC LTPS TFTs have been fabricated on a glass substrate below 600 °C. The small V_th variation, high on-current, and superior s.s. value were clearly observed, indicating the superior gate controllability of the channel region compared to those of TG Ni-SPC LTPS TFTs.
We synthesized mono-functionalized asymmetric benzothienobenzothiophene (Cn-BTBT) and fabricated films by the double-shot inkjet printing technique. It was found that the asymmetric BTBTs also can form exceptionally uniform thin films composed of large single-crystal domain. OTFTs using printed single-crystal films of C11-BTBT exhibited a mobility as high as 9 cm²/V·s.

A new structure of organic thin-film transistor named the “Elevated-Electrode Structure” shows mobility, on/off ratio as high as those of the structure with bottom-gate and top-contact and higher than those of structure with bottom-gate and bottom-contact in actual devices fabricated using DNTT.

A new pixel circuit for an active-matrix organic light-emitting diode (AMOLED) is proposed with a novel driving scheme based on low-temperature, polycrystalline-silicon thin film transistors (LTPS TFTs). The proposed circuit consists of three n-type TFTs and a capacitor to successfully compensate for variations of the threshold voltage and mobility in the TFTs.

The threshold voltage degradation of AMOLED pixel circuit has improved with new programming method. The error rate of OLED current has decreased to 2.06% at least when the degradation ranges of threshold voltage are 0.33 and -0.33 V. The simulation result demonstrates that the proposed circuit can improve the stability current.
This work presents a new pixel circuit design adopting amorphous indium-gallium-zinc-oxide (a-IGZO) thin-film transistors (TFTs) that compensates for the threshold voltage shift of the driving TFT and ameliorates the luminance drop of OLED for active-matrix organic light-emitting diode (AMOLED) display.

Low voltage operation of organic field-effect transistors (OFETs) with embedded source/drain electrodes has been demonstrated. Soluble small molecules of 2,7-dioctyl [1]benzothieno[3,2-b][1] benzothiophene and CYTOP were used as organic semiconducting and insulating layers, respectively. Low voltage operation ($V_{DS}=-10$ V) is shown by thinning the gate insulating layer of the OFETs.

Bridged-grain refers to a device structure incorporating multiple doped “pockets” in the channel of a thin-film transistor. The short-channel and the multi-junction effects are beneficially exploited to increase the on-current and to reduce the leakage current. The physics of the device operation is studied and the benefits are experimentally demonstrated.
Device degradation behaviors of bridged-grain (BG) polycrystalline silicon thin film transistors (TFTs) under DC bias stresses are examined and analyzed. The stress test results reveal that BG TFT has better self-heating reliability, better hot carrier reliability and better negative bias temperature instability, compared to normal TFTs.

Fabrication of MOSFETs by μ-TPJ crystallization of strip channel Si and operation of 8-bit shift register at a supply voltage of 5 V with the clock frequency of 50 MHz have been achieved. A novel layer transfer technique, which enables formation of single-crystalline Si (100) layer on PET substrate is proposed.

High-performance four-terminal embedded metal double-gate CLC poly-Si TFTs were fabricated at a temperature below 550 °C on a glass substrate. The superior $V_{th}$ controllability and high mobility allows the fabrication of a high-speed and low-power-dissipation system-on-glass.
A 65-in. oxide TFT AMOLED TV panel has been demonstrated. The side by side OLED device is realized by fine metal mask. The TFT shows an excellent characteristic—long range threshold voltage uniformity is 0.34 V. The dam and fill encapsulation method shows a simple process procedure and high stability.

Threshold voltage shifts of amorphous In-Ga-Zn-Oxide (a-InGaZnO) TFTs on plastic substrates against bias-temperature stress were reduced below 0.03 V. We have developed a 10.2-in. WUXGA flexible AM-OLED display driven by a-InGaZnO TFTs fabricated on a transparent polyimide film. We demonstrated an interactive prototype flexible-display system integrated with a bend-input function.

Low temperature a-IGZO TFTs were fabricated successfully on plastic substrates at 220°C. The flexible reliability of a-IGZO TFTs is investigated. For a-IGZO TFTs application in flexible display, it suffers not only electrical stress but also mechanical stress. It is found that both of them would affect the electrical characteristic of a-IGZO TFTs.
Thursday December 5

AMD2 - 4 11:50 A Novel Embedded Non-Volatile Memory Utilizing IGZO Conductor Transformation for System-on-Glass Application

N. Ueda, S. Katoh, T. Matsuo
Sharp, Japan

For the first time, we report a novel application of IGZO transformation to conductor, as an electrically programmable non-volatile memory. The transformation is performed by Joule heating of the channel. A very wide read window and excellent retention are demonstrated. This memory is fully compatible with standard IGZO TFT process.

AMD2 - 5L 12:10 Electron-Beam-Induced Crystallization of Amorphous In-Ga-Zn-O Thin Films Fabricated by UHV Sputtering


*Tokyo Inst. of Tech., Japan
**NIMS, Japan

Microscopic structures of a-In-Ga-Zn-O was studied using S/TEM. To avoid crystallization, samples were measured without any thinning and processing, and low electron-beam voltage/current were employed. It was confirmed that all the a-IGZO films were amorphous irrespective of hydrogen content. Instead, crystallization was observed when the probe electron dose was increased.

----- Lunch -----
Influence of Charge Trapping on Hysteresis in InGaZnO Thin-Film Transistors under Negative Bias and Illumination Stress

M. P. Hung, D. Wang, J. Jiang, M. Furuta
Kochi Univ. of Tech., Japan

Double-sweeping mode and positive gate pulse mode were used to investigate the origin of NBIS induced hysteresis in InGaZnO thin-film transistors (IGZO TFTs). The electrons trapping in an ES bulk, holes trapping in a GI, and defect generation in channel were dominant mechanism of instability of IGZO TFT under NBIS.

The Negative-Bias-Illumination-Stress with Channel Length Dependence in a-IGZO TFTs

J. G. Um, S. H. Park, J. U. Han, J. Jang
Kyung Hee Univ., Korea

We investigated the negative-bias-illumination-stress (NBIS) according to channel length modulation in amorphous indium gallium zinc oxide (a-IGZO) thin-film transistors (TFTs). In this result, we obviously found that in the case of longer channel TFT, the $\Delta V_{TH}$ had shown very smaller shift than shorter channel length TFT.

Photo-Response Elimination of Amorphous InGaZnO Thin Film Transistors by Introducing a Mo-doped-ZnO Passivation Layer

Y.-C. Tsai, M.-Y. Tsai, L.-F. Teng, P.-T. Liu, H.-P. D. Shieh
Nat. Chiao Tung Univ., Taiwan

A Mo-doped ZnO (MZO) with a bandgap ~3.3 eV is adopted to eliminate the wavelength-dependent photo-responses in a-IGZO TFTs. The MZO passivated a-IGZO TFTs presents $\Delta V_{in}$ less than 1 V under NBIS while the wavelength varied from 360 nm to 620 nm, whereas the unpassivated a-IGZO TFTs exhibits $\Delta V_{in}$ around -10 V.

----- Break -----
Thursday

15:10 - 16:40 Main Hall B

**AMD4: Oxide TFT: Reliability (2)**

*Special Topics of Interest on Oxide TFT*

Chair: J. K. Jeong, Inha Univ., Korea
Co-Chair: H. Kumomi, Tokyo Inst. of Tech., Japan

**AMD4 - 1: Invited**

**Stability of Oxide TFTs**

15:10

J. Jang, M. Mativenga, J. G. Um, M. D. H. Chowdhury
Kyung Hee Univ., Korea

This paper reviews the electrical instabilities of oxide TFTs under various stress conditions such as PBS, NBS, NBIS, PBTS, and high-current-stress (HCS). Degradation mechanisms explaining experimental results are provided. Stability improvement methods, both process-related and device structure-related, are proposed and evidence supporting their feasibility is provided.

**AMD4 - 2: Invited**

**Enhancement of a-IGZO Oxide TFT Performance by Novel Method Including Ultraviolet and Thermal Annealing**

15:35

B. D. Ahn*, Y. J. Tak†**, H. J. Kim**

*Samsung Display, Korea
**Yonsei Univ., Korea

We proposed the novel method for enhancement of a-IGZO oxide TFT performance by ultraviolet and thermal annealing (UVA) treatment and compared its properties to that of a conventional thermal annealing. Our UVA-treated TFT had a higher field-effect mobility and positive bias-stress stability than those of conventional thermal annealing.

**AMD4 - 3**

**Effect of Back Channel on the Characteristics of Solution-Derived Amorphous InZnO Thin-Film Transistors**

16:00

Y. Osada, Y. Ishikawa, L. Lu, Y. Uraoka
Nara Inst. of S&I, Japan

We investigated the channel layer thickness dependence on the performance of amorphous InZnO thin-film transistor fabricated by spin-coating process. Decreasing the channel layer thickness improved the on-current and the field effect mobility, significantly. These phenomena can be explained by the back channel effect.
We have improved the storage stability, gate bias stress stability, and thermal stability of a-IGZO TFTs by tuning the ESL quality. The a-IGZO TFTs with the high-quality ESL exhibit excellent electric properties and stabilities. A 120 Hz 32-in. UHD resolution TV panel has been developed by using the a-IGZO TFTs.

----- Break -----
A High Mobility Metal Oxide Thin Film Transistor with Solution Coating Process

Evonik Inds., Germany

We fabricate solution-processed metal oxide TFTs with Evonik-developed metal oxide based semiconductor and passivation. The solution material/coating technology can be easily scaled up to larger substrate size without influencing device homogeneity and performance. With high mobility of 20 cm²/Vs, solution-processed TFT is capable for AMOLED driving, high resolution and other high-end applications.

Effect of Annealing on Oxygen Content in SiO₂/a-IGZO/SiO₂ Stacks

LG Display, Korea

The thermal annealing effect of amorphous InGaZnO (a-IGZO) semiconductor layer sandwiched between top and bottom SiO₂ layers is investigated. We illustrate the dynamics of inter-diffusion of constituent atoms, especially oxygen, at the IGZO/SiO₂ interfaces for different annealing temperatures and correlate them with TFT device characteristics.

Printed Organic TFTs for Interfacing Circuits and Active Matrix

Minatec, France
*Eindhoven Univ. of Tech., the Netherlands
**STMicroelectronics, Italy
***Univ. of Catania, Italy

This paper presents a printable organic complementary TFT technology suitable for low cost plastic substrates. By combining state-of-the-art materials, printing technics and silicon-inspired compact modeling and simulation approach, we have fabricated circuits that provide the switching, digital and analog functions required for the development of Printed Systems on Foil.
Device characterizations and application proposals are important besides investigations on device formations and fabrication processes to develop TFTs. We introduce the device characterizations based on low-f C-V methods in the author interview because of time limitation, and propose the novel applications for sensors and general electronics in the oral session.

3-D stacked complementary TFT devices using n-type α-IGZO and p-type F8T2 TFTs
- Comparison between Stacked and Sided Configurations -

We have developed 3-D stacked complementary TFT devices using n-type α-IGZO and p-type F8T2 TFTs on PET substrates. We confirm correct input-output characteristics of inverter circuits. Particularly in this presentation, we compare n-type α-IGZO, p-type F8T2, stacked complementary, and sided complementary inverters.

We demonstrated an ultra-high resolution mobile display with high aperture ratio and slim border. Contrast to conventional design which may suffer aperture ratio above 500PPI, this 512PPI display can achieve high aperture ratio of 60%. A new scan driver was also employed to realize slim border of 0.65 mm width.
Organic thin-film transistors (OTFTs) and metal oxide TFT (MOTFT) are candidates for several new display and electronic circuit applications. Here we demonstrate organic TFTs with carrier mobilities up to 2-5 cm$^2$/V·s and Ion/Ioff > 10$^6$ and oxide/IGZO TFTs with mobilities > 20 cm$^2$/V·s$^{-1}$.

In this study, p-type organic TFTs were fabricated by spin coating method and ink-jet printing method, respectively. The Ion/Ioff ratio of TFTs could be improved by patterning organic semiconductor with Ink Jet Printing method. Due to the low process temperature, the organic TFT on PEN substrate was also demonstrated.

Single grain Si TFTs have been fabricated on a polyimide substrate with mobilities of 378 cm$^2$/Vs and 129 cm$^2$/Vs for electrons and holes, respectively. Pure CPS has been doctor-blade coated, and an excimer laser-crystallization step lead to grains of 3 µm. Transfer to a PEN foil resulted in flexible TFTs and CMOS inverters.
Self-aligned imprint lithography (SAIL) is presented as a unique and fundamental solution to the issue of interlayer misalignment, which is a major obstacle to achieving high resolution and yield in flexible electronics manufacturing. Copper and oxide semiconductors are incorporated to deliver backplanes that can drive flexible OLED displays.

A 4-inch 80-ppi flexible AMOLED display was fabricated using organic TFTs with an inkjetted semiconductor layer. To suppress variations in OTFT characteristics, the process damage to polymer gate insulator was re-covered by surface treatments, giving uniformity of threshold voltages of $-0.2 \pm 0.45$ V.
FMC1: The 20th Anniversary: Past, Present, and Future (1)
Main Hall A
Wednesday, December 4
14:00 - 15:20

Chair: R. Yamaguchi, Akita Univ., Japan
Co-Chair: M. Miyatake, Nitto Denko, Japan

FMC1 - 1: Invited Where is Disruptive Innovation by FPD?
14:00
T. Yunogami
Fine Processing Inst., Japan

Why cannot Japan cause innovation recently? The cause is that Japanese misrecognize with innovation. Innovation is the technology and product which spreads explosively, not "technical break-through". Prof. Christensen said disruptive technology creates a new market, and expels sustaining technology. In lecture, we discuss where is disruptive innovation by FPD.

FMC1 - 2 Past, Present, and Future: Photoresist for FPD Fabrication
14:20
Y. Toyama, K. Taniguchi, T. Suzuki, H. Ikeda
AZ Elect. Materials Manufacturing Japan, Japan

Novolak-DNQ (diazonaphthoquinone) positive type photoresists have been being used in FPD manufacturing process for a long time. Recently requirements for the new process and photoresist materials have been more specified due to increasing functionality of display devices. We have provided proper photoresist for each demand with our experience and technologies.

FMC1 - 3 Past, Present, and Future: Color Filters and Surface Films
14:40
T. Hotta
Dai Nippon Printing, Japan

For flat panel displays such as LCDs, color filters and surface films have been essential components to realize color images with excellent viewing quality. In this paper, past, present and future developments of such components are described.
With higher resolution of a panel, the pattern that needs resolving is approaching the limit of the exposure machine. In order to improve this, we have developed the Mask that has the function to make the falling exposure property enhance. This time, we report two developed New Function Mask.

----- Break -----
This paper presents the transport mechanisms of gas molecules, such as oxygen (OTR) and water vapor (WVTR), through plastic films and organic adhesives used in printed and flexible electronics devices, such as in display applications.

**FMC3 - 1:** *Invited* Structural Relaxation, Crystallization, and Defect Passivation in Amorphous In-Ga-Zn-O

*T. Kamiya, K. Ide, K. Nomura, H. Kumomi, H. Hosono*  
Tokyo Inst. of Tech., Japan

Amorphous oxide semiconductor, represented by a-IGZO, is now used in current FPDs. On the other hand, a-IGZO TFTs require thermal annealing at 300 - 400°C for better uniformity and stability. Here, we discuss structural relaxation, defect annihilation and creation by thermal annealing in relation to hydrogen and oxygen effects.

**FMC3 - 2:**  
Wet Chemical, Damage Free In-Ga-Zn-O TFT Processing  
*P. Vermeulen, P. Janssen, L. Robichaux, C. Allen*  
Sachem, USA

The results of etching formulations for wet chemical, damage free IGZO TFT processing are presented. Selective etching of the source/drain metal can be increased substantially by using SACHEM’s proprietary formulations. The use of an etch stop layer to protect the IGZO channel is therefore not required, allowing for cost effective TFT processing.
FMC3 - 3  9:40  In-Line Process Monitoring for Amorphous Oxide Semiconductor TFT Fabrication Using Microwave-Detected Photoconductivity Decay Technique

Kobe Steel, Japan
*Kobelco Res. Inst., Japan

We have investigated the microwave-detected photoconductivity responses from the amorphous In-Ga-Zn-O (a-IGZO) thin films. The peak values and the lifetime extracted by the reflectivity signals were correlated with TFT performances. It is concluded that the microwave photoconductivity decay (µ-PCD) is a promising method for in-line process monitoring for the IGZO-TFTs fabrication.

FMC3 - 4  10:00  Manufacturing Process of Oxide TFT Using Solution-Processed Photosensitive Passivation Layer

M. Takeshita, S. Abe, T. Kojiri, M. Hanamura, T. Goto*, T. Ohmi*
ZEON, Japan
*Tohoku Univ., Japan

We have developed a solution-processed Photosensitive Passivation Layer (PPL) for an oxide TFT. We have also developed a manufacturing process for oxide TFT that is suitable for the PPL process. By controlling the oxygen concentration in the oxide semiconductor, we have achieved an oxide TFT with the PPL.

----- Break -----
FMC4 - 2:  Invited  Novel Non-Alkaline Glass Substrate with Ultra-Low Thermal Shrinkage for Higher Resolution Active Matrix Displays
Asahi Glass, Japan

A novel non-alkaline glass substrate for higher resolution active matrix displays was newly developed. The new glass substrate “AN Wizus” showed ultra-low thermal shrinkage due to its manufacturing process and glass composition. This glass also had advantages of higher sliming rate, lower sag and lower photoelastic constant.

FMC4 - 3  Optically Specific Inkjet Inks for Displays
11:20
K. Eguchi
JNC Petrochem., Japan

JNC has focused on developing inkjet ink for printed electronics. UV curable type can be used for micro lens of light guide plate by improving in its optical and adhesive properties. Polyimide ink that can be cured at low temperature is useful to transparent insulating layer of touch panel.

FMC4 - 4  Development of Transparent Adhesive Sheet for Optical Applications
11:40
A. Murakami, T. Nonaka
Nitto Denko, Japan

To respond to demands for larger, thinner, and highly-sensitive capacitive touchscreen panels, we consider decreasing dielectric constant of adhesive sheets effective. Noticing that controlling electrical characteristics of adhesive sheets for interlayer adhesion to decrease the dielectric constant can contribute to meeting such demands, we developed a low dielectric adhesive sheet.

----- Lunch -----
Carbon nanotube transparent conductive film can be manufactured through a resource- and energy-saving solution process able to produce a film at room temperature without vacuum or high-temperature processes. The developed carbon nanotube thin film achieves sheet resistance of 68 - 240 $\Omega$/sq at transmittance of 89 - 98%.

Reference films with $10^{-2} - 10^{-4}$ g/m$^2$/day in water vapor transmission rate (WVTR) were developed. Using them, consistency between two WVTR measurement systems was successfully achieved to $10^{-4}$ g/m$^2$/day level. Furthermore, CEREBA’s strategy to achieve a reliable WVTR evaluation technology to $10^{-6}$ g/m$^2$/day is presented.

Si nanoparticles are novel materials for printed electronics. In this study, we demonstrate the carrier injection process and semiconductor layer prepared via laser irradiation of Si nanoparticle film for use in silicon-based FETs. Moreover, $\text{SiO}_2$ dielectric layer and photoluminescence treated Si nanoparticles with application in FPDs and LEDs are introduced.

----- Break -----
FMC6: Optical Films

15:10 - 16:30 Mid-sized Hall A

Chair: T. Ishinabe, Tohoku Univ., Japan
Co-Chair: I. Amimori, A51 Tech, Japan

FMC6 - 1 Analysis of 3D Viewing Angle Characteristics for Film Type Patterned Retarder Panel Using Extended Jones Calculus

15:10


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

We provided an analytical solution for 3D viewing angle of FPR panel using an extended Jones calculus. The shape of 3D crosstalk was predicted, which showed a good agreement with experimental results. We found the retardation in the base film widened the horizontal viewing angle and suggested its optimum value.

FMC6 - 2 Novel Film Patterned Retarder for Improving Viewing Angle Properties in 3D-LCDs

15:30


FUJIFILM, Japan

We have successfully developed a novel FPR that combines a layer of vertically aligned polymerized discotic material and a triacetate cellulose film. It reduces oblique crosstalk in 3D-LCDs. This FPR has wide viewing angle, can be manufactured by a roll-to-roll process, and forms narrow-width boundaries between the patterned line.

FMC6 - 3 Analysis of Grayscale Inversion and Image Quality Improvement of TN-LCDs Using New Wide View Film

15:50


FUJIFILM, Japan

We have developed a new Wide View film for TN-LCDs that dramatically improves grayscale inversion. We elucidated the grayscale inversion mechanism of TN-LCDs with a new polarization analysis method. This new TN-LCD is suitable for mobile applications that require a wide range of viewing angles and low power consumption.
Ellipsoidal Light Diffusing Film by Controlling Collimation Angle of UV Irradiation

B. Katagiri, K. Kusama, T. Orui, S. Shoshi
Lintec, Japan

Optical diffuser films with a microstructured refractive index are promising materials for applications, because of their unique optical diffusion properties. In this study, we describe an ultraviolet (UV) irradiation process for photo-polymerization and report ellipsoidal optical diffuser films by controlling the angle of incidence of the UV light.

----- Break -----

16:50 - 18:10  Mid-sized Hall A
FMC7: Manufacturing

Chair: R. Hattori, Kyushu Univ., Japan
Co-Chair: T. Arikado, Tokyo Electron, Japan

FMC7 - 1: Invited  Printing and Coating Technologies for Organic Electron Devices
16:50
H. Okada, S. Naka
Univ. of Toyama, Japan

Various printing and coating technologies of organic electron devices are presented. Using IJP, OLEDs without bank formation are done. By laminating two substrates, double-faced emission panel has realized. By coating Ag nano-particle, all-organic self-alignment TFTs have fabricated. A sheet-type scanner integrated with OLED, FET, and IJP organic photodiode has demonstrated.

FMC7 - 2: Invited  Wireless Power Transmitting System for Mobile Devices
17:10
R. Hattori, K. Miyamoto, H. Kanaya, S. Tsukamoto, H. Ishinishi
Kyushu Univ., Japan

We present three types of wireless power transmission systems for mobile devices using inductive and capacitive coupling and a radio wave. Capacitive coupling provides a wider reception area than inductive coupling. A radio wave receiving type system has a longer transmission distance than the others; however, it has lower efficiency.
We simulated the thermal conduction of a roll-to-sheet imprinting system. ZrO$_2$ gel films were patterned on large-scale substrates by using the system with direct thermal imprinting. To improve the system’s throughput, we invented a preheater mechanism being incorporated into the roll-to-sheet system.

Single-crystallite ZnO nanorods were fabricated by a novel mist chemical vapor deposition method in argon gas followed a reducing annealing process. It was found that the morphology of ZnO nanorods can be easily controlled, as well as the intensity of UV peak was enhanced with the Mist CVD process.

Sheet resistances and transmission spectra of reduced graphene oxide (RGO) and nano graphene compiled sheets were evaluated for printable transparent conductors. A relation between graphene flake size of RGO and sheet resistance was determined. The sheet resistance of RGO, which has compatible transmittance with ITO, was two-order larger.
Low CTE transparent polyimides (TPIs) with low birefringence have been developed. There are many requirements in transparent film to replace glass substrate. Although it is well-known the relationship between CTE and birefringence is trade-off, our new TPIs could improve the CTE and birefringence by copolymerization of characteristic monomers.

Low thermal shrinkage glass substrate, OA-12, has been developed. Since OA-12 shows 1/3 lower shrinkage than our conventional glass substrate, OA-10G for LCD, this glass is suitable for the high temperature manufacturing process for high definition display with low temperature poly-silicon (LTPS) or oxide TFTs.

We succeeded in development of siloxane-particle hybrid materials by new synthesis method. Here we demonstrate synthesis method and film properties of siloxane-metal oxide hybrid polymer, which has high refractive index (RI). In addition, we propose new air gap material with lower RI with this technique.

A primer, which connects functional materials to plastic film, is used in flexible electronic devices. There is a strong demand for a primer which can adhere strongly to the COP films. We developed a primer which showed strong adhesion against COP films, high refractive index and high durability.
FMCp - 6  Materials Design for High-Resolution Performance of Resin Black Matrix at the 6th Generation Color Filters Mass Production
LG Display, Korea

The materials performance of the extreme resolution was high sensitivity of Photoinitiator and Hard bake Temperature Tg value of binder polymers. We Designed HR-RBM of high sensitivity ($35 \text{ mJ/cm}^2$) & good straightness (1.9 $\text{µm L/S}$). It was demonstration of high resolution at 2.4 $\text{µm}$ pattern at the 6th generation LCD Plant.

FMCp - 7  Withdrawn

FMCp - 8  Roll-to-Roll Deposition on 100 $\text{µm}$ Thick Flexible Glass Substrate
H. Tamagaki, Y. Ikari, N. Ohba
Kobe Steel, Japan

Successful roll-to-roll sputter deposition of ITO on a flexible glass roll 100 $\text{µm}$ thick, 300 mm wide and 50 m long was demonstrated using a compact sputter roll-coater with some modifications for the flexible glass handling. ITO film with 100 $\Omega$Sq sheet resistance and 90% light transmission was obtained.

FMCp - 9  Metal Oxide Thin Films with Excellent Step Coverage Achieved by Pyrosol Process
S. Kodama, K. Arai, T. Oashi, Y. Seta, K. Ogawa, S. Yamada, H. Suzuki
Nippon Soda, Japan

Pyrosol Process is one of the Chemical Vapor Deposition (CVD) methods, which allow formation of metal oxide thin film possessing distinctive features. We recently discovered that this method can be applied to substrates with fine three-dimensional patterns and result in formation of metal oxide films with high step coverage.

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**IDW ’14**
The 21st International Display Workshops
December 3 – 5, 2014
Toki Messe Niigata Convention Center
Niigata, Japan
http://www.idw.ne.jp
We investigated the improvement of stamping mura for overcoat layer and column spacer fabricated by imprint process. The mura was affected stage surface and mold dropping method. The mura was improved by air-floating technology and optimized dropping method.

BCS must have to implement a high Optical Density (OD) & $\Delta H$ properties at the same time. $\Delta H$ refers to the difference in thickness Push and Gap CS. To improve $\Delta H$ we was optimized the transmittance spectrum of the pigment in high optical density (1.0/$\mu$m).

We evaluated quantitatively the degree of thermal shrinkage of an alkali-free aluminosilicate glass substrate by establishing a numerical simulation model on structural relaxation phenomena of glass materials. The appropriate thermal profile of glass manufacturing process and Low Temperature Poly-Si TFT allay fabrication process was investigated.

We have realized a new triple-view display with multiple functions, including horizontal triple views, vertical and horizontal triple views, and secure dual views. The proposed display is composed of three liquid-crystal display (LCD) panels. The multiple-views depending on the viewers’ positions are generated by information sharing between the LCDs.
FMCp - 14  A Reversed Gaussian-Like Algorithm for Reducing Mask Spliced Mura on 110-in. TFT LCD
Y.-Y. Chen, Y.-H. Chen, X. Tan, L. Sun, W. Chen
Shenzhen China Star Optoelec. Tech., China

China Star has successfully developed the world largest 110-in. LCD by the mask stitching method due to the limitation of the mask size. However, mura is a major issue which caused by the mask stitching process. We propose a reversed Gaussian-like algorithm to compensate this mura phenomenon.

FMCp - 15  Effect of Anneal Temperature on Local Structures of In-Ga-Zn-O Films Evaluated by X-ray Absorption Fine Structure Analysis
Kobelco Res. Inst., Japan
*Kobe Steel, Japan
**JASRI, Japan

X-ray absorption fine structure analysis was applied to evaluate the effect of anneal temperature on local structure of In-Ga-Zn-O films. It was found that the coordination numbers of oxygen around In and Zn atoms increased with increasing anneal temperature. In contrast, that around Ga atoms varied only slightly with temperature.

FMCp - 16  Withdrawn

FMCp - 17  Full High Definition Mobile Phone Screen Based on a-Si TFT Technology
BOE Optoelec. Tech., China

With the wing pattern technology and resin passivation layer, a more than 400 ppi LCD using a-Si TFT has been developed. The power consumption of a-Si devices is comparable to or even lowers than those of present LTPS. In this paper, we will show the technology for making FHD LCD.

FMCp - 18  Designing of Side Emitting Lens for Slim Direct LED Back Light Unit
S. Park, J. Seo, G. Kim
Samsung Display, Korea

The light extraction efficiency of side emitting lens was simulated. The amount of light reaching the bottom and side detectors of LUXEON was 52.62%. We developed a new design lens with an extraction efficiency of 81.13%, thereby improving the performance by 154% compared to that of LUXEON.
FMCp - 19  Fiber Optic Illuminator Using Recycling Light Technology for Signage Applications  
K. Li  
Wavien, USA  
A single color and a multi-color fiber optic illumination system using single white LED and RGBW LEDs respectively, powered by Wavien’s Recycling Light Technology (RLT) systems will be described. The multi-color system will open up many applications where this capability is not available using neon tubes or linear LED arrays.

FMCp - 20  Efficient LED Hard Edge Spot Light Using Recycling Light Technology  
K. Li  
Wavien, USA  
A hard-edge LED spot light for PAR and MR lamps using Wavien RLT technology are described. These TruSpot LED spot light also accept GOBO image slides so that it can be used to project advertising images. The RLT technology allows up to 280% improvement in brightness over standard optical configurations.

FMCp - 21  The Design of High Efficiency Light-Guide Plate with Multi Step Wedge Structure  
Y. W. Chang  
AU Optronics, Taiwan  
We successfully release a multi steps wedge design which is better than AUO published in 2012. According to our research, we divide the wedge structure into two parts due to different functions. We do improve the wedge structure to be processed more easily, better performance and more stable.

FMCp - 22  Surface Diffusing System LCDs with Small Viewing Angle Dependence of Contrast Ratio and Color Shift  
N. Munemura, D. Sekine, A. Tagaya, Y. Koike  
Keio Univ., Japan  
We fabricated the scattering film to realize wide luminance angular distribution liquid crystal display with surface diffusing system based on the novel multiple light scattering simulation. With this scattering film, we demonstrated the surface diffusing system liquid crystal display with small viewing angle dependence of contrast ratio and color shift.
FMCp - 23 Thin Seamless LED Flat Lighting Panel Using Highly Scattered Optical Transmission Polymer

K. Mochizuki, K. Sakurai, T. Iwamoto, K. Oosumi, Y. Shinohara, A. Tagaya*, Y. Koike*
Nittoh Kogaku, Japan
*Keio Univ., Japan

We have developed a thin seamless LED flat lighting panel (Seamless Panel) using a highly scattered optical transmission polymer. The Seamless Panels can be connected without showing seams on the lighting surface. The Seamless Panel gives more flexibility to design various illumination systems.

FMCp - 24L Characterization of SiO₂/In-Ga-Zn-O Interface by Hard X-ray Photoelectron Spectroscopy and X-ray Reflectometry

*JASRI, Japan
**SPring-8 Service, Japan

Non-destructive investigation on interface structures between SiO₂ and oxide semiconductor In-Ga-Zn-O (IGZO) was performed by X-ray reflectometry and hard X-ray photoelectron spectroscopy (HAXPES), and suggested that chemical reactions forming silicide occurred between SiO₂ and IGZO. HAXPES signals of silicide depended on SiO₂ deposition condition.

FMCp - 25L Organic Conducting Polypyrrole-Silica Inks

T. Sugiura, S. Maeda
Tokai Univ., Japan

We have prepared organic conducting nanocomposite inks which utilize polypyrrole as conducting parts and small silica particles as dispersants. These polypyrrole-silica nanocomposites can be utilize as inkjet inks for printed electronics due to their colloid stabilities and electric properties.

FMCp - 26L Carrier Injection by Laser Doping of Doped Silicon Nanoparticles in Silicon Field Effect Transistor for Plastic Electronics

*Teijin, Japan
**NanoGram, USA

Si nanoparticles (SiNPs) were developed by laser pyrolysis method. Laser doping (LD) of doped SiNPs was applied for carrier injection process of Si field effect transistors (FETs). We demonstrated a top gate top contact FET on crystalline Si by LD.
FMCp - 27L  Flaw Inspection and Detection for Small-Pixel TFT-Array

Y. C. Wang, B. S. Lin, J. Hsu*
Nat. Chiao Tung Univ., Taiwan
ITRI, Taiwan

The display pixels on array process are getting smaller for advanced display applications. The paper proposed the method of voltage imaging for detection and resulted in small-pixel TFT array between the flaw detection performances and played an important role than previously in non-small-pixel TFT array for managing yield.

FMCp - 28L  Effects of Annealing Temperatures and Substrate on Properties of ZnO Nanorods

K. Utashiro, T. Umakoshi, Y. Abe, M. Kawamura, K. H. Kim
Kitami Inst. of Tech., Japan

The properties of ZnO nanorods are investigated at different annealing temperature and substrates. Within a certain range of annealing temperatures, the alignment and length of nanorods are gradually improved with increasing annealing temperature of seed layer. However, it shows no significant difference for growth of nanorods on two different substrates.

FMCp - 29L  Improving Crystalline Quality of Si Thin Films Solid-Phase Crystallized on Yttria-Stablized Zirconia Layers by Pulse Laser

L. T. K. Mai, S. Horita
JAIST, Japan

A new two-steps irradiation method has been proposed to improve SPC Si film quality on YSZ layer for short annealing time by pulse laser. Firstly, a-Si films were irradiated at low energy to generate nuclei, following by irradiation at high energy to accelerate nuclei growth and films crystallization.

FMCp - 30L  The Effects of Birefringent Fiber Content and the Difference in Refractive Indices of the Constituent Components on the Optical Properties of Isotropic Polymer Diffuser Sheet

T. Kim, E. S. Lee, W. Y. Jeong, D. Y. Lim
KIST, Korea

A novel diffuser comprising birefringent fibers and an isotropic polymer matrix was fabricated. The diffusing behavior showed a dependency on the fiber content and the difference in refractive indices of the constituent components. As the fiber content and the difference in refractive indices were increased, enhanced haze characteristics were shown.
FMCp - 31L  Roll-to-Roll Fabricated Self-Alignment Microstructure Film for Improving the Viewing-Angle Characteristics of LCD


Sharp, Japan

A novel microstructure film, which has no backscatter of the ambient light, has been fabricated by the roll-to-roll self-alignment photolithography for mass-productivity. The microstructures of the film are optimized to improve the viewing-angle characteristics of the TN-LCD by controlling the photolithography conditions of the transparent photoresist.

FMCp - 32L  Adaptive Solar Illuminating Conduction Components with Helios Orbital Segmented Tracing for LCD Window Display

C.-J. Ou, C. H. Lin, C.-W. Lin*, B.-W. Lee*

Hsiuping Univ. of S&T, Taiwan
*Big-Sun Energy Group, Taiwan

Application of the solar illuminating techniques is adopt for LCD display. Prototype verified the possibilities and feasibilities of the concept. Requirement on the display performance is discussed. This concept provides a method to transform the window into the display platform, increase the market of the present display technologies.

FMCp - 33L  Novel Four-Mask Process Using Copper Metal with ITO Buffer Layer in ADSDS TFT-LCD


BOE Tech. Group, China
*BOE Display Tech., China

In this paper, we have successfully developed novel four-mask process using copper with ITO buffer layer in ADSDS structure. The key process is no metal buffer structure under Cu layer and one-step etch process about gate electrode and common electrode. These processes are able to simplify process of 0+4Mask and improve the productivity.

----- Lunch -----
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>13:30</td>
<td>FMC8 - 1</td>
<td>Quantum Dot Enhancement of Color for LCD Systems</td>
<td>J. V. Derlofske, G. Benoit, A. Lathrop, D. Lamb</td>
</tr>
<tr>
<td>13:50</td>
<td>FMC8 - 2</td>
<td>New LED Design Concept for High Color Gamut Application</td>
<td>S. J. Chang</td>
</tr>
<tr>
<td>14:10</td>
<td>FMC8 - 3</td>
<td>Switchable Dual Directional Backlight for Energy Saving in Automotive Displays</td>
<td>A. Yuuki, K. Itoha, T. Satake</td>
</tr>
<tr>
<td>14:30</td>
<td>FMC8 - 4</td>
<td>Optical Characteristics of Directional Backlight Unit for Field-Alternative Full Resolution Auto-Stereoscopic 3D LCD</td>
<td>K. Käläntär</td>
</tr>
</tbody>
</table>

Quantum dot technology promises to significantly extend the color gamut of liquid crystal displays (LCDs). Used in a film format, quantum dots can produce large color gamuts (>96% NTSC) with high efficiency. This paper discusses how quantum dots are incorporated into an LCD system and the factors that dictate performance.

This new type LED is including two-types LED and controlling current ratio by the feedback of signal in LCD. During to dynamic control LED current ratio, pictures on display can be more brightness or colorful. It can solve unbalance of brightness and color by using signal light source.

We have developed a switchable dual directional backlight for LCDs in the center console of automobiles. The backlight can change the luminance ratio between the driver’s direction and the co-driver’s direction, without degrading the luminance and its uniformity. It can save 30% of the lighting energy in solo drive.

In this paper the design and the structure of the directional BLUs used in recent field alternative 3D auto-stereoscopic full resolution medium size LCDs are explained and the constraints of the design for LGP and light deflecting film have been clarified for a BLU diagonal size of 180.34 mm.
FMC8 - 5L 14:50
Optical Design of Novel Microstructure Film for Wide Viewing TN-LCD
S. Katsuta, H. Yui, Y. Asaoka, E. Yamamoto, T. Maeda, T. Kamada, Y. Tsuda
Sharp, Japan

A novel wide viewing film, which contains air micro-cavities in the polymer layer, has been developed. By designing the three dimensional shape of the cavities to optimize the film for TN-LCD, the grayscale inversion of TN-LCD is improved and the contrast ratio is over 10:1 in all directions.

Author Interviews and Demonstrations
16:40 – 17:20

Supporting Organizations:
Japan Electronics Packaging and Circuits Association
Japan Society of Colour Material
RadTech Japan
The Japanese Research Association for Organic Electronics Materials
The Japanese Society of Printing Science and Technology
The Society of Photography and Imaging of Japan
The Technical Association of Photopolymers, Japan

The 20th Anniversary Session
“Past, Present and Future of Display Technology”
by FMC Workshop
Wednesday, December 4, 2013
14:00 – 17:00 (FMC1 & FMC2)
Main Hall A, 1F
See page 87-89 for details

“What’s the Next Display?”
by LCT Workshop
A future manufacturing technologies and newly developed LCD panels will be presented.
Wednesday, December 4, 2013
14:00 – 16:30 (LCT1 & LCT2)
Mid-sized Hall A, 1F
See page 47-48 for details
Workshop on Plasma Displays

Wednesday, December 4

14:00 - 15:15 Meeting Room 206

PDP1: Advanced Materials and Discharge

Chair: L. F. Weber, Consultant, USA
Co-Chair: M. Uchidoi, Japan

PDP1 - 1: Invited Development of Graphene Coated Cu Powders for BUS Electrodes of AC PDPs
14:00
Y.-K. Ko, H.-R. Choi, Y.-S. Kim
Hongik Univ., Korea

CVD coating of graphene layer on copper powder was attempted to explore a possibility of replacing Ag powder in BUS electrodes of AC PDPs. The results indicate that graphene layers can be formed on copper powder and the graphene layer improves the oxidation resistance dramatically, demonstrating the possibility.

PDP1 - 2: Invited Development of the Second Generation Calcium Magnesium Oxide Protective Layer for High Luminous Efficacy PDP
14:20
Q. F. Yan, K. Kotera, H. Liu, H. Zhou, H. Zhao, X. Deng, P. Wang
Sichuan COC Display Devices, China

New combination layer of Ca$_x$Mg$_{1-x}$O(CMO) protecting layer and priming booster layer (PBL) were developed to adopt higher Xe content for high luminous efficacy PDP. New evacuation process allows significant reducing the impact of carbonate formation, over 25% increase of luminous efficacy has been achieved in the 2nd generation CMO panel.

PDP1 - 3: Computational Study on Influence of N$_2$ Addition on Discharge Characteristics of AC PDPs in Xe/Ne Gas Mixture
14:40
A. Oda, Y. Hirano*, K. Ishii*  
Chiba Inst. of Tech., Japan  
*NHK, Japan

1-D fluid simulation of plasma display panel (PDP) discharges in Ne/ Xe/N$_2$ has been performed, in order to clarify the influence of N$_2$ addition on the discharge characteristics. Our simulations reveal that a delay time of voltage and current began to appear in case of N$_2$ addition more than 100 ppm.
We report on a photochromic transition of ZnSiO nanoparticles. It is confirmed that a photochromic transition occurs in the ZnSiO nanoparticles with UV irradiation at 300 K. This indicates that electrons are excited to the stable trap states in ZnSiO formed as a result of a photo-induced structural change.

----- Break -----

AC plasma display panels (AC-PDPs) whose cell structures, gas contents, and waveforms are adapted for radiation detectors. X-rays induce electron emission into discharge gas, resulting in electron avalanche and charge accumulation on dielectrics. The radiation dose rate of X-rays is measured as a breakdown voltage shift between anode and cathode.

Horizontal lines are divided into 4 groups having different subfield arrangement and display period is initiated immediately after addressing. With 8K4K, 6 subfields, dual scan mode, light emission duty ratio is increased from 13% with ADS method to 25% when address interval is 1 μs.
PDP2 - 1: Invited Reproduction of 22.2 Multichannel Sound with FPD-Integrated Loudspeakers for Home Use
16:20
NHK, Japan *Foster Elec., Japan

NHK is in the process of developing a 22.2 multichannel sound system for Super Hi-Vision, an ultra high-definition TV. This article gives an overview of 22.2 multichannel sound and its binaural reproduction with multiple loudspeakers integrated into a flat panel display.

PDP2 - 2: Invited Development of Super-Large-Area Film Display with LAFi Technology
16:40
Shinoda Plasma, Japan

Ambient display needs flexibility while it is very attractive. In order to realize flexible display set, thoroughly we changed arrangement of circuit boards and LAFi structure. In result, really flexible display set is achieved. It is very easy to install on curved wall and pillars.

Author Interviews and Demonstrations
17:20 – 18:00
Sponsor:
Plasma Display Technical Meeting
PHp - 1  Characteristics of SrTiO₃ or TiO₂ Dispersed Dielectric Layer for Powder EL Devices

K. Wani, T. Kanda, E. Hashimoto

TAZMO, Japan

Characteristics of powder EL with several dielectric materials were investigated. Powder EL devices using these materials as dielectric layers with the same capacitance were fabricated. The brightness of the SrTiO₃ or TiO₂ devices was still lower than that of the BaTiO₃ device. The reason for this difference is discussed.

PHp - 2  Laser Etched AC Electroluminescent Lamps

J. Silver, G. R. Fern, P. G. Harris

Brunel Univ., UK

Highly flexible AC electroluminescent display panels were prepared by first using a laser etching process to produce electrode structures on an aluminium covered polymer film substrate, then screen printing a single binder layer (containing the ACEL phosphor powder and the barium titanate ferroelectric particles) before overprinting with transparent conducting electrode.

PHp - 3  Factors Affecting the Colour of the Green Emitting Phosphors in the System Sr₂SiO₄-Ba₂SiO₄ Activated by Divalent Europium Ions

J. Silver, G. R. Fern, P. J. Marsh

Brunel Univ., UK

Herein the XRPD data of 13 compositions in (Ba₁.₉₈₋ₓSrₓEu₀.₀₂SiO₄) phosphor materials (x values in the range = 0 to 1.98) have been fitted in a new detailed approach. That has allowed a full explanation of the surprising distribution of the CIE coordinates when they are plotted on the CIE diagram.
AC electroluminescent lamps have been fabricated on rigid, wood based, biodegradable substrates in order to investigate possibilities of minimising the waste resulting from opto-electronic devices at the end of life. The performance characteristics of these eco-friendly ACEL lamps have been investigated.

We investigated the effect of femtosecond laser irradiation for enhancing the luminance of ZnS-based electroluminescence devices. The luminance value was improved due to the effect of femtosecond laser irradiation. We found that the increasing of the irradiation time and choosing an optimal power of the laser yielded higher luminance.

The effect of manganese in the presence of sodium chloride, and without him on the unit cell dimensions of colloidal zinc sulfide with sphalerite structure. It is shown that manganese in the presence of sodium chloride cubic lattice distorts zinc sulfide and decreases crystallographic symmetry.

DC EL devices having oxide semiconductor were proposed. The n-p-n structure formed with oxide semiconductors were used for current control. These structures also act as hot electron source under negative bias. As a p-type material, cupper aluminate was investigated. Phosphor deposited on the n-p-n structure, stable electroluminescence was observed.
We fabricated ZnO thin films on Si3N4 substrate as a luminescent film of Electron beam excitation assisted optical (EXA) microscope. Cathodoluminescence intensity of annealed films was enhanced by increasing annealing temperature. EXA microscope observation image with annealed at 1000°C could be acquired with high signal to noise ratio.

Red-emitting Na3AlF6:Eu3+ phosphors were synthesized in a single phase by solid-state reaction method using polytetrafluoroethylene as a fluoride source. These phosphors exhibited excellent luminescent efficiency under excitation at 395 nm. These results indicate that these phosphors are candidates of fluoride phosphors for near-UV LEDs.

New Eu-activated phosphors have been discovered using some Sc-based host crystals, which belongs to the perovskite-type structures. Ba2Sc2O5:Eu, BaScO2F:Eu, and Ba2ScO3F:Eu were synthesized. Eu2+ ions can be activated only in the BaScO2F. The optimum Eu2+ concentration of Sr-substituted BaScO2F is approximately at x = 0.025 by X-ray absorption fine structure measurements.

Blue-emitting Sr6Y2Al4O15:Ce3+ phosphors were synthesized in a single phase form by a conventional solid-state reaction method and their photoluminescence properties were characterized. The Sr6Y2Al4O15:Ce3+ phosphors exhibit broad blue emission band assigned to the transition from 4f05d1 excited state to 4f0 ground state of the Ce3+ ions.
PHp - 12  Study on Luminescence Properties of New Borogermanate Phosphors

T. Hasegawa, N. Sato, T. Ishigaki, S. W. Kim, K. Uematsu, K. Toda, M. Sato
Niigata Univ., Japan

Ca$_3$Y$_3$Ge$_2$BO$_{13}$:Ln$^{3+}$ (Ln = Eu, Tb and Sm) phosphors were synthesized by the conventional solid-state reaction method. Eu$^{3+}$- or Tb$^{3+}$-doped Ca$_3$Er$_3$Ge$_2$BO$_{13}$ phosphors showed strong red or green emission under the excitation at 254 nm. Sm$^{3+}$-doped Ca$_3$Er$_3$Ge$_2$BO$_{13}$ phosphor showed reddish-orange emission under the excitation at 405 nm.

PHp - 13  Photoluminescence of Perovskite-Type Alkaline-Earth Stannates Thin Films Using a Thick Nanosheet Seed Layer

H. Takashima, K. Ueda*, K. Ikegami
AIST, Japan
*Kyushu Inst. of Tech., Japan

We obtained the green color photoluminescence in [(Ca$_{0.97}$Mg$_{0.03}$)$_{0.98}$Tb$_{0.02}$]SnO$_3$ thin films. On a glass substrate with the seed layer prepared by spin-coat technique, oriented thin films of [(Ca$_{0.97}$Mg$_{0.03}$)$_{0.98}$Tb$_{0.02}$]SnO$_3$ with sharp and intense emission and transmittance > 80% have been successfully obtained.

PHp - 14  Synthesis of YVO$_4$ Nanophosphors by Microemulsion-Mediated Solution Method

Y. Yamazaki, A. Ikeguchi, A. Isomae, A. Kato
Nagaoka Univ. of Tech., Japan

YVO$_4$:Eu and YVO$_4$:Bi nanophosphors were synthesized by microemulsion-mediated solvothermal and polyol methods. YVO$_4$:Bi nanophosphor with 40 nm particle size without agglomeration was synthesized by microemulsion-mediated polyol method for the first time. The enlargement of particle size and decrease of PL intensity with lowering synthesis temperature were suppressed by introducing microemulsion.


N. Fujita, M. Iwao, S. Fujita, M. Ohji
Nippon Elec. Glass, Japan

Phosphor-glass composites, in which phosphors are dispersed, have been developed. The phosphor-glass composites are expected as the excellent wavelength conversion material for high power solid-state lighting, which have high-humidity resistance, long lifetime and extremely small deviation in emission color.
PHp - 16  **Double-Layered CuInS$_2$/ZnS Quantum Dot-Polymer Plate-Based High-Color Rendering White Light-Emitting Diode**  
*Hongik Univ., Korea*

A free-standing double-layered composite plate, consisting of highly bright orange and greenish-yellow CuInS$_2$ quantum dots (QDs) embedded in polymeric matrix, is combined with a blue light-emitting diode (LED). The QD plate-LED exhibits a high color rendering index of 81 and high luminous efficacy of 71.2 lm/W at 20 mA.

PHp - 17  **Silica-Embedded Quantum Dot-Based White LED and Effect of Silica on Device Stability Behavior**  
*Hongik Univ., Korea*

Blue-to-yellow light-convertible CuInS$_2$/ZnS quantum dots (QDs) are synthesized and then embedded into silica phase via a microemulsion. Bare and silica-embedded QDs are combined, respectively, with a blue LED for white QD-LED fabrication. These two white QD-LEDs are identically subjected to the continuous operation and compared with respect to device stability.

PHp - 18  **Withdrawn**

PHp - 19  **A Study on Thermal Characteristics for High Power LEDs**  
*S. Park, Y. Kim, G. Kim*  
*Samsung Display, Korea*

High-power LED was developed with 17 flip-chips performing 1,500 lumens. A mechanism of heat generation was analyzed and proposed for designing multi-chip LEDs to overcome limitation of 250 degree Celsius on a window in the LED for the application of backlight units.

PHp - 20L  **Improvement of Light Out-Coupling Efficiency by Coating MgO Nanoparticles in Inorganic TFEL Devices**  
*S. Kunioka, Y. Itagaki, K. Ohmi*  
*Tottori Univ., Japan*

An improvement of light out-coupling efficiency has been attempted in inorganic thin film electroluminescent (TFEL) devices coated with MgO nanoparticles. The luminance is increased by 1.5 times by coating the nanoparticles. The technique is effective to easily improve a luminescent efficiency especially for large area TFEL devices.
PHp - 21L  Photo-Luminescence from Carbon Nitride Thin Films Deposited by RF Sputtering Technique

M. Satake, T. Okawa, K. Itoh, K. Kametomo, K. Takarabe, S. Yamamoto
Ryukoku Univ., Japan
Okayama Univ. of Sci., Japan

Carbon nitride thin films were deposited at different RF powers in the range of 10 W to 100 W by radio frequency sputtering. The results of PL have shown that spectra shifted to blue wavelength by irradiating He-Cd laser. Content of nitrogen and C-Nsp\(^3\) bond increased by irradiating He-Cd laser.

PHp - 22L  Cathodoluminescent Properties of UV Emitting (Zn\(_{1-x}\)Mg\(_x\))Al\(_2\)O\(_4\) Phosphor

T. Ishinaga, H. Kominami, Y. Nakanishi, K. Hara
Shizuoka Univ., Japan

ZnAl\(_2\)O\(_4\) which shows UV emission under EB excitation has been investigated. The luminescent properties of (Zn\(_{1-x}\)Mg\(_x\))Al\(_2\)O\(_4\) were drastically changed by firing temperature and Mg-ratio. From the CL spectra, it is thought that the forbidden-gap became bigger according to increasing of Mg-ratio. Furthermore, another energy-level was formed in the phosphor surface.

PHp - 23L  Advanced Microreactor System with Glass Mixer Cell for Synthesizing Nanophosphors

Tottori Univ., Japan
Merck, Japan

A novel microreactor system combining with the Y-branch glass mixer cell has been proposed. YVO\(_4\):Eu,Bi red nanophosphor has been synthesized with in-situ pH monitoring. Spherical grains having about 50 nm in diameter has been obtained. The internal quantum efficiency is 30% under UV excitation at 300 nm.

PHp - 24L  Effect of Temperature and Chemical Potential of Anion on Kinetic Growth of Zinc Sulfide Nanocrystal

T. Lee, E. S. Kim, Y. Lee, D. Y. Jeon
KAIST, Korea

A kinetic growth process of ZnS NCs passivated by oleylamine ligands was studied in this research. Temperature and chemical potential effect of anion on kinetic growth was observed. Morphologies of NCs were changed by temperature to a shape such as rod, tetrapod, etc. We discussed them from a growth rate.
For improve quantum dots (QDs) thermal stability, we synthesized quantum dot embedded silica (QDES). Moreover applying QDES a white LED (WLED) was fabricated using QDES in thin polymer film. Using remote type packaging system, by stacking yellow phosphor in glass plate and QDES film we implemented WLED with high CRI.

Lunch

15:10 - 16:25 Meeting Room 204

PH1: Phosphors & Their Applications (1)

Chair: T.-M. Chen, Nat. Chiao Tung Univ., Taiwan
Co-Chair: R.-J. Xie, NIMS, Japan

PH1 - 1: Invited Finding New Eu\(^{2+}\) Doped Phosphors for Light-Emitting Diodes by Computational Chemistry
15:10
H. Takaba, R. Matsui
Kogakuin Univ., Japan

Theoretical screening of host materials of Eu\(^{2+}\) doped phosphor suitable for LED from more than 8900 oxide structures was carried out by computational chemistry techniques. Predicted result of emission wavelength and efficiency was analyzed with test calculations for conventional phosphors to check the validity of the screening method.

PH1 - 2: Invited Valence Estimation and Local Structure
15:35
Analysis of Luminescence Centers in Phosphor Materials by X-ray Absorption Spectroscopy
T. Honma, T. Kunimoto*, K. Ohmi**
JASRI, Japan
*Tokushima Bunri Univ., Japan
**Tottori Univ., Japan

We have reviewed the XAFS studies on BaMgAl\(_{10}\)O\(_{17}\):Eu, CuAl\(_2\):Mn and Y\(_3\)Al\(_5\)O\(_{12}\):Ce phosphors using transmission, fluorescence yield and conversion electron yield detection. The valence states and local structures of luminescent centers investigated by XAFS measurements will be compared with the luminescent properties of the phosphor materials in detail.
PH1 - 3:  
**Invited** High Resolution Optical Microscopy with Nanometric Light Source Excited with Electron Beam


*Shizuoka Univ., Japan  
**JST-CREST, Japan

We have developed electron beam excitation assisted optical microscope, and demonstrated its resolution higher than 50 nm. A light source in a few nanometers size is excited by focused electron beam in a luminescent film. The microscope makes it possible to observe living biological specimens in various surroundings.

----- Break -----

16:50 - 18:20  
Meeting Room 204

**PH2: Phosphors & Their Applications (2)**

Chair:  
J. Silver, Brunel Univ., UK

Co-Chair:  
K. Ohmi, Tottori Univ., Japan

**PH2 - 1:**  
**Invited** A Phosphor Sheet Providing Wider Color Gamut for LCDs and the Backlight System Using It

Y. Ito, T. Hori, T. Kusunoki, H. Nomura, H. Kondo

Dexerials, Japan

A phosphor sheet providing wider color gamut and having a simple structure with an aluminum film edge-seal was developed. Employing blue LEDs with spherical encapsulates can provide the backlight with higher brightness as well as wider color gamut. Sufficient reliability of it was also shown.

**PH2 - 2:**  
**Invited** Photoluminescent Quantum Dots in Display Products

S. Coe-Sullivan, W. Liu, P. Allen, J. S. Steckel

QD Vision, USA

In all geometries, QD LCDs will provide the broadest available color gamut to the user, in addition to potential benefits in power efficiency, brightness, and contrast. This work will compare and contrast the three primary geometries that will likely be explored during the pursuit of a potentially dominant design.

**PH2 - 3:**  
**Invited** A Novel Light Source for Projection Display

Y. Li, Y. Xu, F. Hu, Z. Tian

Appotronics, China

We present an advanced laser phosphor display technology (ALPD). Blue lasers are used to illuminate a rotating phosphor wheel. By keeping phosphor low working temperature, efficiency is maintained even at high power. Light source using ALPD is also compact and has long lifetime. It meets the requirement for commercial display.
Nematic Liquid Crystalline Phase of Red-Emitting HEu(MoO₄)₂ Nanoscroll

M. Watanabe, K. Uematsu, S. W. Kim, K. Toda, M. Sato
Niigata Univ., Japan

We synthesized the novel red-emissive nematic inorganic liquid crystal, HEu(MoO₄)₂ nanoscrolls by the exchange of K⁺ to H⁺ in KEu(MoO₄)₂ phosphor. This material exhibit red emission under excitation of 465 nm assigned to the f-f transition of Eu³⁺. Microscope images under crossed polarizers indicated HEu(MoO₄)₂ nanoscrolls show liquid crystal phase.

Author Interviews and Demonstrations
18:30 – 19:10

Friday, December 6

9:00 - 9:55 Main Hall A

PH3: Phosphors for Lighting
Special Topics of Interest on Lighting Technologies

Chair: Y. Li, Appotronics, China
Co-Chair: K. Hara, Shizuoka Univ., Japan

PH3 - 1: Invited New Blue Light Excitable Red-Emitting Phosphate Phosphor
9:00 Phosphate Phosphor
K. Toda, S.-W. Kim, T. Ishigaki, T. Hasegawa,
K. Uematsu, M. Sato
Niigata Univ., Japan

A novel red-emitting olivine-structure type phosphor NaMgPO₄:Eu²⁺ was synthesized for the first time by the melt synthesis technique. The NaMgPO₄:Eu²⁺ phosphor shows red emission band centered at 628 nm under blue light excitation. The internal quantum efficiency of this phosphor at the excitation wavelength of 450 nm was 81%.

PH3 - 2 Synthesis and Luminescence Characterizations of New Thiosilicates Phosphors for LED Lighting
Nat. Chiao Tung Univ., Taiwan
ITRI, Taiwan
**Nat. Synchrotron Radiation Res. Ctr., Taiwan

Unprecedented M(La₁₋ₓCeₓ)₂Si₄S₈ (M = Ca, Sr, Ba) phosphors were investigated and evaluated for potential application in white-light LEDs. The Ce³⁺-activated thiosilicates can be excited by near-UV to blue light and show green broadband emissions. Recent progress on their luminescence and applications are discussed.
Comparison of ACELs Formed on Copper, Silver and Gold Back Electrodes


Brunel Univ., UK
*Intrinsiq Materials, UK
**Johnson-Matthey Tech. Ctr., UK
***Printed Elect., UK

AC electroluminescent display panels were prepared by first ink-jet printing electrode structures (either copper, silver or gold) onto substrates, then screen printing first a single binder layer (containing both the ACEL phosphor powder and the barium titanate ferroelectric particles) before finally overprinting with a transparent conducting electrode.

----- Break -----
Cathodoluminescence spectra have been collected from eight nanometer-sized crystals of Gd$_2$O$_2$S:Tb$^{3+}$ using the Gatan Vulcan cathodoluminescence imaging spectrometer and the temperature dependence of the CL spectrum of a single nanometer-sized crystal reported. Slight variation observed in the 8 CL spectra are explained and discussed in relation to bulk samples.

Cathodoluminescence (CL) spectra have been collected from single nanometer-sized crystals of Y$_{1.9}$Tb$_{0.1}$O$_2$S using the Gatan Vulcan cathodoluminescence imaging spectrometer. The slight variation observed in the CL spectra taken from the four crystals are explained, and discussed in relation to bulk samples.

----- Lunch -----
Opening Remarks
9:00

H. Mimura, Shizuoka Univ., Japan

Chair: M. Nagao, AIST, Japan
Co-Chair: Y. Neo, Shizuoka Univ., Japan

FED1 - 1: Invited Field Assisted Photocathode with Plasmonic Antennas
9:10

M. Niigaki, T. Hirohata, W. Akahori
Hamamatsu Photonics, Japan

We present a novel field-assisted photocathode exhibiting an enhanced photoemission by plasmonic antennas fabricated on the surface. The plasmonic antennas serve to guide the incident photon fluxes into the nanoscale apertures of the photocathodes by the surface plasmon resonance.

FED1 - 2: Invited Active-Matrix Drive Circuit for Image Sensor Consisting of Field Emitter Array and Avalanche Photoconductor
9:40

Y. Honda, M. Nanba, K. Miyakawa, M. Kubota, N. Egami
NHK, Japan
*Kinki Univ., Japan

A novel active-matrix drive circuit was simulated and fabricated to develop a compact ultrahigh-sensitivity image sensor consisting of an active-matrix Spindt-type FEA and avalanche photoconductive film. Simulation and experimental results showed that the novel active-matrix drive circuit can shorten a response time and can potentially meet the HDTV standard.
By using a multilayer base electrode that consists of aluminum-2at% neodymium alloy, a hillock-less structure on the base electrode was fabricated, enabling the development of highly reliable MIM-cathode-arrays for large-size FED. As a result, the probability of short-circuits occurring between the scan-line and data-line was decreased to less than 0.001%.

----- Break -----

10:40 - 12:10 Meeting Room 206

FED2/PH4: Applications & New Materials

Chair: Y. Gotoh, Kyoto Univ., Japan
Co-Chair: T. Kusunoki, Dexerials, Japan

FED2/PH4 - 1: Invited Performance of Microcolumn for Fine Electron Beam Applications
10:40
Shizuoka Univ., Japan
Meijo Univ., Japan
AIST, Japan

The newly designed microcolumn consists of an acceleration lens and an electron gun, which is composed of a field emitter and a condenser lens. The microcolumn could focus the electron beam to a diameter of 40 µm at a working distance of 2 mm without any acceleration field to the anode.

FED2/PH4 - 2: Cathodoluminescence in Transparent Perovskite Films for RGB Colors
11:10
H. Takashima, M. Nagao
AIST, Japan

Thin-film cathodoluminescence has been successfully obtained in the chemically stable perovskite oxide films. By using the field emitter with a gate electrode for the source of electrons, high-quality blue, green and red color and whole-surface intense cathodoluminescence were observed.
Cathodoluminescence spectra have been collected from eight nanometer-sized crystals of Gd$_2$O$_2$S:Tb$^{3+}$ using the Gatan Vulcan cathodoluminescence imaging spectrometer and the temperature dependence of the CL spectrum of a single nanometer-sized crystal reported. Slight variation observed in the 8 CL spectra are explained and discussed in relation to bulk samples.

Cathodoluminescence (CL) spectra have been collected from single nanometer-sized crystals of Y$_{1.9}$Tb$_{0.1}$O$_2$S using the Gatan Vulcan cathodoluminescence imaging spectrometer. The slight variation observed in the CL spectra taken from the four crystals are explained, and discussed in relation to bulk samples.

----- Lunch -----
Evaluations for Graphene Flower Cloth as a Field Emitter and Its Applications

*Onizuka Glass, Japan
**Incubation Alliance, Japan
***Shizuoka Univ., Japan

We have fabricated a novel graphene material named graphene flower cloth (GFC). GFC has numerous graphenes for creating high electric field on the surface. Huge field emission current exceeding 1.5 mA from GFC was obtained. X-ray tube with the GFC will be demonstrated.

Fabrication of Carbon Nanotube Field Emitter with Side-Gate Electrode and Its Emission Property

S. Okawaki, S. Nitta, S. Abo, F. Wakaya, M. Takai
Osaka Univ., Japan

CNT field emitters with side-gate electrodes were fabricated by screen printing with several surface treatments and their emission properties were evaluated. The CNT field emitter with tape peeling showed the highest anode current. The CNT field emitter with KrF excimer laser irradiation and high-electric-field pulse aging showed the longest lifetime.

Microscopic Properties of Carbon Films That Remarkably Improves Field Emission Features

S. Horie, K. Asanagi, T. Higuchi, Y. Yamada, M. Sasaki
Univ. of Tsukuba, Japan

Field emission features are remarkably improved upon coating with flat carbon thin films consisting of nanometer-scale grains. Here, to clarify the mechanism, we have examined microscopic properties of shape-controlled W tips coated with the carbon films by using FIM and FEM.

Work Function Measurements of W(100) Surface Modified by Neodymium Oxide by Using PEEM and FEM

T. Kawakubo, H. Nakane*
Kagawa Nat. College of Tech., Japan
*Muroran Inst. of Tech., Japan

It is well known that the work function of W(100) surface is reduced after application of a very thin surface layer of transition metal and heating in an oxygen environment. In this research, we measured the work function of W(100) modified by Neodymium and oxygen by using PEEM and FEM.
Measurement of Work Function of Hafnium Nitride Films at Elevated Temperatures in Ultra High Vacuum

S. Fujiwara, S. Hogyoku, H. Tsuji, Y. Gotoh
Kyoto Univ., Japan

Hafnium nitride thin films were prepared by radio frequency magnetron sputtering, and the work function of the films was investigated at the temperatures up to 380°C in ultrahigh vacuum. The work function showed a monotonous decrease with the increase in the temperature.

Evaluation of Radiation Tolerance of Hafnium Nitride Field Emitter Arrays

Y. Gotoh, Y. Yasutomo, H. Tsuji
Kyoto Univ., Japan

Attempts to evaluate the radiation tolerance of hafnium nitride field emitter arrays was performed by comparing the current-voltage characteristics of the gate/insulator/emitter structure before and after exposure either to a proton or an alpha beam. No significant degradation of insulating property was observed up to the fluence of 10 µC.

Photoresponse of MOS Cathodes Based on Nanocrystalline Silicon

H. Shimawaki, Y. Neo*, H. Mimura*, F. Wakaya**, M. Takai**
Hachinohe Inst. of Tech., Japan
*Shizuoka Univ., Japan
**Osaka Univ., Japan

We investigate the photoassisted electron emission from metal-oxide-semiconductor (MOS) cathodes based on nanocrystalline silicon (nc-Si) induced by laser pulses. Here, we report the results on the photoresponse of the cathode device under illumination of blue laser pulses.
OLEDp1 - 1 Optical and Electrical Properties of MoO$_3$/Ag/MoO$_3$ Multilayer as Transparent Anode in Inverted Top-Emitting Organic Light Emitting Devices by Using Multistep Vacuum Deposition

M. Shibasaki, T. Matuzaki, K. Sakurai, T. Uchida
Tokyo Polytechnic Univ., Japan

We investigated the MoO$_3$/Ag/MoO$_3$(MAM) transparent conducting film (TCF) for inverted OLEDs. The MAM film was fabricated a transparent electrode by thermal evaporation with high transmittance and conductivity (68% and 6.1 $\Omega$/sq). The multilayer MAM film was suitable for a transparent electrode in OLEDs.

OLEDp1 - 2 Influence of Substrate Temperature on Luminance Characteristics of Organic Light-Emitting Diode Fabricated by Ultrasonic Deposition Method

A. Sato, T. Fukuda, N. Kamata, T. Yoshitomi*
Saitama Univ., Japan
Calsonic Kansei, Japan

We demonstrated organic light-emitting diode (OLEDs) fabricated by the temperature-controlled ultrasonic deposition method. The evaporation speed of the solvent affects the surface morphology of the organic thin film, and maximum luminance of 3,540 cd/m$^2$ and the current efficiency of 1.04 cd/A were achieved by optimizing the fabrication condition.

OLEDp1 - 3 Novel Polymerizable Liquid Crystal and Its Reverse Wavelength Dispersion Property

K. Sakamoto, K. Okuyama, S. Kiriki, K. Taira,
M. Aimatsu, H. Ooishi, H. Shu
ZEON, Japan

We have already reported a polymerizable liquid crystal, LCK-5001, and its reverse wavelength dispersion property that is suitable for OLED displays. This paper describes polymerizable liquid crystal, LCK-5059 that has improved reverse wavelength dispersion property. Optical performances of circular polarizing film using LCK-5059 was drastically improved from LCK-5001 films.
We demonstrate the efficiency control of organic light-emitting diodes with a hole-delay layer (HDL) by adjusting of the exciton recombination zone for high contrast ratio. An optimized HDL allows efficiency to suppress at the black level of active matrix driving mode and it gets greater at higher luminance.

Here, we used a single-layer mixed-host with SimCP2 to achieve the orange-red phosphorescent organic light-emitting diode with the current efficiency improved from 14.9 to 21.5 cd/A @ 500 cd/m² as compared with using PVK. A better charge balance obtained from SimCP2 host was the main cause for this high efficiency.

The polyimide-graphene composite films were made by film coating of mixture of polyamic acid with reduced graphene oxide. The flexible OLEDs were fabricated by using the polyimide-graphene composite films on ITO/Ag/ITO films were deposited by roll-to-roll sputter and properties of flexible OLEDs were examined from the viewpoint of flexible substrates.

In this paper, we have developed highly efficient white organic light-emitting devices using a single host structure. The mCP used as host for the blue and orange red phosphorescent Flrpic and Ir(2-phq)3 molecules. The maximum current efficiency was which is theoretically achievable efficiency of 55 cd/A.
OLEDp1 - 9 Highly Efficient Phosphorescent Yellow OLED for Two Peak White Tandem OLED Application

Y. J. Kim, Y. H. Son, S. H. Kim, J. H. Kwon
Kyung Hee Univ., Korea

We report highly efficient phosphorescent yellow OLEDs for tandem white OLED application. Fabricated device structure was ITO/ di-[4-(N,N-ditolyl-amino)-phenyl]cyclohexane (50 nm)/ bis[2-(2-hydroxyphenyl)-pyridine] beryllium: iridium(III) bis-(4-t-butylphenyl)thieno[3,2-c]pyridinato-N,C2 acetylacetonate) (3%, 10 nm)/ (1,3,5-tri[(3-pyridyl)-phen-3-yl] benzene (40 nm)/ LiF (1.5 nm)/ Al (100 nm). The extremely high EQE of 25.0%, current efficiency of 84.4 cd/A are reported.

OLEDp1 - 10 White Organic Light-Emitting Diodes Using p- and n-Type Emissive Host Materials with Single Red Dopant in Emitting Layer

*Hoseo Univ., Korea
**McMaster Univ., Canada

WOLEDs were fabricated using p-, n-type host materials and red dopant material with different structures of the emitting layer. The best performance out of devices was achieved when double emissive layer consists of BAIlq and DPVBi. Luminous efficiency and CIExy of WOLED were 7.13 cd/A at 50 mA/cm² and (0.34,0.33) at 8 V.

OLEDp1 - 11 Yellow Emitting Material for OLED and Remote Phosphor Application for Lighting

A. Stankevich, A. Murauski, A. Muravsky, V. Petushok, V. Olkhovic, V. Agabekov
NAS Belarus, Belarus

We investigated electrochemical properties of novel yellow luminescent material Pt284. This material shows good electrochemical stability on air conditions and have HOMO LUMO levels -5.28 eV and -2.78 eV respectively. Remote phosphor device with CEI color coordinates u=0.27 v=0.45 have been done using LED 460 nm and Pt284 in PBMA matrix.

OLEDp1 - 12 Flexible Thin Film Encapsulation with Spatially Resolved Atomic Layer Deposition

S. H. Yong, H. S. Yoo, S. M. Cho, H. Chae
Sungkyunkwan Univ., Korea

Al₂O₃ thin film was prepared by spatially resolved atomic layer deposition (ALD) process and the inorganic layer was used for OLEDs thin film encapsulation process. In this work we characterized various process variables in the spatially resolved ALD process.
OLEDp1 - 13 Characterization of Metal Nanowire Synthesis for Flexible Transparent Electrodes
S. Choi, W. Hwang, S. M. Cho, H. Chae
Sungkyunkwan Univ., Korea

Metallic nanowires are emerging transparent electrodes for their flexible property, high transmittance and conductivity. Specially, silver nanowires can be synthesized by the polyol method at low cost. As control the variables such as stirring rate, molar ratio of source and temperature, we can control the scale of silver nanowires.

OLEDp1 - 14 OLED Deposition System Using Plane-Source Evaporation Techniques
S.-H. Lai, C.-C. Chen, C.-C. Wang, F.-C. Tung,
S.-H. Chen, Y.-S. Wang
ITRI, Taiwan

The equipment with plane-type evaporation source for thin film evaporation is proposed. The parallel direct simulation Monte Carlo (DSMC) method is also developed for obtaining large-area uniformity for various organic materials on substrate. The system maintains film thickness non-uniformity of less than ±5% and provides high material utilization of over 70%.

OLEDp1 - 15 High Color Rendition White Organic Light-Emitting Diodes with Excimer and Fluorescent Emitter for Lighting Application
Y. Jiang, Z. Xie*, W.-Y. Wong*, H.-S. Kwok
Hong Kong Univ. of S&T, Hong Kong
*Hong Kong Baptist Univ., Hong Kong

A novel Pt based triplet emitter with broadband yellow-red emission, was employed in the fabrication of WOLEDs. This broadband emission was a result of the combined effect of monomer and excimer emission of the Pt compound. By mixing with BCZVBi, a high CRI of 95.6 WOLED was demonstrated.

OLEDp1 - 16 Electroluminescence Improvement of Quantum Dots Light Emitting Diodes through Organic Hole Transport Layer Optimization
M. D. Ho, D. Kim, N. Kim, H. Chae
Sungkyunkwan Univ., Korea

In this research, we investigated improvement of electroluminescence (EL) performance of QD-LED through a composition of organic hole transport materials (polymer and small molecules). Furthermore, the effects of thermal annealing of hole transport layer on the morphology and EL performance of QD-LED were also demonstrated.
OLEDp1 - 17L Withdrawn

OLEDp1 - 18L An Organic-Inorganic Hybrid Light-Emitting Diode Containing Molybdenum Disulfide Flakes inside the Emissive Layer

T.-H. Song, H. S. Lee*, J. H. Jeon**, S. Im†, W.-S. Hong

Univ. of Seoul, Korea
*Yonsei Univ., Korea
**Korea Aerospace Univ., Korea

Organic-inorganic hybrid light-emitting diodes were fabricated by inserting flakes of molybdenum disulfide in the middle of the emissive layer of a standard OLED. Brightness of the hybrid diode containing MoS₂ flakes was approximately three times higher than that of all-organic samples.

OLEDp1 - 19L MoO₃/Metal/MoO₃ Transparent Electrode for OLEDs

K. Banzai, S. Naka, H. Okada

Univ. of Toyama, Japan

MoO₃/metal/MoO₃ multilayers were prepared on glass substrate by a vacuum deposition for transparent electrode in organic light-emitting diodes (OLEDs). Thin silver was used as a metal layer. Bright emission that was similar to indium-tin-oxide anode device was obtained from the OLEDs with multilayer anode.

OLEDp1 - 20L Solution-Processed White Organic Light-Emitting Diodes


ITRI, Taiwan

The solution-processed white organic light-emitting diode composed of a newly developed yellow emitter, PO-08, and orange-red emitter, PR-08, are studied. White devices composed of the two emitters with power efficacies of 23.9 and 11.0 lm/W are reported at the brightness of ca. 1000 nits.

OLEDp1 - 21L Withdrawn
AMDp3/OLEDp2: AMOLED

Poster

13:40 - 16:40 Main Hall C

AMDp3/ OLEDp2 - 1 A Pixel Circuit for AMOLED Displays Compensating for Threshold Voltage and Mobility Variation

C.-K. Kang***, B.-D. Choi**
*Samsung Display, Korea
**Sungkyunkwan Univ., Korea

A new pixel circuit for an active-matrix organic light-emitting diode (AMOLED) is proposed with a novel driving scheme based on low-temperature, polycrystalline-silicon thin film transistors (LTPS TFTs). The proposed circuit consists of three n-type TFTs and a capacitor to successfully compensate for variations of the threshold voltage and mobility in the TFTs.

AMDp3/ OLEDp2 - 2 A Compensation Driving Gear for the Electronic Degradation of AMOLED

B.-J. Sun, Y.-Y. Huang, C.-H. Huang, S.-C. Huang
Chunghwa Picture Tubes, Taiwan

The threshold voltage degradation of AMOLED pixel circuit has improved with new programming method. The error rate of OLED current has decreased to 2.06% at least when the degradation ranges of threshold voltage are 0.33 and -0.33 V. The simulation result demonstrates that the proposed circuit can improve the stability current.

AMDp3/ OLEDp2 - 3 New Pixel Circuit Using a-IGZO TFTs to Compensating for OLED Luminance Drop of AMOLED Displays

P.-S. Chen, W.-Y. Chang, F.-C. Chang, C.-L. Lin
Nat. Cheng Kung Univ., Taiwan

This work presents a new pixel circuit design adopting amorphous indium-gallium-zinc-oxide (a-IGZO) thin-film transistors (TFTs) that compensates for the threshold voltage shift of the driving TFT and ameliorates the luminance drop of OLED for active-matrix organic light-emitting diode (AMOLED) display.
Low voltage operation of organic field-effect transistors (OFETs) with embedded source/drain electrodes has been demonstrated. Soluble small molecules of 2,7-dioctyl [1]benzothieno[3,2-b][1] benzothiophene and CYTOP were used as organic semiconducting and insulating layers, respectively. Low voltage operation (V_{DS}=-10 V) is shown by thinning the gate insulating layer of the OFETs.

**Author Interviews and Demonstrations**

18:30 – 19:10

**Thursday, December 5**

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| 9:00 - 10:30 | Conference Hall

**OLED1: Materials and Devices**

Chair: T. Wakimoto, Merck, Japan
Co-Chair: T. Inoue, TDK, Japan

**OLED1 - 1: Invited** New Routes of Triplet Harvesting in Organic Light Emitting Diodes

C. Adachi
Kyushu Univ., Japan

By using unlimited freedom of molecular structures, we designed new light emitting molecules having highly efficient delayed fluorescence. In this report, we clarify the molecular design and device architecture for high efficiency and demonstrate the promising reliability.

**OLED1 - 2: Invited** High Performance All-Phosphorescent Three Color White OLEDs Based on a New Blue Phosphorescent Emitter

S. Watanabe, S. Metz, P. Murer, H. Wolleb, G. Wagenblast, C. Lennartz, U. Heinemeyer, I. Münster BASF, Germany

The use of all-phosphorescent OLED lighting devices is mandatory to satisfy efficiency demands. However, due to the limitation of emission color and lifetime of blue phosphorescent emitters, color quality and lifetime are still limited. To overcome these limitations, a new class of stable pure blue phosphorescent emitters was developed.
Towards higher efficiency of OLED, development of blue-phosphorescent emitters is awaited. However, the short lifetime of blue phosphorescent OLED is regarded as the bottleneck of commercialization. We will report our technology which enables both high efficiency and long lifetime (EQE 23%, LT50 100khrs) by designing suitable host materials for emitters.

The relationship between molecular shape of blue fluorescent dopants (BDs) and device performance was studied. BDs with larger ovality had strong tendency to show higher orientation factor and higher EQE of over 10%. It was suggested that increasing parallel dipole contributed to higher optical out-coupling.
### Thursday December 5

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<th>Time</th>
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<th>OLED2: Display Technologies</th>
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| 10:40 - 12:00 |                | Chair: H. Kuma, Idemitsu, Japan  <br>Co-Chair: S. Enomoto, Toshiba Lighting & Tech., Japan  

**OLED2 - 1**  <br>10:40  
Active Matrix OLED Microdisplay for Augmented Reality Applications with Improved Color Space  
M. Thomschke, K. Fehse, B. Richter, P. Wartenberg, <br>R. Pfeifer, U. Vogel  
*Fraunhofer Ctr. for Organic Materials & Elect. Devices, Germany*  

Our contribution describes the optimization of OLED microdisplays to increase the color gamut and to reduce the OLED complexity. We show that these improvements can be reached by a 3-color RGB-white OLED approach that features a single layer multicolor emitting zone, respectively.

**OLED2 - 2**  <br>11:00  
Improved Bi-Directional Illumination Transparent White Organic Light-Emitting Diodes with Asymmetric Multilayer Electrode  
*Nat. Taiwan Univ. of S&T, Taiwan*  
*Ming Chi Univ. of Tech., Taiwan*  

A controllable bi-directional illumination from white organic light-emitting diode was demonstrated. By adjusting the transparency of transparent electrode, the bottom-to-top emission ratio can be modulated and exhibited more balanced properties than traditional transparent cathode. The use of asymmetric multilayer electrode showed a much improved current efficiency and total external efficiency.

**OLED2 - 3**  <br>11:20  
Wide View-Angle Top-Emitting Organic Light-Emitting Diodes Based on Green Fluorescent Dopant: Research on Transparent Electrode and Angular Characteristic  
*Ming Chi Univ. of Tech., Taiwan*  
*Nat. Taiwan Univ. of S&T, Taiwan*  

The authors reported a wide view-angle top-emitting organic light-emitting diode by using MoO_2/Ag/WO_3 (MAW) as an asymmetric dielectric/metal/dielectric transparent electrode. MAW electrode led to a further improved current density and luminance due to an efficient carrier injection and transport. Moreover, it also exhibited a low angular-dependent luminance for display technology.
Enabling Dark Injection SCLC to Characterize Trapping in OLED Charge Transport Layers

F. Bloom, O. Langguth, T. Canzler
Novaled, Germany

Dark injection space charge limited current (DI-SCLC) is used to evaluate hole transport layers (HTLs) with different trap concentrations resulting from different HTL purities. We show that by varying the measurement duty cycle DI-SCLC can determine in a sample with significant trapping the trap-free mobility and the mobility with traps.

13:30 - 14:55 Conference Hall

OLED3: Flexible and Backplane Technologies

Chair: K. Monzen, Nissan Chem. Inds., Japan
Co-Chair: Y. Sakai, Mitsubishi Chem., Japan

OLED3 - 1: Invited Polymer and Crystalline Small Molecule Organic Semiconductor Materials for Mass Produced Displays
Merck Chems., UK

We demonstrate how development of organic semiconductors, passive materials and formulation enables the manufacture of high performance OTFT arrays suitable for mass production of printed display backplanes. We utilize polymer or small molecule organic semiconductors, which can be printed or coated to fabricate OTFT’s with mobilities greater than amorphous silicon.

OLED3 - 2: Fabrication of High Performance, Flexible and Solution Processed OTFTs for Display Backplanes
K. L. McCall, B. A. Coombs, S. D. Ogier
Ctr. for Process Innovation, UK

This paper details progress towards optimum OSC/OTFT processing and performance to enable their integration into ultra-flexible AM-OLED backplanes. Using rapid solution processing and chemical wet etching we demonstrate high resolution OSC patterning, resulting in OTFT arrays on plastic with flexibility tested to 1mm bend radius.
Flexible AM-OLED Display on Ultra-Thin Glass

Chunghwa Picture Tubes, Taiwan

Last year, we had demonstrated the flexible EPD display using 0.1 mm ultra thin glass as substrate. Furthermore, we demonstrate 6-in. flexible AMOLED display on 0.1 mm ultra-thin glass in this year. The module thickness of the AMOLED display is about 0.25 mm which can realize thinner and lighter portable device.

Invited Flexible and Printed Organic TFT Devices and Integrated Circuits

S. Tokito
Yamagata Univ., Japan

Fine patterning of silver nanoparticle inks was demonstrated with spin-coating and inkjet printing processes were applied to the source and drain electrodes of organic thin-film transistors (OTFTs). Fully-printed OTFT devices and integrated circuits including pseudo-CMOS, logic and ring oscillator circuits were fabricated on plastic film substrates and showed good electrical performance.

----- Break -----
We fabricated polymer light emitting diodes (PLEDs) with highly conductive and transparent polymeric anode material, PEDOT:PSS, deposited by inkjet printing process. The PEDOT:PSS was doped with new element such as NMF and NMP. Our PLEDs shows the comparable efficiency to the device with the conventional ITO anode.

A new innovative technology for vacuum based fine patterning of organic materials is presented. The Flash-Mask-Transfer-Lithography is based on a transfer from a pre-patterned transfer-mask which design is close to actual LCD masks with flash-lamps as energy source. Results on resolution, layer morphology, fabricated OLEDs and OTFTs are presented.

This paper reports the features of the newly developed low viscous type desiccant and the hardening type one. By filling this transparent liquid desiccant directly into an organic EL panel, the generation and/or the growth of non-luminescent area inside the panel can be retarded.

IDW Best Paper Award
IDW Outstanding Poster Paper Award
These awards will go to the most outstanding papers selected from those presented at IDW ‘13. The 2013 award winners will be announced on the IDW website: http://www.idw.ne.jp/award.html
Thursday December 5

16:50 - 18:15 Conference Hall

OLED5: OLED for Lighting Applications
Special Topics of Interest on Lighting Technologies

Chair: Y. Kijima, Sony, Japan
Co-Chair: T. Ikuta, JNC Petrochem., Japan

OLED5 - 1: Invited Recent Progress of OLED Performance for Lighting Application
16:50

K. Furukawa, K. Kato, T. Iwasaki
Konica Minolta, Japan

To compete with LED in general lighting fields, one of the important and insufficient requirements for OLED lighting is the luminous efficacy. Recent progress of OLED performance, especially in phosphorescent materials and light out-coupling technology, will be discussed. In addition the alternative electrode technology to ITO will be touched on.

OLED5 - 2 Out-Coupling Enhancement of OLEDs with Diffractive Micro Lens Film
17:15

Y. Kurita, H. Koshitouge, K. Mizuhara, D. Okuno, T. Tokimitsu
Mitsubishi Rayon, Japan

A diffractive micro lens alley (MLA) film enhances emission from organic light-emitting diodes (OLEDs). The film had MLA molded on diffraction grating. The film showed superior improvement of out-coupling efficiency, luminous intensity and chromatic stability. The simulation results explained the advances of these films.

OLED5 - 3 Highly Transmissive One-Side-Emission OLED Panel with Solid Encapsulation and Peripheral Grid Electrode
17:35

Toshiba, Japan

We developed a transmissive one-side-emission OLED panel with solid encapsulation and peripheral grid electrode to enhance the transmittance of whole panel. The transmittance of solid encapsulation was 1.2 times higher than that of cavity encapsulation. As a result, we achieved the high transmittance of ~65% for the whole panel.
We reported a 56-in. indium tin zinc oxide thin film transistors active-matrix organic light-emitting diode television. The long range threshold voltage uniformity is ~0.98 V. The mobility can reach $33.2 \text{ cm}^2/\text{Vs}$. It’s ~3.3 times of amorphous indium gallium zinc oxide thin film transistors. The thin film transistor shows an excellent characteristic.
**Poster 3Dp: 3D and Hyper-Realistic Displays**

**3Dp - 1**  
**Development of 55-in. Active Retarder 3D Displays**  
W. H. Hu, Y. P. Liao, L. Q. Guo, Y. F. Du, C. G. Huang,  
X. B. Shao, D. K. Yoon, D. Wang, Z. Z. He, Y. B. Yu,  
Beijing BOE Display Tech., China

We have successfully demonstrated a 55-in. Active Retarder 3D display with no flicker and full resolution image. We have evaluated warm-up time which is special features for OCB mode. And the effects of driving pulse on crosstalk have also been studied. The warm-up time below 70 second and crosstalk below 3.0% is available.

**3Dp - 2**  
**Multiple Line R/L Inversion Method for 4K 2K 3DLCDs**  
K. Matsuhiro*  
*Arisawa Manufacturing, Japan

A new 3D LCD technology to obtain 4K2K full resolution 3D images and simultaneous perception of right and left eye images by using the Xpol and a double lines R/L inversion method was studied. The double lines R/L inversion method gives the vertical 3D viewing angle of +/- 15 degrees.

**3Dp - 3**  
**An Apparatus with Easy Processes Used to Visually Evaluate Imaging Performance with Respect to Color Subpixel Arrangements in Autostereoscopy via Lenticular Lenses**  
C.-Y. Yeh, Y.-C. Wang, C.-R. Sheu  
Nat. Cheng Kung Univ., Taiwan

We investigate imaging performance for various color subpixel arrangements of FPDs via a simulated apparatus like a real autostereoscopic display. It is obvious that serious color separation occurs when using vertical rather than horizontal or mosaic color subpixel arrangements. In addition, a quantitative evaluation with visual perceptions is also compared.
Wednesday

3Dp - 4  Viewing Zone Expansion for Autostereoscopic Display with Directional Backlight Using Convex Lens Array

T. Mukai, H. Kakeya
Univ. of Tsukuba, Japan

This paper proposes a couple of methods to expand viewing zone of autostereoscopic display with directional backlight composed of convex lens array and dot matrix light source. In this paper the crosstalk that emerges in the conventional method and the proposed methods is analyzed based on the optical simulation.

3Dp - 5  Enhanced Diffraction Efficiency of Switchable Holographic Splitter for Stereo-Display

W.-C. Su, H.-Y. Hsiao
Nat. Changhua Univ. of Education, Taiwan

Two electrically controllable holographic polarization gratings are spatially multiplexed to serve as an image splitter for stereogram application on display panel. A higher diffraction efficiency of the proposed holographic grating was generated by applying an external AC voltage during recording process.

3Dp - 6  ADS Mode Shutter Glasses 3D Display System Research of Crosstalk

Beijing BOE Display Tech., China

Crosstalk is a big problem in 3D display, exactly in ADS mode LCD. This paper is based on ADS Mode shutter glasses 3D to do the in-depth study. Several directions has been analyzed, including backlight, LCD driving, Liquid Crystal response and temperature, and put forward for improving image quality.

3Dp - 7  Visual Comfort for Advanced 3D Image Scaling

Nat. Taiwan Univ. of S&T, Taiwan
*AU Optronics, Taiwan

The aim of this paper is to explore visual comfort when the objects in 3D image contents are scaled with different scaling ratios. We investigated the 3D visual comfortable threshold in terms of scaling 3D content, changing distances between two objects on an autostereoscopic display of 3D laptop computer.
In this study, we measured simultaneously the variation of subject’s visual accommodation and convergence as they viewed handheld 3D games consoles. We changed the intensity of illumination as well as the brightness of the viewing screen to understand how accommodation and convergence were dependent on pupil diameter.

A projector-style display system was newly created, in which a scent was emitted to viewers directly through a display. The purpose of the system was to enhance the viewers to acquire more feelings. Then its psychological influence on viewers was analyzed through a gaze detecting device.

In this paper, we propose a new DFD (Depth-fused 3D) display in which LED pixels of front and rear panels are not overlapped at all. Even in this non-overlapped DFD display, perceived depth can be successfully changed almost linearly by changing luminance ratio between front and rear LED panels.

We propose a new DFD (Depth-fused-3D) viewer composed of two pairs of small-gap front/rear planes with a large-gap to estimate how background-image influences to perceived depth of 2D/3D image. The results indicate that perceived depths of 2D/3D images are increased when background-image with different depth is added behind 2D/3D images.
Magnifying a Three-Dimensional Image Displayed by a Volumetric Display Based on Optical Scanning of an Inclined Image Plane

Y. Maeda, D. Miyazaki, T. Mukai
Osaka City Univ., Japan

We propose to include an image magnification system in a volumetric display based on image plane scanning for creating a large three-dimensional (3D) volume image without using a large optical scanner. The 3D volume image magnified more than twice in length of each side was displayed.

Reduction of Ghost 3D Image in the Volumetric 3D Display by Using a Half-Wave Plate to Polarization-Switching Device

T. Kurokawa, R. Tanimoto, Y. Okada, H. Yamamoto, S. Suyama
Univ. of Tokushima, Japan

In order to remove ghost 3-D image in our volumetric 3-D display, we estimated the characteristics of inappropriate polarization light in polarization-switching device and propose improvement method to inappropriate polarization light. By using a half-wave plate behind polarization-switching device, we can successfully suppress ghost 3-D image to invisible.

One-Colored Time-Division Electroholography Using a NVIDIA GeForce GTX TITAN

Kochi Univ., Japan
*VASA Entertainment, Japan
**Chiba Univ., Japan

We tried to display the real-time reconstructed 3-D image consisting of a large number of object points. We propose one-colored time-division electroholography using the persistence of vision. Finally, we succeed to display a reconstructed 3-D image consisting of 44,647 object points using a NVIDIA GeForce GTX TITAN at 12 fps.

Large-Scale Digital Holographic Display with Wide Viewing Angle

ETRI, Korea
*Kyungpook Nat. Univ., Korea
**Korea Univ., Korea
***Chungnam Nat. Univ., Korea

Holographic display system with 22-in. LCD panel is developed to provide wide viewing angle and large holographic 3D image. It is realized by steering a narrow viewing window resulting from very large pixel pitch compared to the wave length of laser light.
We constructed a semi-portable full-color electro-holographic display with small size. The system can be assembled at ease. This system displays high resolution full-color holographic movie calculated by computer generated holograms, and enables observers to view the augmented reality scene with see-through structure.

We have implemented Computer Generated Hologram calculation into GRAPE-DR processor. GRAPE-DR is one of multi-core processors and has 512 processor elements. The calculation speed of the GRAPE-DR system is about 8.8 times faster than that of CPU at 11,632 particles. It is expected that this system will contribute to 3DTV.

Real-time electroholography requires the high computational performance. The study of fast parallel computation using excellent cost-effective and general-purpose computer system as multi-GPU system is very important. We proposed the parallel algorithm to compute multiple computer-generated holograms using multi-GPU cluster system with infiniband network simultaneously.

We proposed a real-time time-division color electro-holography using a USB-to-Parallel module for simple synchronous control of one-chip RGB LED. The pro-posed system is low-priced. Host PC can directly synchronize the lighting of one-chip RGB LED with the CGH computation by using Message Passing Interface (MPI).
3Dp - 21L Improving Viewpoint Interpolation Image Quality by Displaying Images in Stereoscopic 3D

M. Date, Y. Honda*, H. Takada, S. Ozawa, S. Mieda, A. Kojima

NTT, Japan
*Nagoya Univ., Japan

Image quality of viewpoint interpolation using linear blending was evaluated by subjective test. By displaying images in stereoscopic 3D, image quality was significantly improved compared with that of 2D. It was also discovered that binocular image differences are essential for achieving this improvement.

3Dp - 22L Accommodative Response while Gazing Moving 3D Objects and the Effects of Aging

T. Ikeda, Y. Okada, M. Miyao

Nagoya Univ., Japan

We carried out experiments to obtain a relationship between aging and response speed of accommodative focus for various movements of 3D targets. In the experiments, we measured accommodative change and pupil diameter. This study found dependency between accommodative response and the effects of aging.

3Dp - 23L The Degree of Recognition of the 3D Image Jumping Out in a Very Large Disparity

T. Ohashi, T. Kojima, Y. Honda, M. Miyao

Nagoya Univ., Japan

We carried out experiments targeting about the 100 young and elderly subjects to verify the visibility of 3D contents. Most subjects recognized that the 3D object projected from the screen at the parallax of 2.0. Moreover, each of the subjects recognized the virtual image near the theoretical condition.

3Dp - 24L Influence of Latency on Perceived Depth with a 3D Display Based on Monocular Motion Parallax


Univ. of Tokushima, Japan
*Hiroshima Univ., Japan

We have developed a 3D display system based on purely motion parallax. Use of a high speed camera enabled 1000 Hz sampling of a viewer’s position. High speed sampling provides smooth pursuit to the viewer’s movements. Influence of latency on perceived depth has been investigated experimentally.
3Dp - 25L Analysis of the Depth of Field by Lens-Tilt Imaging
Y. Yoshida, S. Suyama, H. Yamamoto
Univ. of Tokushima, Japan

We propose a method to control the depth of field continuously with the shooting angle and the tilted angle of the lens. This configuration is derived from a practical shooting problem based on lens-tilt imaging. The proposed method blurs objects that give double images in a stereoscopic display.

3Dp - 26L Perceived Depth Change in Edge-Based DFD Display by Shifting Edge Pattern outside from Overlapped Position
T. Soumiya, A. Tsunakawa, H. Yamamoto, S. Suyama, H. Kuribayashi
Univ. of Tokushima, Japan, Nikon, Japan

We have investigated perceived depth change by shifting edge pattern horizontally from overlapped position in edge-based DFD display. Perceived depth dependence is almost the same when amount of shifting edge pattern is under disparity of front and rear plane, which indicates viewing angle can be increased by appropriate edge shift.

Thursday, December 5

9:00 - 10:15 Mid-sized Hall B
3D1: Practical 3D Systems
Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: J.-Y. Son, Konyang Univ., Korea
Co-Chair: S. Yano, Shimane Univ., Japan

3D1 - 1 Invited 3DTV Broadcasting Technologies, Trials, and Standardization Effort in Korea
9:00
J. Kim, S. Cho, S.-H. Kim, J. S. Choi
ETRI, Korea

In this paper, recent efforts on development of various 3DTV broadcasting technologies, field trials and standardization from Korea will be presented. Some technical details of different schemes are explained, followed by current status and future prospect.

3D1 - 2 A Service Compatible 3DTV Broadcasting System
9:20 Based on MPEG-2 and HEVC
ETRI, Korea

We propose a service-compatible 3DTV system which consists of 3DTV encoder using MPEG-2 and HEVC, auto-synchronizing 3DTV multiplexer and 3DTV receiver. We verify in this paper that the proposed 3DTV system guarantees higher video qualities of HDTV as well as 3DTV than those of the current 3DTV system using AVC/H.264.
3D1 - 3 Stereoscopic Display System with Integrated Motion Parallax
M. F. Flynn, J. C. Tu
zSpace, USA

We present a description of a time sequential stereoscopic display which separates the images using a segmented polarization switch and passive eyewear. Additionally, integrated tracking cameras and an SDK on the host PC allow us to implement motion parallax in real time.

3D1 - 4L Inpainting Embedded Virtualized-Reality Indoor Modeler
10:00
K. Thangamani, T. Ishikawa*, K. Makita, R. Ichikari, T. Kurata
AIST, Japan 'Kodo Lab, Japan

This paper discusses the integration of the inpainting algorithm with the virtualized-reality indoor modeler. Embedding of the texture and structure preservable inpainting method with the virtualized-reality indoor modeler makes the whole system interactive and intuitive.

----- Break -----
An Algorithm to Reduce Background Distractions for Improving Visual Comfort of Stereoscopic Images

P.-L. Sun, I.-T. Chang, N. Chang*, H. Tsao*

Nat. Taiwan Univ. of S&T, Taiwan
*AU Optronics, Taiwan

A fast algorithm for improving visual comfort of 3D images is proposed to reduce contrast and sharpness of background and objects where the disparities are considerably different to the main objects. It consists of Focal Plane Estimation, Blurred Layer Generation and 3-Layer Image Fusion.

The Effects of Viewing a Lengthy Film in Stereoscopic on the Human Body

K. Yoshikawa, Y. Okada, T. Kojima, H. Takada*, M. Miyao

Nagoya Univ., Japan
*Univ. of Fukui, Japan

The equilibrium function in humans can deteriorate when viewing three-dimensional (3D) films. We measured body sway and focus distance of accommodation and convergence while subjects viewed 3D films. In this study, we examined the effects of a watching a long stereoscopic film on human equilibrium and visual accommodation and convergence.

Assessing the Impact of Crosstalk on 3D Image Quality Using EEG

Y. He, Y. Tu, L. Wang, W. Zhang*

Southeast Univ., China
*Shenzhen China Star Optoelect. Tech., China

We investigate the impact of crosstalk on three-dimensional image quality using Electroencephalogram and demonstrate that the presence of crosstalk reliably elicits a measurable response in the brain. We furthermore show that the reaction varies depending on the seriousness of crosstalk. It may be used to objectively quantify image quality.
16:50 - 18:10 Mid-sized Hall B

3D3: Holography

Chair: J.-W. Kim, ETRI, Korea
Co-Chair: K. Yamamoto, NICT, Japan

3D3 - 1: Invited New Multi-Color and Rewritable Holographic Polymer Film for 3D Holographic Display
16:50
S. Miura, S. Kobayashi
Toyo Kohan, Japan

We have developed a new multi-color holographic polymer film that can be recorded and reconstructed with the ability to rewrite the image. Our film produces a high diffraction efficiency and adequate image quality.

3D3 - 2: Display Chips for Electro-Holographic Display
17:10
J.-Y. Son, C.-H. Lee*, V. P. Guschin, M.-C. Park**
Konyang Univ., Korea
*Joongbu Univ., Korea
**KIST, Korea

The display chips are promising display devices for hologram display, but the diffraction pattern induced by the digital nature of the pixel array and the regularity in the fringe pattern of the hologram deteriorate the reconstructed image quality. To mitigate the deterioration, the image should made smaller and brighter.

3D3 - 3: Enlargement of Viewing Zone of a Holographic Image Generated from an Image Captured by Integral Photography
17:30
T. Hayashi*,**, N. Hirata*,**, Y. Ichihashi*, K. Yamamoto*,
T. Kakue*, T. Shimobaba*, T. Ito**
*NICT, Japan
**Chiba Univ., Japan

We succeeded in enlarging the viewing zone of a holographic image which was generated from an image captured by integral photography (IP). We confirmed that we could observe the image of a large viewing zone (~15 degrees) by using a lens array having a short focal length (2.2 mm).

IDW ’13 Tutorial in Japanese
Organized by SID Japan Chapter
Tuesday, December 3, 2013
Mid-sized Hall B, 1F
Sapporo Convention Center
Detailed information is available on http://www.sidchapters.org/japan/
A head-mounted display combined computer-generated hologram for vision training was proposed in this study. The hologram based on modified Gerchberg–Saxton algorithm to calculate the phase distribution of light wave in different disparity patterns, the images with the position multiplexing are therefore successfully coded as phase only function.

Author Interviews and Demonstrations
18:30 – 19:10

Friday, December 6

<table>
<thead>
<tr>
<th>9:00 - 10:20</th>
<th>Mid-sized Hall B</th>
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<tr>
<td><strong>3D4: 3D Display (1)</strong></td>
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<tr>
<td><strong>Chair:</strong></td>
<td>H. Y. Lin, Nat. Taiwan Univ., Taiwan</td>
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<tr>
<td><strong>Co-Chair:</strong></td>
<td>M. Tsuchida, NTT, Japan</td>
</tr>
</tbody>
</table>

**3D4 - 1:** 
**Invited Content-Aware Image Manipulations Based on Depth of Scene**
9:00

K. Utsugi, T. Naemura*
Hitachi, Japan
*Univ. of Tokyo, Japan

We studied techniques of computer aided artistic manipulation for depth cue representation and introduce two of them in this work: (1) stereo image retargeting to change the image aspect ratio while preserving depth, and (2) multi-perspective rendering to exaggerate pictorial depth cue in a manner analogous to hand-drawn illustrations.

**3D4 - 2:** 
**Withdrawn**

**3D4 - 5L**

**Comfort Fusion Evaluations of a Stereo Image Pair Using the Structure Similarity**
9:20

C.-H. Wen, Y.-H. Li, N. Chang*, H. Tsao*
Nat. Taiwan Univ. of S&T, Taiwan
*AU Optronics, Taiwan

This paper proposes a comfort fusion approach for a stereo image pair using the structure similarity. The experiment was conducted to investigate the comfort fusion of stereo image pairs in terms of Structure Similarity and Peak Signal-to-Noise Ratio. Results indicated that there were different criteria for 3D to conventional 2D.
We propose a 4-view parallax barrier system based on time-division multiplexing that shows full resolution per view, and apply it as a 2-view system with wider viewing zone. We also reduce flickers of 4 time-division system under 120 Hz by applying time-division anaglyph and adjusting the width of parallax barrier.

In this paper, CSOT will show a method that can reduce 3D crosstalk, and remove flash or scanning function in a 3D display backlight unit. B/W crosstalk is less than 0.15%; average G2G crosstalk is less than 5%. This method could reduce BLU’s cost and get better 3D image quality.

----- Break -----
Modification of Lenslet Shape of Lenticular Lens Array for Auto-Stereoscopic Multi-View Display

F. Mukhtarov, S. D. Hwang
Samsung Elect., Korea

Multi-focus and elliptic cylindrical lenslet concept for lenticular lens array show us promised diffuser-free solutions for auto-stereoscopic multi-view display, which is not only decrease cost and complicity of glasses-free 3D TV set, but also improves image quality: increase image contrast ratio and decrease multi-view crosstalk.

A Novel Electrode Structure of LCL Lens Designed for 55-in. 3D/2D Switchable Auto-Stereoscopic Display

Q. S. Liao, C. M. Yang, C. W. Chen, C. C. Hsiao
Shenzhen China Star Optoelect. Tech., China

We proposed a liquid-crystal-lenticular (LCL) lens for 55-in. 3D/2D switchable auto-stereoscopic display. A novel electrode structure was employed to obtain a parabolic effective refractive index (neff) profile. The measured neff profile matched well with simulated profile. Moreover, the distinction of each electrode control the neff profile was investigated.

Super Multi-View Display with 1-mm-pitch Viewpoints and Accommodation Measurements

Y. Toda, J. Takagi, Y. Takaki
Tokyo Univ. of A&T, Japan

A viewing-zone scanning super multi-view display was optimized to enable low-crosstalk generation of viewpoints with a pitch of 1 mm. The accommodation measurements show that accommodation was appropriately evoked when three-dimensional images were displayed at distances of 500 - 750 mm from viewers.

Author Interviews and Demonstrations
16:40 – 17:20

Supporting Organizations:
3-D Image Technology Research Group, ITE
Holographic Display Artists and Engineers Club
Workshop on Applied Vision and Human Factors

Wednesday, December 4

13:40 - 16:40 Main Hall C

Poster VHFp1: Applied Vision and Human Factors (AR)
Special Topics of Interest on Augmented Reality and Virtual Reality

VHFp1 - 1 A Cognitive Model for Fast Recognition in Images Displayed by Automotive Augmented Interface Systems
H. Hasegawa, S. Yano, S. Okabayashi, T. Wake*
Meijo Univ., Japan
*Kanagawa Univ., Japan

We have proposed and verified a new cognitive model, called “Mental Expansion”, to explain the superiority of automotive Augmented Reality Interface Systems (ARIS) incorporating AR technologies, over other automotive display systems based on visual optical experiments.

13:40 - 16:40 Main Hall C

Poster VHFp2: Applied Vision and Human Factors

VHFp2 - 1 Kansei Evaluation of Skin Colors under Different Color Temperatures of White LEDs
C.-J. Chou, J.-W. Huang, H.-S. Chen
Nat. Taiwan Univ. of S&T, Taiwan

The aim of this study is to find the emotional relationships between skin colors and white LEDs. The skin color samples were evaluated under different conditions of white LEDs and simulated daylights. Psychophysical experiment was conducted to investigate color emotional responses of skin colors.

VHFp2 - 2 Calculated and Measured Values of the Helmholtz-Kohlrausch Effect in Natural Images
Shizuoka Univ., Japan
*NEC Display Solutions, Japan

In this study, we propose a derivation method of the Helmholtz-Kohlrausch effect in natural images. The calculated values are derived by the prediction equation of the Variable-Chromatic-Color method adapted to natural images. It confirmed the effectiveness of the calculated values by comparing it with the measured values.
The 3D LAB color gamuts of RGBW-based OLED under varying ambient lighting conditions were evaluated. The performances of RGB-to-RGBW conversion algorithms were approached in terms of image’s color channels and 3D LAB color gamut. The RGB to RGBW conversions at different RGB stages were also discussed in this study.

This study was to evaluate lighting quality of LED light fixture based on human visual perception. We present the perceived brightness and visual comfort under different LED stimuli and surrounding lighting conditions. An evaluation model is established and the rendered image represents the brightness information for LED light fixture.

In this paper, quantitative measures of motion induced artifacts on OLED TVs are determined based on a small set of measurements using a pursuit camera and simulations based on colorimetric modeling. Performance of the proposed measure is verified by comparing calculated values of measures and results of human visual experiments.

We examined effects of 3D display on performance for change detection task using spatial CG images comparing with those of 2D display. We found that displacement in 2D would be easier to be detected than displacement in 3D. We also found that subjective task difficulty could significantly affect the task performance.
VHFp2 - 7  A Method for Quantitative Assessment of Elderly Cognitive Function While Driving
K. Miyabe, Y. Ogura, H. Yamasaki, M. Yamada, S. Yamamoto, T. Nakano
Meijo Univ., Japan

Almost elderly traffic accidents are caused by decrease in cognitive function (attention, etc.). We have developed the method for measuring and evaluating cognitive function while driving and have constructed the new driving simulator. Some experiments by elderly drivers have largely showed the effectiveness of this method and driving simulator.

VHFp2 - 8L Comparison of Visual Fatigue When Reading on Electronic Paper and Tablet LCDs
H. Isono, H. Yaguchi
Tokyo Denki Univ., Japan

We conducted comparison testing of visual fatigue when subjects read for 90 minutes using electronic paper and tablet LCDs by means of objective evaluation and subjective evaluation. The results clearly indicated that visual fatigue was greater when reading using a tablet LCD in comparison with electronic paper.

VHFp2 - 9L Effect of Blue Light on Visual Fatigue When Reading on LED-Backlit Tablet LCDs
H. Isono, A. Kumar*, T. Kamimura, Y. Noguchi, H. Yaguchi
Tokyo Denki Univ., Japan
*IIT-H, India

We examined the visual fatigue caused when reading on LED-backlit tablet LCDs in white and sepia background. The results indicate that when we switch from white to sepia background, the eye strain reduces, suggesting that the high intensity blue light emitted from LED-backlit tablet LCDs adds to visual fatigue.

VHFp2 - 10L A Novel Method of Display Evaluation through Development of Image-Measurement-Based Metric
Samsung Elect., Korea

Purpose of this study is to propose a novel method of display evaluation which modifies the procedure of appearance-based metric specified in ISO19751. An image-measurement-based metric is developed with 2D colorimetric-device. It provides a measurement of objective display performance as well as the image quality attributes of digital images perceived.
Thursday, December 5

13:30 - 14:45 Mid-sized Hall B

DES4/VHF1: Sensing Technologies for Virtual/Augmented Reality
Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: M. Kanbara, Nara Inst. of S&T, Japan
Co-Chair: J. Bergquist, Nokia, Japan

DES4/VHF1 - 1: Invited Position and Direction Estimation System of User's Viewpoint for Wide Indoor Environment
13:30
M. Kanbara
Nara Inst. of S&T, Japan

This paper introduces real-time viewpoint estimation system with invisible markers for wide indoor area. The system can estimate the position and direction of user's viewpoint precisely by affixing wallpapers containing printed invisible markers on ceilings. This system can be applied to augmented reality, view depended display or human robot interaction.

DES4/VHF1 - 2: Useful Field of View in Augmented Reality: Comparison Between Distribution of Attention
13:55
Osaka Univ., Japan
*Kansai Univ. of Welfare Scis., Japan
**Toshiba, Japan

We conducted two experiments to compare binocular and monocular observations when an Augmented Reality image was presented during a useful field of view (UFOV) task. We found the detection of a luminance change in the peripheral field of view was more difficult under binocular AR observation than under monocular observation.

DES4/VHF1 - 3: Invited e-Heritage, Cyber Archaeology, and Cloud Museum
14:15
T. Oishi, K. Ikeuchi
Univ. of Tokyo, Japan

This paper summarizes our research project, e-Heritage, to digitize cultural heritage assets over the world. We also propose cyber archaeology that provides new findings based on the digital analysis on those data. e-Heritage data is uploaded to cloud as well as archeological findings for a comprehensive visualization system.

----- Break -----
Thursday December 5

15:10 - 16:30 Mid-sized Hall B

3D2/VHF2: Visual Comfort for 3D Display

Chair: K. Utsugi, Hitachi, Japan
Co-Chair: S. Clippingdale, NHK, Japan

3D2/ VHF2 - 1: Invited Evaluation of Fatigue Caused by Watching 3DTV
15:10 T. Morita
NHK, Japan

To evaluate the fatigue caused by watching 3DTV under conditions that resemble typical viewing situations at home, we conducted experiments with 500 participants who watched 3D programs for approximately one hour on commercially available 3DTVs. This report describes the findings of fatigue caused by watching 3DTV based on these experiments.

3D2/ VHF2 - 2: An Algorithm to Reduce Background Distractions for Improving Visual Comfort of Stereoscopic Images
15:30 P.-L. Sun, I.-T. Chang, N. Chang*, H. Tsao*
Nat. Taiwan Univ. of S&T, Taiwan
*AU Optronics, Taiwan

A fast algorithm for improving visual comfort of 3D images is proposed to reduce contrast and sharpness of background and objects where the disparities are considerably different to the main objects. It consists of Focal Plane Estimation, Blurred Layer Generation and 3-Layer Image Fusion.

3D2/ VHF2 - 3: The Effects of Viewing a Lengthy Film in Stereoscopic on the Human Body
Nagoya Univ., Japan
*Univ. of Fukui, Japan

The equilibrium function in humans can deteriorate when viewing three-dimensional (3D) films. We measured body sway and focus distance of accommodation and convergence while subjects viewed 3D films. In this study, we examined the effects of a watching a long stereoscopic film on human equilibrium and visual accommodation and convergence.
Assessing the Impact of Crosstalk on 3D Image Quality Using EEG

Y. He, Y. Tu, L. Wang, W. Zhang
Southeast Univ., China
Shenzhen China Star Optoelect. Tech., China

We investigate the impact of crosstalk on three-dimensional image quality using Electroencephalogram and demonstrate that the presence of crosstalk reliably elicits a measurable response in the brain. We furthermore show that the reaction varies depending on the seriousness of crosstalk. It may be used to objectively quantify image quality.

Author Interviews and Demonstrations
18:30 – 19:10

Friday, December 6

VHF3: Improving Visual Experience

9:00 - 10:15 Meeting Room 204

Chair: T. Kurita, NHK, Japan
Co-Chair: A. Yoshida, Sharp, Japan

VHF3 - 1: Invited Using Image Dimension Dissection to Study Viewer Preferences of Luminance Range in Displayed Imagery
9:00
S. Daly, T. Kunkel, S. Farrell
Dolby Labs., USA

A viewer preference study was performed to find how much luminance range High Dynamic Range (HDR) displays should have. Careful experimental design bypassed hardware limitations such as absolute range, signal limitations such as quantization and clipping, and perceptual effects such as simultaneous contrast, Steven’s effect, Hunt effect, and sharpness-contrast interactions.

VHF3 - 2: Invited UHDTV Systems for Wide-Gamut Color Reproduction
9:30
K. Masaoka, T. Soeno, T. Yamashita, Y. Nishida, M. Sugawara
NHK, Japan

ITU-R Recommendation BT.2020 specifies wide-gamut system colorimetry for ultra-high definition television (UHDTV). The color gamut covers most object colors. This paper introduces the design process of our proposal to the ITU-R standard system colorimetry for UHDTV and the development of our 8K camera and laser projector.
We propose a real-time animation technique for virtual fitting applications. Our method uses key frames finding from a database which uses skeletal data as a search key, and then create in-between images by using morphing processing.

----- Break -----
Simulation of Ambient Light Impact on Public Displays
S. Maeda, Y. Inoue, T. Sasagawa
Mitsubishi Elec., Japan

This study relates to the screen displays installed indoor or outdoor in public areas. More particularly, the study is intended to visually and quantitatively predict the reflected glare caused by light from illuminations and sun beams that disturbs the display of contents on the screens.

----- Lunch -----
A Self-Adaptive Method for Image Enhancement Based on CIELAB Color Difference Analysis

L.-X. Chen, C.-T. Kang

Shenzhen China Star Optoelect. Tech., China

We propose a new method for image enhancement which is based on color difference analysis. According to XYZ stimulus of LCD panel, matrix of RGB grays can be transferred to $\Delta E^{*ab}$ matrix. With a special threshold of $\Delta E^{*ab}$ and a median filter, the enhancement can be achieved.

----- Break -----
Characterization of Methods for Resolution and Noise in Medical Displays

A. Yamazaki*, **C.-L. Wu*, W.-C. Cheng*, A. Badano*

*U.S. Food and Drug Admin., USA
**Nagoya Univ., Japan

This study characterizes the resolution and noise for liquid crystal displays and organic light-emitting diode displays in workstation and handheld formats, and for a stereoscopic display with consistent methodologies including luminance and viewing-distance factors, and demonstrates the applicability of the methods for various display technologies.

Author Interviews and Demonstrations
16:40 – 17:20

Supporting Organizations:
Technical Group on Information Display, ITE
Technical Committee on Electronic Information Displays, Electronics Society, IEICE
Workshop on Projection and Large-Area Displays and Their Components

Wednesday, December 4

14:00 - 15:00 Mid-sized Hall B

PRJ1: Projection AR

Special Topics of Interest on Augmented Reality and Virtual Reality

Chair: D. Cuypers, imec, Belgium
Co-Chair: S. Shikama, Setsunan Univ., Japan

PRJ1 - 1: Invited Wearable Communication Device Leads the Future of Optical Technology
14:00
M. Takaso, K. Suzuki, T. Iguchi
Telepathy, USA

The evolution of computing has been occurring in changes in the actual display and how the user can interface with and communicate. Telepathy has been targeting to be the first wearable communication device, and optics out of all the technologies supporting Telepathy, will make it possible to be the one.

PRJ1 - 2: Invited Projector-Based Augmented Reality in Medicine
14:20
T. Nakaguchi
Chiba Univ., Japan

Although laparoscopic surgery has substantial merits for patients, it makes the surgical procedure much difficult and gives large burden on physicians. Since 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.

PRJ1 - 3: Invited Projection Mapping Technology and Advanced Optical Features of Digital Projectors
14:40
H. Yoshida, M. Hanzawa, P. Salvini*, R. Anthony*
Christie Digital Syss., Japan
*Christie Digital Syss., Canada

Projection mapping is getting a big boom around the world. And most big mapping events use over 20,000 lumen, Xenon lamp based Christie projectors. Automatic color management tools, warping and blending functions, and product reliability, etc. are assessed by well-known mapping designers. Describe the current projection mapping technology and projector features for projection mapping.

----- Break -----
Digital eyewear (or AR Glasses) allowing hands-free mobile computing applications is a new product category in the world of wearable displays. It will enable many yet unimagined “always-on” hands free mobile applications including geo-localization (GPS), sports, messaging, situation awareness, and more. This paper is an overview of various digital eyewear display technologies.

The key design of this invention is the see-through HMD based on light guide plate with trapezoid microstructures. With this design, we could offer a much extremely compact comparing to the traditional HMD. The HMD serve as the near-eye viewing optics that magnifies the image which is displayed through a microdisplay.

The fringing field effect in a high resolution phase-only spatial light modulator is studied. A novel structure of local electric field enhancement and dielectric separation is proposed to reduce the effect. It is confirmed by numerical simulation.

A new type of 1D beam deflector based on a hollow Bragg reflector waveguide for RGB colors was proposed. Large steering range is possible by only 100 nm change in the hollow core thickness. Ultra-small divergence angle and super-high resolution are expected for device lengths shorter than 1 cm.
Analog driven LCOS panels can exhibit flicker due to Vcom offset rooted in both electro-chemical reactions at the interfaces and ionic impurities in the liquid crystal. A possible solution is offered where a combined alignment layer and suitable barrier layer is obtained in a single step using oblique evaporation.

Author Interviews and Demonstrations
17:20 – 18:00

Thursday, December 5

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<th>9:00 - 10:20</th>
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<td><strong>PRJ3: Projection Technologies</strong></td>
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Chair: F. P. Shevlin, DYOPTYKA, Ireland
Co-Chair: H. Kanayama, Panasonic, Japan

**PRJ3 - 1:** Invited How the Environmental Changes in Projection Display Market?
9:00
T. Suzuki, K. Kusumoto
Techno Syss. Res., Japan

Projector Market has been growing since it appeared, especially for education/business use, and makers has been enjoying its market growth. However, it is now remarkable that projector market environment has been changing. This report will focus on the changes of Projector market and its external environment.

**PRJ3 - 2:** Invited Color Performance Evaluation of Different Business Projector Architectures
9:20
B. Maximus, M. Tarpan, H. Nakano
Barco, Belgium

For business projectors, the brightness specification (lumens) is most important, but it may be required to provide colorful images as well. This subject is typically covered by color gamut specifications, but this paper wants to stress the additional importance of primary color brightness to achieve the best image quality.
Interactive Laser Pico-Projection System Using a Fiber Bundle Combiner for Wavelength and Image Multiplexing

M. Ide, S. Fukaya, K. Yoda
Citizen Holdings, Japan

We present a novel interactive laser pico-projection system using a fiber bundle combiner for wavelength and image multiplexing. The projection system simultaneously employs both RGB imaging and near-infrared depth sensing capabilities by using a single scanning MEMS mirror with a near-infrared camera.

Liquid Cooling High Power Laser Phosphor Light Source for Digital Projection

K. Li
Wavien, USA

This paper describes liquid cooling of phosphor in sealed chambers for high efficiency operations. For higher power operation suitable for digital cinema, a liquid suspension of phosphor is used for screen brightness of over 30,000 lumens. The aging issues of phosphor can also be solved by using replacing phosphor cartridges.

----- Break -----
The authors propose a microcapsule diffuser to reduce the speckle noise generated in laser display. The microcapsule contains light diffusion particles that are electrically charged. Since the particles can move within the microcapsule because of the electrical field in it, the proposed device reduces speckle noise.

In this paper, we demonstrate a speckle-reduced zoomable holographic projection. This holographic projection realizes the zoom function using a numerical method, called scaled Fresnel diffraction. In addition, the speckle noise of projected images is reduced by the combination of optimized holograms, a low-speckle laser and a vibrating multi-mode fiber.

DYOPTYKA's innovative solution for the reduction of speckle, using a phase-randomizing deformable mirror, is shown to perform well in an illumination system where at least one of the color primaries is a laser which is also used to excite fluorescence of other wavelengths from a volume of stationary, heat-sinked, phosphor.

Reliability of high power 638 nm broad stripe LD with a window-mirror structure was studied. Though the LD has a measure to COD, it shows the COD at over-drive condition. The results unveiled that MTTF due to COD is proportional to optical density to the power of -3.2.
All authors of poster papers for the PRJp session will give a brief, 3-minute oral presentations with no discussion time in advance.

----- Lunch -----
Thursday December 5

PRJp - 5 Full Color Image in a Holographic Head-Mounted Display

W.-C. Su, L.-P. Chen, H.-T. Lin

Nat. Changhua Univ. of Education, Taiwan

In this paper, we propose a see-through head mounted display (HMD) system implemented with a holographic optical elements (HOE) in polymer-dispersed-liquid-crystal (PDLC). With the light diffracting from two HOEs in correct position and angel successively, a full-color image without dispersion has been successfully demonstrated.

Author Interviews and Demonstrations
18:30 – 19:10

Supporting Organizations:
Technical Group on Information Display, ITE
Laser Display Technology Research Group, Optical Society of Japan

EXHIBITION

12:40 – 18:00 Wednesday, Dec. 4, 2013
10:00 – 18:00 Thursday, Dec. 5, 2013
10:00 – 14:00 Friday, Dec. 6, 2013

Lobby, 1F
Sapporo Convention Center

Demonstration Session
Augmented Reality and Virtual Reality (AR & VR)

by 3D, VHF, PRJ, DES and INP Workshops
Thursday, December 5, 2013
14:50 – 17:50
Main Hall C, 1F
### Workshop on Electronic Paper

**Wednesday, December 4**

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<td>14:00</td>
<td><strong>EP1: New Displays</strong></td>
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<td>14:00</td>
<td>Invited Trend of Ch-LCD e-Paper Technologies</td>
<td>J. Chen, J.-W. Shiu, C.-C. Tsai, W.-W. Chiu, C.-Y. Huang (ITRI, Taiwan)</td>
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<td>Ch-LCD with advantages of bi-stability, good color and multiple addressing methods, has become one of the attractive technologies for e-paper. This paper summarizes status of research and product activities for various applications. The results in ITRI on conformal multi-color display, and i2R e-paper for card usage are also revealed.</td>
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<td>A novel dual mode LCD was developed for high energy-efficient image display. The first mode is a memory mode in which images are rewritten by applying the vertical or the horizontal electric fields. The second mode is a moving picture mode that is operated by applying a horizontal electric field.</td>
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<td>Multi-functional composite films showing thermoresponsive absorption and emission was demonstrated by using thermochromic leuco dyes, developer and luminescent molecules. The composite films enabled control of the coloration and emission by thermal stimuli, resulting in multicolor dual mode representation.</td>
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**EP1 - 4**

**15:05**

Alternating-Current-Driven Electrochemiluminescence for Solution-Based Multicolor Light-Emitting Device

*T. Nobeshima, M. Nakakomi, K. Nakamura, N. Kobayashi*

*Chiba Univ., Japan*

Emission color tuning of electrochemiluminescence (ECL) cell was demonstrated. This color tuning was conducted with modulation of the voltage or the frequency of AC voltage applied to a single ECL cell containing two luminescent molecules. Such ECL device is introduced as a unique and novel light-emission device has high productivity.

----- Break -----**

**EP2: Electrochromic Displays**

**16:05**

Invited Silver Deposition Based Electrochromism as a Color e-Paper Technology

*A. Tsuboi, K. Nakamura, N. Kobayashi*

*Chiba Univ., Japan*

Novel multicolor electrochromic (EC) device based on electrochemical silver deposition mechanism was successfully demonstrated. The novel EC device achieved reversible change of primary colors - magenta, cyan, yellow, and black (CMYK) - in a single cell by using electrochemical method which controlled the size of deposited Ag nanoparticles.
Metallo-supramolecular polymers show electrochromic properties by the redox of the metal ions. The polymer film was prepared by spin- or spray-coating on a substrate. Here we report stretchable solid-state devices with the polymer films. The reversible electrochromic changes in the devices were observed by applying a voltage.

We have developed a new fabrication technology for electrochromic devices. Electrochromic layer, stacked between working and counter electrodes, can be directly fabricated onto a curved plastic substrate by using new process. Smart Glasses has been successfully demonstrated. This is the first report of smart glasses having electrochromic devices fabricated without cover substrate.

This paper describes optimum approach for developing products using epaper, based on long term experience since early 2000’s. Our goal is to make optimum products which people feels to transfer from paper to digital paper lifestyle. The key is to realize paper like visibility, thickness, weight, durability, metaphor, and writing.
The holy grail for smart windows is a solution for active, independent control of incident light and heat. In this paper a novel concept is presented that can realize this goal based on e-Skin.

In-situ and non-destructive diagnostic method for electrophoretic particles in solvent by dielectric dispersion spectra is proposed in this report. We measured the spectra for charged particle dispersion and uncharged particle dispersion. The charge of an acryl core/fluoric shell particle with negative charges was estimated to be $10^{-17} - 10^{-16}$ C.

Ambient light degrades the image quality of displays. We improved image enhancement algorithms for bright light perception by a new $\Delta L/L$ approach. Evaluation and tests with subjects were successfully performed. The combination of raising lower grey levels (also for reflective e-paper) and color management was judged best.
This paper offers an overview of electronic paper for the international standards with the history of electronic displays, introduces the electronic paper consortium’s activities in Japan, reports the progress situation for standardization of the electronic paper displays, and finally describes proposals for the next leap to the electronic paper concepts.

This paper describes two experiments that compare paper and computer displays in cross-reference reading for multiple documents. Results show the superiority of paper regarding the operability of pointing to text and moving documents. Considering the results, we provide a new direction of e-paper that aims at supporting cross-reference reading.

All authors of poster papers for the EPP session will give a brief, 3-minute oral presentations with no discussion time in advance.

The focus of this paper is to explore the functional paper sheets in anti-counterfeit fields using the hybrid technology which consist of rotating balls in e-papers and hollow tubes in fibers. Model experiments were carried out using a synthetic or natural hollow fiber containing rotating balls or magnetic particles, respectively.
Twisting ball type electronic papers contain tiny Janus particles which are electrically anisotropic. In this study, we synthesized Janus particles having both electrically and magnetically anisotropic. Synthesized Janus particles rotated under the applied electric and magnetic field and electronic papers with these Janus particles realized writing with magnetic pen freely.

Effect of interaction between liquid crystal and photoalignment material on speed of optical rewriting process was investigated. For ORW cells with same photoalignment material and different liquid, the azimuthal anchoring energy is mainly dependent on dose of exposure. With the same dose, the azimuthal anchoring energy is the same.

We studied on the effect of external additives and electrical charge of particle on the display characteristics in a toner display. Nanosized additives were used in the experiment. The use of additives is effective in improving the display contrast and also in lowering the threshold voltage.

We have prepared organic conducting nanocomposite particles which utilize polypyrrole as conducting parts and small silica particles as dispersants. These polypyrrole-silica nanocomposites can be utilize as inkjet particles and display elements in electrophoretic display due to their colloid stabilities and electric properties.
A novel electrochromic smart window with three-way reversible states - transparent, mirror, and black - was successfully fabricated using a pair of flexible plastic Tin-doped Indium Oxide (ITO) films. The devices had the same mechanical flexibility with a three-way state.

We carried out experiments to evaluate the visibility of reading tablet devices and e-papers under conditions of staged illuminance. In the experiments, we measured reading time and conducted subjective evaluations. This study found a dependency between visibility and illuminance of each device by age groups.

We carried out experiments to evaluate the visibility of reading tablet devices and e-papers under conditions of staged illuminance. In the experiments, we measured viewing distance and conducted subjective evaluations. This study found a dependency between visibility and illuminance of each device.

**Author Interviews and Demonstrations**

18:30 – 19:10

**Supporting Organization:**

The Imaging Society of Japan
Thursday, December 5

Workshop on MEMS and Emerging Technologies for Future Displays and Devices

Thursday, December 5

9:00 - 9:05 Meeting Room 206

Opening

Opening Remarks
9:00

M. Nakamoto, Shizuoka Univ., Japan

9:05 - 10:25 Meeting Room 206

MEET1: Fundamental Components and Process Technologies

Chair: D. Pribat, Sungkyunkwan Univ., Korea
Co-Chair: S. Coe-Sullivan, QD Vision, USA

MEET1 - 1:

Invited Graphene for Field Emission Applications
9:05


*Univ. of Cambridge, UK
**Southeast Univ., China
***Kyung Hee Univ., Korea
****Trinity College, Ireland

Here we will describe novel approaches to create novel field emitting structures based on graphene which can be fabricated over large areas. We will also discuss the use of a hybrid gate field emission triode structure based on an electron transparent free-standing graphene gate structure.

MEET1 - 2:

Invited Carbon Nanotube Electron Beams for High Efficiency Lighting Bulb
9:25

K. C. Park, J. S. Kang, H. R. Lee, S. Y. Park

Kyung Hee Univ., Korea

Stable and long life cold cathode electron emitter is strongly required for lighting devices. The high performance emitters with carbon nanotubes were studied for lighting device application. More than 24 kcd/m² luminance was achieved with 1.95 W driving powers. Detail of lighting performance of light bulbs will be discussed.
We developed smart digital X-ray tubes by optimizing carbon nanotube (CNT) emitters and their driving. The CNT emitters were strongly adhered to the cathode substrate by adding a proper filler material into the CNT paste. The active current control was adopted to improve the performance of the digital X-ray tubes.

Cathodoluminescence (CL) were observed from silicon thin films exposed by electron beam (E-beam). The CL of the silicon film has a spectra at the range of 300 ~ 800 nm. This spectra is different from a silicon thin film which was not exposed by E-beam. This phenomenon will be presented.

Quantum dot light emitting devices (QLEDs) are a solution processable thin film electroluminescent technology that delivers exceptional color and efficiency at low cost of manufacture for display and solid-state lighting applications. We report on our high efficiency device structure.
MEET2 - 2: *Invited* Quantum-Dot Light-Emitting Diodes for Full-Color Displays
11:00


Seoul Nat. Univ., Korea
* Dong-A Univ., Korea
** KETI, Korea

Light-emitting diodes based on colloidal quantum dots (QLEDs) have attracted interests as the next generation display technology due to their advantages of easy color tunability, high color purity and low-cost solution-based fabrication. Here, we review recent progress in developing efficient red, green, and blue QLEDs for full-color displays.

MEET2 - 3 Highly Uniform Transfer Mold Quantum Dot Light Emitting Diodes
11:20

R. Matsuhana, M. Nakamoto, J. Moon

Shizuoka Univ., Japan

Highly uniform and reproducible quantum dot light emitting diodes have been developed by using Transfer Mold fabrication method to realize highly efficient and luminescent flat panel displays having the good color purity. The luminance of Transfer Mold QLEDs was as high as 633 times that of flat substrate QLEDs.

MEET2 - 4: *Invited* Pick-and-Place Transfer of Quantum Dot for Full-Color Display
11:40


Samsung Advanced Inst. of Tech., Korea
* Univ. of Oxford, UK

Full-color colloidal quantum dot (QD) display has recently realized by solvent-free pick-and-place transfer method. In this talk, the issues of embodiment of full-color QD display by transfer patterning and the controlled multi-stacking of quantum dot layers with different band gaps using layer-by-layer transfer will be presented.

----- Lunch -----
MEET3: Emerging Quantum Dots Technologies

Chair: K. C. Park, Kyung Hee Univ., Korea
Co-Chair: C. Lee, Seoul Nat. Univ., Korea

MEET3 - 1: Invited Quantum-Dot Light Emitting Diodes for Improvements of Brightness and Efficiency
13:30
J. Jang, A. Castan, H.-M. Kim
Kyung Hee Univ., Korea

This paper reviews quantum-dot light emitting diodes (QLEDs) for high brightness under various method, including doped materials, inter-layer and device structure. Improvement methods of efficiency or brightness of QLED explaining experimental results are provided. Characteristic improvement methods, both doped material-related and device structure-related, are proposed and evidence supporting their feasibility is provided.

MEET3 - 2: Invited Photoluminescent Quantum Dots in Display Products
13:50
J. S. Steckel, R. Colby, W. Liu, K. Hutchinson, C. Breen, J. Ritter, S. Coe-Sullivan
QD Vision, USA

Quantum dots (QDs) are a luminescent semiconductor nanomaterial technology that delivers exceptional color for liquid crystal display backlighting unit (LCD-BLU) applications. We report on the scale-up of the rapid-injection, batch synthetic method, and compare it to other proposed manufacturing methods.

MEET3 - 3: Invited Recent Progress of Nanophotonic Device Operated by a Dressed Photon
14:10
T. Yatsui
Univ. of Tokyo, Japan

This paper reviews recent progress of nanophotonic device operated by a dressed photon using semiconductor quantum structure including quantum dots, quantum well, and quantum rings.

----- Break -----
MEET4 - 1: Invited  Graphene Synthesis on Thin Metal Films
15:10  
Y. W. Kim, E. Moyen, D. Pribat
Sungkyunkwan Univ., Korea

We study graphene synthesis on high-temperature annealed copper thin films deposited on sapphire substrates. The high temperature annealing is performed at reduced pressure under a cap, which prevents excessive Cu evaporation. The Cu thin films display a strong (111) texture after annealing and their surface exhibits steps with atomic height.

MEET4 - 2: Invited  Direct Observation of Al₂O₃ Barrier Film Properties Made by Low Temperature Atomic Layer Deposition onto Fluorescent AlQ₃ Molecular Films
15:30  
T. Maindron, B. Aventurier, T. Jullien, J.-Y. Simon, E. Viasnoff
CEA-LETI, France

Properties of Al₂O₃ barrier film made by atomic layer deposition at 85°C has been investigated by depositing the oxide onto fluorescent AlQ₃ films. Observation of non-fluorescent black spots has been made revealing that Al₂O₃ needs to be overprotected from water ingress by an additional moisture-stable layer.

MEET4 - 3: Invited  Compact DC Modeling of Organic Field-Effect Transistors
15:50  
Y. Bonnassieux, C. H. Kim, G. Horowitz
École Polytechnique, France

In this invited paper, we review recent progresses and future perspectives on physics-based compact modeling of organic field-effect transistors (OFETs). It is challenging to develop a universal model that would cover a huge variety of materials and device structures available for state-of-the-art OFETs.

MEET4 - 4  Withdrawn
MEET4 - 5L  High Performance Solid State Thermoelectric Power Generation Modules for Self-Powered Electronics
16:10  X. Wang, B. Yu, M. Engber, T. Pantha, M. Cleary, J. Yang, Y. Zhang*, G. Joshi, Y. Ma, I. Chao
GMZ Energy, USA
*Boise State Univ., USA

Recently, thermoelectric modules have gained great attentions worldwide due to their potential in increasing the energy efficiency. GMZ Energy successfully improved the performance of several thermoelectric materials through nanostructuring approach. Here, we show the power generation modules developed from those materials that suit for various applications in electronics industry.

----- Break -----
Thursday  

**MEET5 - 3**  
17:30  

**Commercial Sub-THz Video Camera**  
G. E. Tsydynzhapov, V. M. Muravev, A. A. Fortunatov, I. V. Kukushkin  
*Terasense Dev. Labs., Russia*

We present room-temperature sub-THz imaging system capable of video-rate image acquisition. It is sensitive in a wide range frequency range between 100 GHz and 0.7 THz with peak sensitivity of up to 10V/W. The sensors are fabricated by common semiconductor fabs and the camera is commercially available.

**Author Interviews and Demonstrations**  
18:30 – 19:10

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**The 20th Anniversary Keynote & Special Session**

**“What’s the Next Display?”**  
by LCT Workshop

A future manufacturing technologies and newly developed LCD panels will be presented.

Wednesday, December 4, 2013  
14:00 – 16:30 (LCT1 & LCT2)  
Mid-sized Hall A, 1F  
See page 47-48 for details

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**The 20th Anniversary Session**

**“Past, Present and Future of Display Technology”**  
by FMC Workshop

Wednesday, December 4, 2013  
14:00 – 17:00 (FMC1 & FMC2)  
Main Hall A, 1F  
See page 87-89 for details
Wednesday, December 4

Opening Remarks
14:00

H. Okumura, Toshiba, Japan

DES1: Vehicle Applications
14:05 - 15:15 Main Hall B

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

DES1 - 1: Invited Recovery of Sustained Attention by Brief Stimulus Exposure in the Peripheral Visual Field
14:05 K. Uchikawa, D. Endou, K. Fukuda
Tokyo Inst. of Tech., Japan

Our visual ability of detecting objects tends to decline over time while driving when we continuously pay attention on a road. This study showed that the visual performance could be recovered by presenting brief lights in the peripheral visual field, suggesting an effective warning display for vehicle drivers.

DES1 - 2: Invited Obstacle Detection System Using Stereo Vision for Driver Assistance
14:30 K. Saneyoshi
Tokyo Inst. of Tech., Japan

Stereo vision is suitable for obstacle detection to avoid collision because of its wide field of vision, simultaneous detection of multiple objects. We have developed several stereo vision systems including the first demonstration system in 1991, the commercialized system in 1999 and newly developed system with 160 fps.

DES1 - 3: Development of Full-Color HD Resolution Automobile HUD User Interface
14:55 Z. Chen, Y. Tang, B. Wang
Southeast Univ., China

A set of full color HD resolution automobile HUD UI design is presented, which provide variety of driver assistance functions with friendly UI elements. It has been implemented in Android embedded system. An HUD evaluation system has been built for demonstration and user test.

----- Break -----
What are the challenges in creating interfaces that allow a user to intuitively express his/her intentions? Today’s HCI systems are limited, and exploit only visual and auditory sensations of technologies. We will introduce several approaches that use multi/cross modal interfaces with “implicit interaction” for enhancing human I/O.

We describe a new method for accurate manipulation of AR objects at a distance. We address this problem and show how combining AR technology with touch pad operations such as tapping, dragging, and pinching can provide an easy way to position remote AR objects with high accuracy.

The possibility of eyeglass-type devices for mobile use is discussed. We introduce a prototype of a hands-free videophone that can capture the wearer’s own face by using seven head-mounted fish-eye cameras, and allows video calls to be made without holding the phone.

We propose a cartoon-character costume. The costume equips a web camera and display panel. The system of the costume is able to change facial expressions and looks freely. The actor wearing the costume is able to play more than one role in the costume of one body.
Thursday, December 5

10:40 - 12:10 Mid-sized Hall B

**DES3: Human Perceptions in Augmented Reality**

*Special Topics of Interest on Augmented Reality and Virtual Reality*

Chair: T. Kuroda, Kyoto Univ. Hospital, Japan
Co-Chair: K. Makita, AIST, Japan

**DES3 - 1:** Invited  How AR Reforms Social Medical System?

10:40  

Kyoto Univ. Hospital, Japan
Osaka Univ., Japan
*Gunma Pref. College of Health Sci., Japan
***Kinki Univ., Japan

No clinical procedure is performed without computational support in modern hospitals. The Augmented Reality (AR) is expected as the silver bullet for the problems happens among computerized clinics. This lecture surveys on-going medical AR trials and forecasts how AR changes our social medical system in the near future.

**DES3 - 2:** Invited  Augmenting Human Experience with Perception-Based Displays Utilizing Illusions

11:05  
*T. Narumi
Univ. of Tokyo, Japan

In cross-modal interactions, our perception through one sense is changed by stimuli simultaneously received through other senses. By utilizing this, we can provide people to multi-modal experience with limited sensory feedbacks. In this paper, I introduce examples of perception-based displays augment our experience by using cross-modal interactions and augmented reality.

**DES3 - 3:** Invited  Blue Light Matters: The Eye Is a Camera and a Clock!

11:30  
*K. Tsubota
Keio Univ., Japan

Energy-efficient blue LED lights and visual display terminals proliferate nowadays. Two concerns of blue light are potential retinal damage leading to age-related macular degeneration and circadian rhythm disruption from exposure at night. Appropriate intervention for eye protection is necessary for the long-term healthy incorporation of blue light into modern society.
This paper discusses the effectiveness of the implementation of the freehand modeling interface of BlueGrotto in CSCW systems using immersive VR environments. A demonstration shows that the interface naturally reinforces the mutual communications among the users without making them take the trouble to use additional communications tools.

All authors of poster papers for the DESp session will give a brief, 3-minute oral presentations with no discussion time in advance.

This paper introduces real-time viewpoint estimation system with invisible markers for wide indoor area. The system can estimate the position and direction of user's viewpoint precisely by affixing wallpapers containing printed invisible markers on ceilings. This system can be applied to augmented reality, view depended display or human robot interaction.

IDW ’13 Tutorial in Japanese
Organized by SID Japan Chapter
Tuesday, December 3, 2013
Mid-sized Hall B, 1F
Sapporo Convention Center
Detailed information is available on http://www.sidchapters.org/japan/
We conducted two experiments to compare binocular and monocular observations when an Augmented Reality image was presented during a useful field of view (UFOV) task. We found the detection of a luminance change in the peripheral field of view was more difficult under binocular AR observation than under monocular observation.

This paper summarizes our research project, e-Heritage, to digitize cultural heritage assets over the world. We also propose cyber archaeology that provides new findings based on the digital analysis on those data. e-Heritage data is uploaded to cloud as well as archeological findings for a comprehensive visualization system.

The proposed dynamic dimming algorithm including four steps is applied to edge-type LED backlight. The experiment shows the power can be decreased to 64.46% of the non-dimming origin, the clipping ratio is 0.61%, the mean PSNR of typical pictures is 62.36 dB, and the max contrast ratio can reach to 24000:1.
We have developed a “smart” LED tile module integrated with a microcontroller, a wireless communication chip, and various sensors, including an acceleration sensor, a magnetic sensor, a light sensor and a MEMS microphone. The LED tiles share sensor information and show the current status in real-time on the LED screen.

This paper proposed a practical method to suppress image upsampling ringing artifacts in transferring FHD to 4K2K resolution of LCD TCON circuit. The method utilized the geometric features of ringing artifacts to adaptively reduce these effects efficiently. The final results based on the 1-D filter interpolation to achieve real-time implementation.

We propose an eyeglass-based videophone. The developed glasses have fish-eye cameras to capture the wearer’s face and background, and the images are fused to generate a self-portrait image. The system also has a HMD displaying the intended party and enables a video call without holding camera and display devices.

This paper demonstrates a weighted roll-off local dimming scheme for low power LCD applications which eliminates block artifacts at a real backlight with light spreads. Both simulation and experimental results represent that a proposed weighted algorithm alleviates color difference values and block artifacts without any increases in power consumption.

Author Interviews and Demonstrations
18:30 – 19:10
Friday, December 6

9:00 - 10:20 Small Hall

**DES5: Display Driving (1)**

**Chair:** T. N. Ruckmongathan, Raman Res. Inst., India  
**Co-Chair:** T. Yamamoto, NHK, Japan

**DES5 - 1: Invited**  
Micro Pulse Width Modulation for Grayscales in Display Devices  
*T. N. Ruckmongathan*  
*Raman Res. Inst., India*

Introduction of group weights by factoring bit weights of grayscale leads to micro pulse width modulation (MPWM), a method to achieve drastic reduction in number of time intervals to display grayscales as compared to pulse width modulation and low power in fast responding displays.

**DES5 - 2**  
A New Smart Charge Sharing Method for Liquid Crystal Displays with Lower Power Consumption in Z-Inversion  
*S.-R. Kim, J.-M. Kim, M. Kim, J. W. Kim*, S.-W. Lee  
*Kyung Hee Univ., Korea  
*Homestead High School, USA*

This paper proposes a novel charge sharing method to reduce the power consumption in Z-inversion. Simulation results show that NCS method can save more power compared to the conventional one.

**DES5 - 3**  
New Pixel Circuit Based on a-IGZO TFTs for Blue-Phase LCDs  
*P.-C. Lai, M.-H. Cheng, C.-D. Tu’, C.-L. Lin  
Nat. Cheng Kung Univ., Taiwan  
AU Optronics, Taiwan*

This work presents a new pixel circuit using a-IGZO TFTs for driving polymer-stabilized blue-phase liquid crystal displays (BPLCDs). This circuit can increase the driving voltage range to -20 V ~ 20 V and enhance the charging capability with 0 V ~ 15 V supplied voltage range of data driver IC.

**DES5 - 4L**  
Micro Pulse Width Modulation to Drive Matrix LCDs  
*T. N. Ruckmongathan*  
*Raman Res. Inst., India*

About 45% reduction in supply voltage of drivers as compared to that of successive approximation method and about 90% reduction in number of time intervals as compared to pulse width modulation are achieved by using micro pulse width modulation to drive PM LCD.

----- Break -----
DES6: Display Driving (2)

Chair: O.-K. Kwon, Hanyang Univ., Korea
Co-Chair: S. Ono, Panasonic, Japan

DES6 - 1: Invited AMOLED Pixel Structure Using the Negative Feedback Method for High Resolution Displays
10:40

O.-K. Kwon, S.-K. Hong, N.-H. Keum
Hanyang Univ., Korea

The negative feedback method (NFM) for high resolution active matrix organic light emitting diode displays has been researched. NFM compensates the gate voltage distortion of the driving TFT. In this paper, previously reported pixel structures using NFM are discussed in details.

DES6 - 2: A Low-Power Scan Driver Using a-IGZO TFTs for 10-in. WQXGA AMFPDs
11:10

Hanyang Univ., Korea

A low-power scan driver using amorphous indium-gallium-zinc-oxide (a-IGZO) TFTs is proposed for 10-inch WQXGA. The proposed scan driver reduces short-circuit current for low-power consumption. The power consumption of the proposed scan driver is reduced by 36.7% compared to the previously reported scan driver with the lowest power consumption.

DES6 - 3: Invited Digital Drive as an Enabling Technology for AMOLED Displays
11:30

C. Xu, P. Volkert
Saarland Univ., Germany

Digital drive operates the driver transistor of an AMOLED pixel as switch, so that the Vth variation is no more an issue. In addition, the power consumption is nearly halved. Reasonable visual quality may be achieved by specific image decomposition compensating non-uniformity and self-heating as well as avoiding contours.

----- Lunch -----
A memory-in-pixel system optimized to reduce power consumption will be described. The advantages of newly-designed pixels which improve image quality and provide the capability to read in a dark environment by a novel approach will be presented. A 7.03-inch XGA prototype reflective LCD using MIP technologies will also be demonstrated.

We discussed the importance of not only display point of view but also total image systematic point of view approach to reduce power consumption for FPDs. We have developed low power interface techniques using image compression methods, and the prototype FPGA reduced the power consumption of 14-in. SXGA LCD circuit by around 14-15%.

The power consumption of CMOS image sensors (CISs) is lower than that of CCDs. A signal readout circuit in CISs consumes the largest power. A 1.4 MPixel CIS with a low-power signal readout circuit is presented. The figure-of-merit is twice better than that of the state-of-the-art article.

We present an algorithm for local dimming of panels with just (few) LEDs on the short edge and therefore with a rather global backlight distribution. Our approach uses a global optimization which allows high power saving rates and a higher image quality without LED light coupling artifacts.

----- Break -----
DES8: Display Electronic Systems

Chair: A. Sakaigawa, Japan Display, Japan
Co-Chair: R. Hattori, Kyushu Univ., Japan

DES8-1: Invited Electronic Paper System Using High Resolution Electrophoretic Display
15:10
S. Nebashi, Y. Kodama, I. Hayaishi, K. Kajino, Y. Kuchiki
Seiko Epson, Japan

A new e-paper system which is suitable for applications of document works has been developed. By using high resolution EPD and the binary driving technology, the system has the same readability of paper, capability of handwriting, and convenience as IT equipment.

DES8-2: A 3-Gbps Integrated-Stream Protocol Plus for Ultra High-Definition TFT-LCD Applications
15:35
H.-C. Wang, W.-C. Huang, H.-D. Lin, C.-H. Yang
AU Optronics, Taiwan

This paper proposes a chip on film (COF) architecture of integrated-stream protocol plus (iSP+) in ultra high-definition application. The phase locked loop (PLL) type clock data recovery (CDR), an 8b/9b encoding technique are employed to the system. The simulation results show that data rate is work up to 3 Gbps.

DES8-3: Efficient Edge Directed Unsharp Masking Super Resolution
15:55
K.-S. Peng, F.-C. Lin*, H.-P. D. Shieh*, Y.-P. Huang*
Nat. Tsing Hua Univ., Taiwan
Nat. Chiao Tung Univ., Taiwan

This paper proposed an efficient and practical super resolution process - Edge Directed Unsharp Masking approach, which focused on transferring FHD to 4K2K resolution. The algorithm provided an artifacts free directional edge enhancement method with detail stretch to increase the visual resolution in a computational efficiency design for real-time implementation.

Author Interviews and Demonstrations
16:40 – 17:20

Supporting Organizations:
- Technical Group on Information Display, ITE
- Information Sensing Research Committee, ITE
- Special Interest Group on Mixed Reality, 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
Workshop on Flexible Displays

Thursday, December 5

9:00 - 12:00 Main Hall C

Poster FLXp: Flexible Display Technologies

FLXp - 1 Screen-Printing Fabrication of Interconnections for TFT

Y. Maeda*, K. Fukada*, A. Matoba**, S. Takagi***,
S. Inoue*, T. Shimoda*****

*JAIST, Japan
**Ind. Res. Inst. of Ishikawa, Japan
***Tokyo Process Service, Japan
*****JST-ERATO, Japan

To fabricate microscopic fine lines by screen printing, we first simulated the behavior of a paste during printing. Optimized printing conditions based on the results were then used to Ag lines 30 µm-width separated by 30 µm on a glass substrate were successfully screen-printed.

FLXp - 2 Preparation of Ruthenium Metal and Ruthenium Oxide Thin Films by a Low-Temperature Solution Process

Y. Murakami**, P. T. Tue**, H. Tsukada**, J. Li***, T. Shimoda****

*,**, JAIST, Japan
***Mitsubishi Materials Elect. Chems., Japan
****JST-ERATO, Japan

Highly conductive ruthenium metal thin films and ruthenium oxide ones were prepared by a solution process at low temperature (e.g., 6.9 × 10⁻⁶ Ωcm at 300°C for RuO₂). Their structure and electric properties depend on the annealing conditions. The process allowed us to fabricate ruthenium electrodes on flexible substrates.

FLXp - 3 Withdrawn

FLXp - 4 Development of Ch-LC Microencapsulated Flexible Displays with Reduced Driving Voltage and Much Simplified Manufacturing Process


*,**Hanyang Univ., Korea
**, Image Lab, Korea

We developed a novel Ch-LC microencapsulated flexible display with the characteristics of the reduced driving voltage and much simplified manufacturing process. And the fabrication processes was greatly simplified by taking advantage of both coating method using a bar coater and direct printing of opposite electrode using a screen print.
FLXp - 6 Hybrid Inorganic-Organic Multilayer Structures for Flexible Moisture-Barrier Films of Flexible OLED Lightings
S.-W. Seo, E. Jung, H. Lee, S. M. Cho
Sungkyunkwan Univ., Korea
ALD/PECVD are applied as the hybrid multilayer, which has property for the moisture barrier for the thin film encapsulation of flexible OLEDs. Plastic substrate was used for the substrate, HMDSO as the organic layer, Al$_2$O$_3$ as inorganic layer. The moisture barrier property was estimated by measuring WVTR by Ca test.

FLXp - 7 Metal Grid Embedded Transparent Electrode for Flexible OLEDs
H. Lee, S.-W. Seo, E. Jung, S. M. Cho
Sungkyunkwan Univ., Korea
We fabricated the flexible OLED using metal grid as an anode. The metal grid was fabricated by etching or imprinting. The Al was deposited and patterned by photo-lithography and etched by etchant. Ag grid was manufactured by imprinting. The electrode showed sheet resistance and transmittance of 8.5Ω/□ and 74%.

FLXp - 8 Colorful Thermoformable LCD and Its Sequential Segment Driving
ITRI, Taiwan
A color thermoformable liquid crystal display is demonstrated in this paper. A curved opera face pattern designed segments on the thermoforming LCD can be addressed to show six facial expressions. This high aspect ratio conformal display has potential applications for smart electronic skin and shell of products.

FLXp - 9L A 5-in. Flexible AMOLED on PEN Substrate Driven by Ln-IZO TFTs Based on Anodic Aluminum Oxide
*South China Univ. of Tech., China
**Guangzhou New Vision Opto-Elect. Tech., China
A flexible AMOLED on PEN (Polyethylene-Napthalate) substrate, with an anodic amorphous Al$_2$O$_3$ as gate insulator, is presented. Through the anodic oxidation, the high quality gate insulator was deposited at room temperature, which ensured good characteristics in the TFTs. The maximum processing temperature during the fabrication was controlled below 180°C.
The effect of amount of SiO$_2$ nanoparticles with PR as soft mask on surface texturization is investigated. The surface texture is improved with nanoparticles enhances etching nucleation. The surface texture is affected by etching condition and amount of nanoparticles. Higher amount of nanoparticles is better for reflection reduction loss.

**FLXp - 11L**  
**Damage-Induced Black Spot Expansion of Thin-Film Encapsulated OLED Devices**  
S. Zhu, H. Hirayama, X. Huang  
*Kunshan New Flat Panel Display Tech. Ctr., China*

In this paper, an attempt is made to improve the robustness of thin-film encapsulation against black spot expansion by optimizing the deposition conditions in the light of understanding the process-related phenomena. A damage-induced black spot expansion model is proposed for a thin-film encapsulation that is less sensitive to particles.

----- Lunch -----
Invited Challenges toward Reliable Evaluation of High Water Barrier Property
S. Hara*, A. Suzuki**, H. Takahagi**
*AIST, Japan
**CEREBA, Japan

Reference films with $10^{-2}$ - $10^{-4}$ g/m$^2$/day in water vapor transmission rate (WVTR) were developed. Using them, consistency between two WVTR measurement systems was successfully achieved to $10^{-4}$ g/m$^2$/day level. Furthermore, CEREBA’s strategy to achieve a reliable WVTR evaluation technology to $10^{-6}$ g/m$^2$/day is presented.

Invited Novel Materials for Printable Electronics
Y. Ikeda*, T. Imamura*, Y. Tomizawa*, T. Shiro**
*Teijin, Japan
**NanoGram, USA

Si nanoparticles are novel materials for printed electronics. In this study, we demonstrate the carrier injection process and semiconductor layer prepared via laser irradiation of Si nanoparticle film for use in silicon-based FETs. Moreover, $\text{SiO}_2$ dielectric layer and photoluminescence treated Si nanoparticles with application in FPDs and LEDs are introduced.

----- Break -----
Investigation of Roll to Sheet Imprinting for a Process to Fabricate TFTs

*Toppan Printing, Japan
**, JAIST, Japan
***JSR, Japan
****JST-ERATO, Japan

We applied a roll-to-sheet imprinting process to a large-scale substrate. Patterned RuO₂ electrodes were fabricated on both glass and flexible substrates (200 x 150 x 0.7 mm³). The resistivity of the electrodes on a glass substrate was 3.5 x 10⁻⁵ Ω cm, making this technique useful for electrodes of TFTs.

Development of a Wet-On-Wet Process for a Fully-Printed TFT Fabrication

Y. Kusaka, K. Sugihara*, M. Koutake**, H. Ushijima
*AIST, Japan
**, Tokyo Electron, Japan
***DIC, Japan

We achieved a reduction in the misregistration of overlying patterns printed on a flexible plastic film, and a drastically shorter processing time with fully printed TFT fabrication. This was achieved using a newly developed wet-on-wet printing process wherein a subsequent layer can be printed on a previous semi-dried (not-sintered) layer.

Fabrication of Carbon Nanotube TFT for Sheet Electronic Device by Printing Method

*NEC, Japan
**, TASC, Japan
***Univ. of Tokyo, Japan

For pressure-sensing sheet, carbon nanotube thin-film transistor arrays were fabricated on a plastic film. The pressure-sensing cell was prepared to combine printed-TFT, a conductive rubber sheet and a film with a copper foil. Drain current changes in response to pressure applied to the current changes were observed.
This paper reports on the effect of several key variables on optoelectronic performance of Carbon Nanotube transparent conductive films. Variables include Carbon Nanotube composition, Ink formulation, Coating / Printing method, Flexible substrate type and use of Topcoat. Additionally, the synergy between Graphene and CNT were studied.

We have developed double-walled carbon nanotube (DWCNT) transparent conductive film (TCF). Our CNT TCF has very high transparent conductivity, which are currently among the top in the world. And it has great characteristics such as high flexibility (bending and stretching durability) and high environmental stability.

We had developed low coefficient of linear thermal expansion polyimide film "XENOMAX". In order to make TFT device on this film, we developed an attachment technology to glass. This technology can use 400°C process. By removing polyimide film from glass, the device formation on a filmboard becomes easy.
We are developing a high barrier film for flexible OLED devices. It has achieved a water vapor transmission rate (WVTR) of $10^{-6}$ g/m$^2$/day which meets the standard that barrier films for OLED should satisfy, and has been found to form very few dark spots in OLED device evaluation.

Silazane coating material is very unique Si polymer comprising of SiN bond. We studied Silazane coating material as gas barrier film and had good property without high temperature cure. Here we demonstrate successful usage of Silazane material as barrier coating on plastic film.

We are developing the laser fusing cutting method by using a CO2 laser as a cutting method for ultra-thin glass. The fused glass edge is formed into a smooth fire-polished surface without chamfering. Here, we will report our current situation, problems and future development of laser fusing cutting.

A polyamino acid film formed by this piezoelectric ink exhibited high piezoelectricity after only drying treatment and without any polarization treatment. Therefore, direct pattern printing of the piezoelectric polymer on a plastic substrate was realized. Moreover, a printed flexible pressure sensor array was fabricated using the polyamino acid ink.
FLX5 - 2: Invited Flexible Piezoelectric Films with Alternate Rows of Optical Isomers of Poly-Lactic Acid Film
11:05

T. Yoshida, A. Kato, T. Yoshimura, Y. Tajitsu*
Teijin, Japan
*Kansai Univ., Japan

We developed a poly-lactic acid multilayer film as the first step toward realizing a polymer actuator with a large size and flexibility. The fabricated multilayer film has a piezoelectric performance equivalent to that of PZT ceramics, and its piezoelectric resonance can also be observed.

FLX5 - 3: Invited Development of Materials and Innovative Deposition Processes for Organic TFTs
11:30

J. Brill*,**, T. Musiol*,**, D. Kaelblein*,**, T. Gessner*,**, T. Staudt****
*BASF SE, Germany
**InnovationLab, Germany

The future of displays is heading towards rugged, conformable, finally flexible displays. Air-stable, n-type organic semiconductors based on naphthalene diimides will presented, that have shown mobilities of above 1cm²/Vs when deposited by vacuum evaporation. A new deposition process has been found which combines advantages of vacuum deposition and solution processing.

----- Lunch -----
IGZO TFT array was fabricated on a Ployimide (PI) flexible substrate at 200°C. Two methods of laminating the PI substrate on carrier glass plate have been examined. This paper demonstrated and analyzed the TFT device performances in terms of the two different lamination methods.

We present a low-temperature metal oxide transistor backplane technology using PECVD dielectrics. We show successful integration of the backplane in flexible 200 ppi AMOLED displays on ultrathin polymer films. The displays are encapsulated with a thin-film barrier and the total stack thickness is less than 150 μm.
**Workshop on Touch Panels and Input Technologies**

**Wednesday, December 4**

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<th>Time</th>
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<tr>
<td>14:00 - 15:25</td>
<td><strong>INP 1: Touch Panel (1) &amp; Haptics</strong></td>
<td>Small Hall</td>
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**Chair:** H. Noma, Ritsumeikan Univ., Japan  
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**INP 1 - 1: Invited**  
**Risk Management for Pressure Ulcers Using MEMS Tactile Sensor**  
H. Noma, K. Lee*  
*Ritsumeikan Univ., Japan  
*Osaka Univ., Japan

We evaluated FEM simulation of human skin deformation to prevent pressure ulcers in this paper. The results shows that both pressure and shear force causes huge inner skin deformation, so tactile sensor that can measure 3D force is necessary for ulcer management.

**INP 1 - 2: Invited**  
**A Deformation Detection Touch Panel using a Piezoelectric Poly(L-lactic acid) Film**  
M. Ando* ,** ,†, H. Kawamura*, H. Kitada*, Y. Sekimoto* ,  
Y. Tajitsu***  
*Murata Manufacturing, Japan  
**Mitsui Chems., Japan  
***Kansai Univ., Japan

Poly(L-lactic acid) (PLLA) is a well-known, eco-friendly polymer used in piezoelectric applications for sensors. This material does not exhibit pyroelectricity. In this study, we successfully produced a deformation detection touch panel using a piezoelectric PLLA film. This flexible apparatus shows considerable potential for future sensor applications.

**INP 1 - 3**  
**Driving Schema of High Integrated Panel with TSP and 3D**  
Chunghwa Picture Tubes, Taiwan

Chunghwa Picture Tubes, LTD. (CPT) has presented an improved architecture for integrating TSP into 3D. Comparing with conventional structures, it can effectively decrease cost of manufacturing process and glasses. Besides, we also have presented the driving architecture to provide a driving method which has high integration for TSP+3D architecture.
AdDetect: Recognition above the Surface in Multi-Touch Tabletop Environments

T. Terada, H. Nonaka, T. Yoshikawa, H. Mi*, M. Sugimoto
Hokkaido Univ., Japan
Univ. of Tokyo, Japan

In this paper, we propose an approach to recognizing both touches on a tabletop surface and physical objects above it. We present an outline of our system and several example applications. Demonstrations of the system will be conducted in the conference site.

----- Break -----
INP2/ DES2 - 4 17:00
A Cartoon-Character Costume with Active Facial Expression
Y. Oka, M. Yamamoto
Niigata Univ., Japan

We propose a cartoon-character costume. The costume equips a web camera and display panel. The system of the costume is able to change facial expressions and looks freely. The actor wearing the costume is able to play more than one role in the costume of one body.

Author Interviews and Demonstrations
17:20 – 18:00

Thursday, December 5

9:00 - 12:00 Main Hall C

Poster INPp: Touch Panel

INPp - 1 Touch Sensing Optimization for Large Size Capacitive Touch Panel
C. Ye, C. Chang, R. Fu, J. Qiu, Y. Lin
China Star Optoelect. Tech., China

We proposed a method to decrease the RC loading in large size mutual capacitive type touch panel. A novel electrode structure is employed and also easy to modify to decrease the RC loading effectively. Moreover, we come out a non-symmetric mutual capacitance distribution design of sensor pattern.

INPp - 2 A-Si Touch Driver Integrating with Gate Driver for Flat Panel Display Application
G.-T. Zheng, M.-C. Wu, P.-T. Liu*, R.-J. Chen†, F.-J. Yang‡, C.-Y. Wu**
Nat. Tsing Hua Univ., Taiwan
*Nat. Chiao Tung Univ., Taiwan
**Giantplus Tech., Taiwan

In this paper, the proposed touch driver on array (TOA) for a-Si technology integrated with the gate driver on array (GOA) has been demonstrated. The proposed design replaces the touch IC for delivering part and transfers the touch signals to the sensing circuit for IC.
INP - 3  A Novel Stylus for LCD Base on Capacitive Touch
Chunghwa Picture Tubes, Taiwan

CPT has developed a stylus for dual mode touch. The stylus can touch on the screen with wide sensor pitch. The stylus tip is 0.8 mm and the sensor pitch is 5.4 mm. In addition, the stylus touch accuracy can be less than 1 mm. So it will be more accurately in writing.

INP - 4  Multi-Source Touch Implementation in Multi-Touch System
J.-H. Chen, Y.-C. Kang
AU Optronics, Taiwan

Touch control system has been widely used on many devices. But most products only apply one type of touch technology and the usage of touch system is limited at all. We propose a technology which integrates multi type of touch system and widely increase the purpose of touch system.

----- Lunch -----
Noise Immunity Enhancement for Capacitive Touch-Screens

D. Sugimoto, H. Haga, K. Takatori, H. Asada
NLT Techs., Japan

Correlated Noise Subtraction (CNS) has been demonstrated by implementing it into an FPGA on a touch-screen controller board. Our prototype shows the improvement in S/N ratio from 5.98 to 27.9, reduction of jitter and smooth tracking of finger movement under an environment where noise frequency coincides with signal frequency.

High Efficient Anti-Noise Touch in Cell Display

Chunghwa Picture Tubes, Taiwan

Chunghwa picture tubes, LTD. has been successive to develop a 4.5-in. capacitive touch in cell (TIC) with a-Si wide view angle HD (780x1280) LCD. We proposed innovative structure not only solve noise problem from display in normal capacitive touch in cell (TIC) type, but also can be decreased RC loading in sensor pattern design.

----- Break -----
We developed time-multiplexed 3D camera system based on time-of-flight technology using an electro-optical filter alternately transmitting visible and NIR radiation. Experimental measurements a polarizer based filter prototype shows 18% of visible and 25% of NIR light transmittance. The fast switching of the modulator reduces motion artifacts in the camera system.

We report the nano-Si photonic sensor integrated in TFT technology as Image-scan/Fingerprint. We using nano-Si as sensitizer sandwiched between two electrodes structure, and integrating optical input function for image scanner, fingerprint recognition application. A 1-transistor passive pixel sensor is used to integrate 500 ppi image sensor elements within each pixel.

A multi-mode integrated compound-eye camera that will simultaneously offer multiple functions is proposed. A prototype camera is designed and fabricated. Field-of-view of 62 degrees is realized by combining 5 elemental images with 4 sets of two prism mirrors. Two sets of visible and near-infrared stereoscopic images are also obtained.

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M. Esashi  Tohoku Univ.
H. Fujita  Univ. of Tokyo
J. Jang  Kyung Hee Univ.
H. Kikuchi  NHK
J. Kim  Univ. of Oxford
K. Matsumoto  Olympus
W. Milne  Univ. of Cambridge
S. Sugiyama  Ritsumeikan Univ.
H. Tuller  MIT
S. Uchikoga  Toshiba
J.-B. Yoon  KAIST
Y. Yoshida  Mitsubishi Elec.

Workshop on Display Electronic Systems
Workshop Chair: H. Okumura  Toshiba
Program Chair: R. Hattori  Kyushu Univ.
General Secretary: S. Takamura  NTT
Vice-Secretary: T. Yamamoto  NHK
Program Committee:

T. Fujine  Sharp
K. Kagawa  Shizuoka Univ.
K. Käläntär  Global Optical Solutions
L. Kerofsky  Sharp Labs. of America
T. Kim  Apple
H. Nam  Kyung Hee Univ.
O.-K. Kwon  Hankyung Univ.
K. Makita  AIST
K. Morita  Nat. Traffic Safety & Environment Lab.
A. Nagase  Mitsubishi Elec.
H. Nitta  Hitachi
S. Ono  Panasonic
A. Sakaigawa  Japan Display
K. Sekiya  Kanagawa Inst. of Tech.

Workshop on Flexible Displays
Workshop Chair: H. Fujikake  Tohoku Univ.
Program Chair: M. Ito  Toppan Printing
General Secretary: H. Maeda  DNP
Program Committee:

K. Akamatsu  Sony
T. Eguchi  Sumitomo Bakelite
M. Funahashi  Kagawa Univ.
T. Furukawa  Yamagata Univ.
H. Hirata  Toray Eng.
T. Kamata  AIST
M. Kimura  Nagaoka Univ. of Tech.
Y. Mishima  FUJIFILM
M. Nakata  NHK
T. Sekitani  Univ. of Tokyo
T. Shiro  Teijin
K. Takimiya  RIKEN
T. Tomono  Toppan Printing
K. Uemura  Nippon Steel & Sumitomo Metal

Workshop on Touch Panels and Input Technologies
Workshop Chair: K. Nakatani  Touchpanel Labs.
Program Chair: K. Kagawa  Shizuoka Univ.
General Secretary: I. Mihara  Toshiba
Program Committee:

I. Fujieda  Ritsumeikan Univ.
H. Haga NLT Techs.
N. Hashimoto Citizen Holdings
M. Inoue Innolux
H. Kato Sharp
F. Koo Minghsin Univ. of S&T
Y. Mizushima Corning Holding Japan
T. Nakamura Japan Display
H. Noma Ritsumeikan Univ.
H. Okumura Toshiba
Y. Sasaki Mitsubishi Elec.

Special Topics of Interest on Oxide TFT
Facilitator: M. Kimura Ryukoku Univ.
Program Committee:
AMD: H. Kumomi Tokyo Inst. of Tech.
FMC: R. Yamaguchi Akita Univ.
OLED: T. Uchida Tokyo Polytechnic Univ.
FLX: T. Sekitani Univ. of Tokyo

Special Topics of Interest on Augmented Reality and Virtual Reality
Facilitator: H. Okumura Toshiba
Vice Facilitator: M. Date NTT
Program Committee:
3D: M. Tsuchida NTT
VHF: T. Matsumoto Sony
T. Kurita NHK
PRJ: O. Akimoto Sony
DES: K. Makita AIIST
INP: I. Mihara Toshiba

Special Topics of Interest on Lighting Technologies
Facilitator: Y. Kijima Sony
Program Committee:
FMC: M. Shinohara Omron
PH: K. Hara Shizuoka Univ.
OLED: T. Ikuta JNC Petrochem.

FINANCIAL SUPPORTING ORGANIZATIONS (as of November 1, 2013)
ADEKA CORPORATION
Applied Materials, Inc.
ASAHI GLASS CO., LTD.
Corning Holding Japan GK, Corning Technology Center
JNC CORPORATION
JSR Corporation
Nichia Corporation
Semiconductor Energy Laboratory Co., Ltd.
SHARP CORPORATION
TOKYO ELECTRON LIMITED
Ube Material Industries, Ltd.

SUPPORTING MEMBERS (as of November 1, 2013)
EIZO Corporation
JAPAN BROADCASTING CORPORATION
Merck Ltd. Japan
NLT Technologies, Ltd.
Panasonic Corporation AVC Networks Company
SHIMADZU CORPORATION
Toshiba Corporation
ULVAC, Inc.
ZEON CORPORATION
COMPANIES LIST OF EXHIBITORS (as of November 1, 2013)
Fraunhofer COMEDD
Japan Science Engineering Co., Ltd.
KONICA MINOLTA, INC.
NAGASE & CO., LTD.
PTT Company Limited
SHINTECH, Inc.
SILVACO Japan., Ltd.
Soken Chemical & Engineering Co., Ltd.
TOYO Corporation
Wexx Co., Ltd.

UNIVERSITIES LIST OF EXHIBITORS (as of November 1, 2013)
Kanagawa Univ.
Maeda Lab., Tokai Univ.
Mutsu Matsu Lab./Ryukoku Extension Center, Ryukoku Univ.
Nagaoka Univ. of Technology
Nakamoto Lab., Shizuoka Univ.
Suyama and Yamamoto Lab., Univ. of Tokushima
Univ. of the Ryukyus
Electron Device Engineering Labs., Univ. of Toyama

Demonstration Session
Augmented Reality and Virtual Reality (AR & VR)
by 3D, VHF, PRJ, DES and INP Workshops
Thursday, December 5, 2013
14:50 – 17:50
Main Hall C, 1F

IDW ’14
The 21st International Display Workshops
December 3 – 5, 2014
Toki Messe Niigata Convention Center
Niigata, Japan
http://www.idw.ne.jp
### IDW ‘13 Timetable

<table>
<thead>
<tr>
<th>Date</th>
<th>Conference Hall</th>
<th>Main Hall A</th>
<th>Main Hall B</th>
<th>Main Hall C</th>
<th>204</th>
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<th>Main Hall C</th>
<th>1F Lobby</th>
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### IDW ‘13 Special Topics of Interest Navigator

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*Including Short Presentations*
**IDW '13 Session Navigator**

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<th>Wednesday, Dec. 4</th>
<th>Thursday, Dec. 5</th>
<th>Friday, Dec. 6</th>
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<tr>
<td>9:30-12:30 PM</td>
<td>17:20-18:00 AM</td>
<td>16:40-17:20</td>
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### LCT
- Opening & Keynote Presentation: 
  - Mid-sized Hall A
  - Main Hall C
- Special Session (1): 
  - Mid-sized Hall A
  - Main Hall C
- LC Materials: 
  - Mid-sized Hall A
  - Main Hall C
- Posters: 
  - Mid-sized Hall A
  - Main Hall C
- Display Mode (1): 
  - Main Hall C
  - Mid-sized Hall C
- LC Materials: 
  - Poster Session: 
    - A.I.
  - Poster Session: 
    - A.I.
- Display Mode (2): 
  - Evaluation: 
    - A.I.
  - Photo Alignment: 
    - A.I.

### AMD
- Keynote & Special Session: 
  - Main Hall A
  - Main Hall C
- Poster Session: 
  - Mid-sized Hall A
  - Main Hall C
- Advanced Si TFT: 
  - Expenses: 
    - A.I.
  - Oxide TFT: 
    - Reliability: 
      - A.I.
  - Oxide TFT: 
    - Reliability: 
      - A.I.
  - Display Mode (1): 
    - LC Materials: 
      - Posters: 
        - A.I.
  - Display Mode (2): 
    - Evaluation: 
      - A.I.

### FMC
- 20th Anniversary: 
  - Past, Present, and Future: 
    - Mid-sized Hall A
    - Main Hall C
  - Advanced Si TFT: 
    - Reliability (1): 
      - Oxide TFT: 
        - Reliability (2): 
          - A.I.
  - Advanced Si TFT: 
    - Reliability (1): 
      - Oxide TFT: 
        - Reliability (2): 
          - A.I.
  - A.I. Novel Applications: 
    - Printed TFT: 
      - A.I.

### PDP
- Main Hall A
- Small Hall
- Main Hall C
- Main Hall C
- Main Hall C
- Main Hall C
- Main Hall A
- Main Hall C
- Main Hall C
- Main Hall C
- Main Hall C
- Poster Session: 
  - Mid-sized Hall B
  - Main Hall C
  - Mid-sized Hall B
  - Main Hall C
  - Mid-sized Hall B
  - Main Hall C

### PH
- Main Hall C
- Mid-sized Hall B
- Main Hall C
- Small Hall
- Main Hall C
- Main Hall C
- Main Hall C
- A.I.
- Display Mode: 
  - A.I.
- Posters: 
  - Main Hall C
  - Conference Hall

### OLED
- Poster Session: 
  - Materials & Devices: 
    - Display Technologies: 
      - Flexible & Fabrication: 
        - Process Technologies: 
          - OLED for Lighting: 
            - A.I.
  - Process Technologies: 
    - OLED for Lighting: 
      - A.I.
  - Visual Comfort for 3D Display: 
    - Holography: 
      - A.I.
  - 3D Display (1): 
    - 3D Display (2): 
      - A.I.
  - Visual Comfort for 3D Display: 
    - Visual Perception: 
      - Color: 
        - Display Parameters: 
          - Human Performance: 
            - A.I.

### FED
- Main Hall C
- Conference Hall
- Poster Session: 
  - Display Technologies: 
    - Flexible & Fabrication: 
      - Process Technologies: 
        - OLED for Lighting: 
          - A.I.
  - Process Technologies: 
    - OLED for Lighting: 
      - A.I.
  - Visual Comfort for 3D Display: 
    - Holography: 
      - A.I.
  - 3D Display (1): 
    - 3D Display (2): 
      - A.I.
  - Visual Comfort for 3D Display: 
    - Visual Perception: 
      - Color: 
        - Display Parameters: 
          - Human Performance: 
            - A.I.
  - Poster Session: 
    - Main Hall C
    - Conference Hall
  - Main Hall C

### VHF
- Main Hall C
- Mid-sized Hall B
- Main Hall C
- Main Hall C
- Main Hall C
- Mid-sized Hall B
- Main Hall C
- Main Hall C
- Main Hall C
- Main Hall C
- Small Hall
- Main Hall C
- Poster Session: 
  - Main Hall C
  - Conference Hall

### PRJ
- Main Hall C
- Mid-sized Hall B
- Main Hall C
- Small Hall
- Main Hall C
- Small Hall
- Main Hall C
- Poster Session: 
  - Main Hall C
  - Conference Hall
  - Main Hall C

### DES
- Main Hall B
- Mid-sized Hall B
- Main Hall C
- Mid-sized Hall B
- Main Hall C
- Small Hall
- Main Hall C
- Poster Session: 
  - Main Hall C
  - Main Hall A
  - Conference Hall
  - Main Hall C

### INP
- Small Hall
- Mid-sized Hall B
- Main Hall C
- Main Hall C
- Small Hall
- Main Hall C
- Poster Session: 
  - Main Hall C
  - Conference Hall
  - Main Hall C

### FLX
- Main Hall C
- Conference Hall
- Main Hall C
- Main Hall C
- Main Hall C
- Poster Session: 
  - Main Hall C
  - Conference Hall
  - Main Hall C

### LCT: Workshop on LC Science & Technologies
- A.I.: Author Interviews & Demonstrations
  - Joint Session

### AMD: Workshop on Active Matrix Displays
- A.I.: Author Interviews & Demonstrations

### FMC: Workshop on FPD Manufacturing, Materials & Components
- A.I.: Author Interviews & Demonstrations

### PDP: Workshop on Plasma Displays
- A.I.: Author Interviews & Demonstrations

### PH: Workshop on EL Displays & Phosphors
- A.I.: Author Interviews & Demonstrations

### FED: Workshop on Field Emission Display & CRT
- A.I.: Author Interviews & Demonstrations

### OLED: Workshop on OLED Displays & Related Technologies
- A.I.: Author Interviews & Demonstrations

### 3D: Workshop on 3D/Hyper-Realistic Displays & Systems
- A.I.: Author Interviews & Demonstrations

### VHF: Workshop on Applied Vision & Human Factors
- A.I.: Author Interviews & Demonstrations

### PRJ: Workshop on Projection & Large-Area Displays & Their Components
- A.I.: Author Interviews & Demonstrations

### DES: Workshop on Display Electronic Systems
- A.I.: Author Interviews & Demonstrations

### FLX: Workshop on Flexible Displays
- A.I.: Author Interviews & Demonstrations

### INP: Workshop on Touch Panels & Input Technologies
- A.I.: Author Interviews & Demonstrations

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**Legends:**
- **LCT**: Workshop on LC Science & Technologies
- **AMD**: Workshop on Active Matrix Displays
- **FMC**: Workshop on FPD Manufacturing, Materials & Components
- **PDP**: Workshop on Plasma Displays
- **PH**: Workshop on EL Displays & Phosphors
- **FED**: Workshop on Field Emission Display & CRT
- **OLED**: Workshop on OLED Displays & Related Technologies
- **3D**: Workshop on 3D/Hyper-Realistic Displays & Systems
Special Topics of Interest on
• Oxide TFT

Workshops on
• LC Science and Technologies (LCT)
• Active Matrix Displays (AMD)
• EL Displays and Phosphors (PH)
• Field Emission Display and CRT (FED)
• Plasma Displays (PDP)
• and Components (FMC)
• 3D/Hyper-Realistic Displays and Systems (3D)
• Electronic Displays and Devices (DES)
• MEMS and Emerging Technologies (MEET)
• Display Electronic Systems (DES)
• Flexible Displays (FLX)
• Touch Panels and Input Technologies (INP)
• Electronic Paper (EP)
• and Their Components (PRU)
• Projector and Large Area Displays (PAL)
• 2D/3D Displays and Devices (2D/3D)