



IDW '13

THE 20TH INTERNATIONAL DISPLAY WORKSHOPS

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)

Final Program



***Sapporo Convention Center
Sapporo, Japan
December 4(Wed) – 6(Fri), 2013***

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PROGRAM HIGHLIGHTS

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

(excluding late-news papers). 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 Television 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.

	Until Nov. 1	On and After Nov. 2
Individual Member (ITE/SID/ASO*)	¥ 35,000	¥ 45,000
Non-Member**	¥ 45,000	¥ 55,000
Student***	¥ 8,000	¥ 10,000
Life Member of ITE/SID	¥ 8,000	¥ 10,000
Reception	¥ 8,000	¥ 10,000

*ASO: Academic Supporting Organizations

(See p.14 as well as "Supporting Organizations and Sponsors" at the end of each workshop section.)

**Non-Member: If you intend to join either ITE or SID, the one year membership fee will be subsidized by IDW '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.

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

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 Miizumi 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

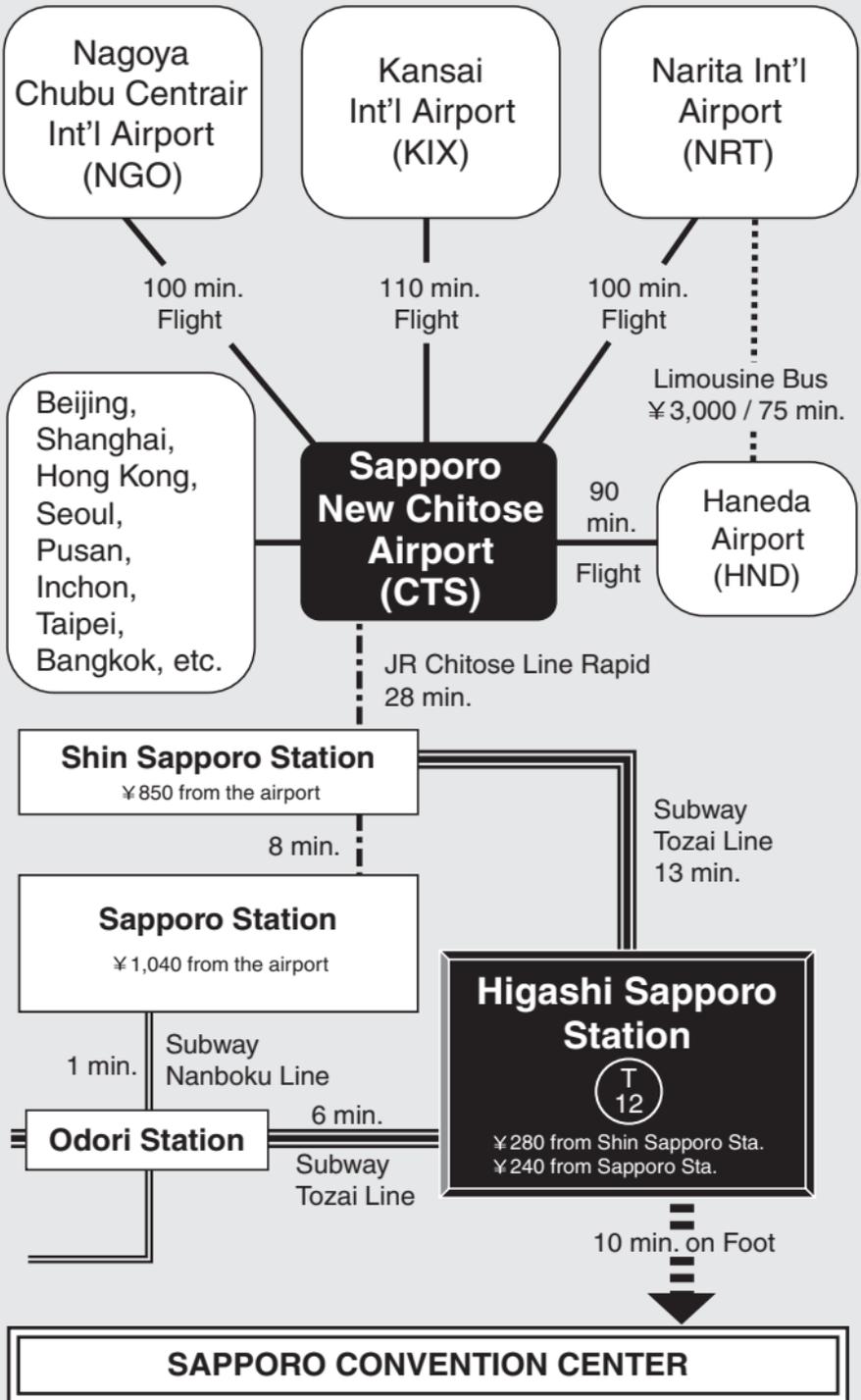
Sapporo Official Travel Guide

<http://www.welcome.city.sapporo.jp/english/>

Sapporo Tourism Association

<http://www.sta.or.jp/english/>

ACCESS TO SAPPORO CONVENTION CENTER



(as of November 1, 2013)

Hotel Map



JR Sapporo Sta. Area

- ① JR Tower Hotel Nikko Sapporo
- ② Keio Plaza Hotel Sapporo
- ③ Mitsui Garden Hotel Sapporo
- ④ Hotel Gracery Sapporo
- ⑤ Hotel Keihan Sapporo
- ⑥ Hotel Route Inn Sapporo Ekimae Kitaguchi

Subway Odori Sta. Area

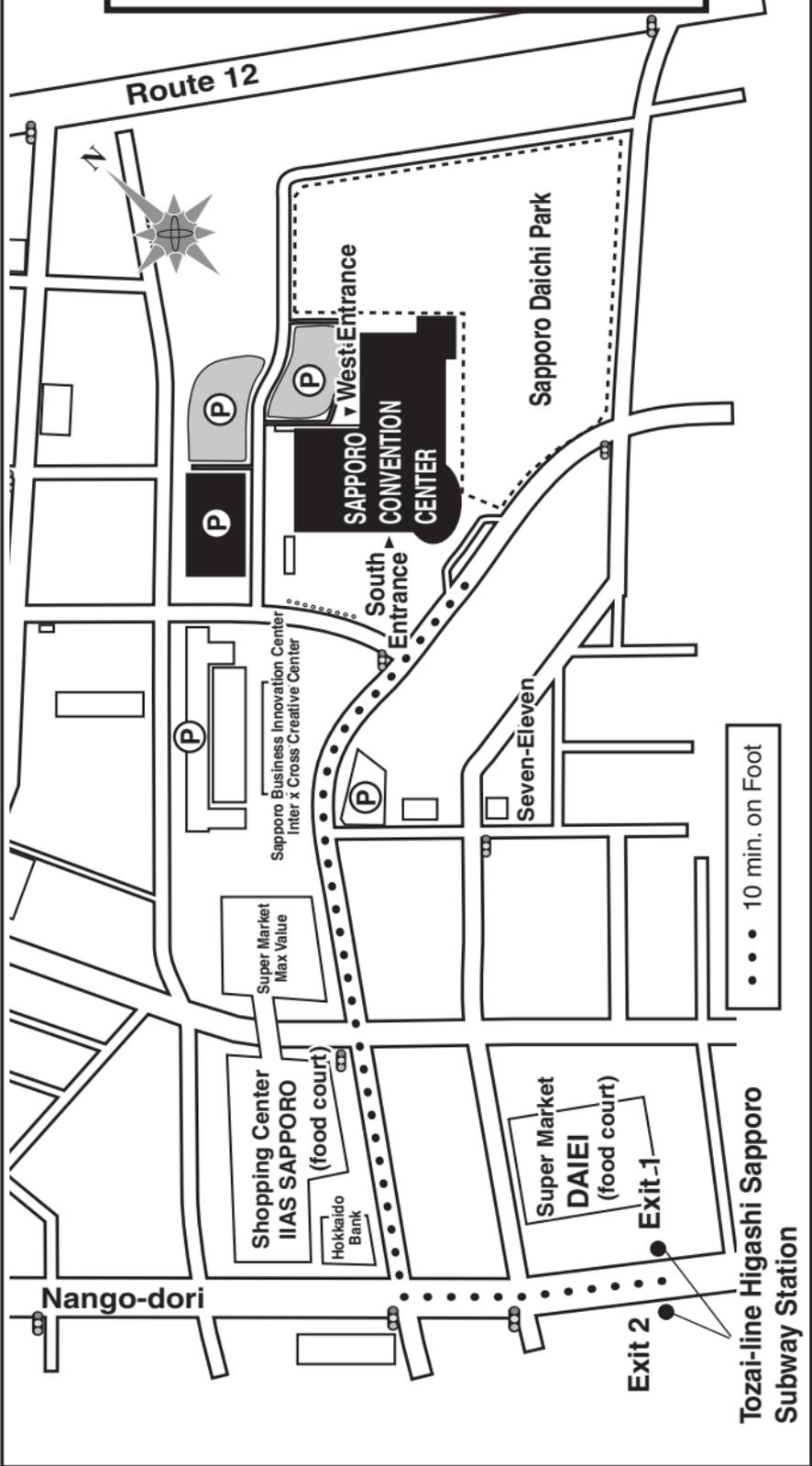
- ⑦ Sapporo Grand Hotel
- ⑧ Tokyo Dome Hotel Sapporo

- ⑨ Hotel Sapporo Garden Palace
- ⑩ Hotel Resol Trinity Sapporo
- ⑪ Hotel Sunroute New Sapporo

Subway Nakajima Koen Sta. Area

- ⑫ Sapporo Park Hotel
- ⑬ Art Hotels Sapporo
- ⑭ Hotel Lifort Sapporo
- ⑮ Hotel Resol Sapporo Nakajimakouen
- ⑯ Hotel North City

Sapporo Convention Center Map and Directions



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 expanded 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.

**Keynote Address - 3 Recent Development of Metamaterials:
11:10 Novel Optical Application of Artificially
Structured Materials with Extraordinary
Optical Constant**

M. Hangyo

Osaka Univ., Japan

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.

Plenary

----- 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

Special Topics of Interest on Oxide TFT

Wednesday, December 4

13:40 - 16:40

Main Hall C

Poster AMDp1: Oxide TFT

AMDp1 - 1 Investigation on the Oxide TFT Gate Driver Circuits Using Bias Offset Method

Y. H. Jang, H. N. Cho, W. S. Choi, K. I. Chun, M.-G. Kang, K. Choo, B. Cho, J. U. Bae, W. Shin, I. Kang

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

*S.-C. Liu, C.-Y. Su, W.-H. Li, L.-Q. Shi, X.-W. Lv, Y.-T. Hu, H.-J. Zhang, C.-Y. Tseng, Y.-F. Wang, C.-C. Lo, A. Lien**

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 cm²/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 H₂O molecules into films and terminate the traps in films by the oxidization.

AMDp1 - 4 New a-IGZO TFT Gate Driver Circuit with AC-Driven Pull-Down Circuit

*C.-E. Wu, F.-H. Chen, M.-H. Cheng, C.-L. Lin
Nat. Cheng Kung Univ., Taiwan*

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.

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*

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

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*

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.

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*

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 $0.05 \text{ cm}^2/\text{Vs}$ and an on/off current ratio over 10^3 .

AMDp1 - 8 Process Improvement for Reliability of Oxide TFT Display

M. Zhang, Y. Zhang, J. Hu, Y. Shi, X. Zhang, Y.-C. Chung, J.-K. Kim, G. Tion, Y. Xu

Hefei BOE Optoelect. Tech., China

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.

AMDp1 - 9 Self-Aligned Top-Gate a-IGZO Thin-Film Transistor with N₂ Plasma-Treated Source/Drain Regions

S. Chi, X. Xiao, X. He, S. Zhang

Peking Univ., China

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.

AMDp1 - 10 Influence of Temperature Annealing on Electrical Performances of Oxide TFT

B.-L. Yeh, C.-N. Lin, C.-C. Wu, C.-M. Chang, W.-B. Wu, C.-Y. Chen

AU Optronics, Taiwan

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.

AMDp1 - 11L High Mobility Atmospheric-Pressure-Processed IGZO TFT with AlO_x/IGZO Stack Fabricated by Mist Chemical Vapor Deposition

M. Furuta, T. Kawaharamura, T. Kaida, D. Wang

Kochi Univ. of Tech., Japan

High-mobility IGZO TFTs were demonstrated at 360°C with an IGZO channel and AlO_x 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.

13:40 - 16:40

Main Hall C

Poster AMDp2: Active-Matrix Devices**AMDp2 - 8 An AMOLED Pixel Circuit with Negative V_{TH} Compensation Function***C. Leng, L. Wang, S. Zhang**Peking Univ., China*

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.

13:40 - 16:40

Main Hall C

Poster AMDp3/OLEDp2: AMOLED**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.

Thursday, December 5

9:00 - 10:20

Main Hall A

FMC3: Oxide TFT: Process Technologies

Chair: T. Kamiya, Tokyo Inst. of Tech., Japan

Co-Chair: T. Arikado, Tokyo Electron, Japan

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

9:00

*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
9:20 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 In-Line Process Monitoring for Amorphous Oxide
9:40 Semiconductor TFT Fabrication Using Microwave-
Detected Photoconductivity Decay Technique**

*H. Goto, H. Tao, S. Morita, Y. Takahashi, A. Hino,
T. Kishi*, M. Ochi, K. Hayashi, T. Kugimiya*

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

M. Takeshita, S. Abe, T. Kojiri, M. Hanmura, 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.

9:00 - 12:00

Main Hall C

Poster FLXp: Flexible Display Technologies**FLXp - 2 Preparation of Ruthenium Metal and Ruthenium Oxide Thin Films by a Low-Temperature Solution Process**

Y. Murakami^{,**}, P. T. Tse^{**}, H. Tsukada^{**,***}, J. Li^{**,****},
T. Shimoda^{**,****}*

**JSR, Japan*

***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., $6.9 \times 10^{-5} \Omega\text{cm}$ at 300°C for Ru^0). Their structure and electric properties depend on the annealing conditions. The process allowed us to fabricate ruthenium electrodes on flexible substrates.

FLXp - 9L A 5-in. Flexible AMOLED on PEN Substrate Driven by Ln-IZO TFTs Based on Anodic Aluminum Oxide

H. Xu^{}, M. Xu^{*}, J. Pang^{**}, J. Zou^{*}, H. Tao^{*}, M. Li^{*}, D. Luo^{*},
L. Wang^{*}, J. Peng^{**}*

**South China Univ. of Tech., China*

***Guangzhou New Vision Opto-Elect. Tech., China*

A flexible AMOLED on PEN (Polyethylene-Naphthalate) substrate, with an anodic amorphous Al_2O_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 .

10:40 - 12:25

Main Hall B

AMD2: Oxide TFT: Applications

Chair: M. Wong, Hong Kong Univ. of S&T, Hong Kong

Co-Chair: N. Morosawa, Sony, Japan

AMD2 - 1: Invited 65-in. OLED TV Developed by Oxide TFT and Fine Metal Mask Technologies

10:40

*L.-F. Lin, T.-H. Shih, J.-Y. Lee, W.-H. Wu, S.-C. Wang,
Y.-H. Chen, C.-C. Chen, C.-L. Chen, P. P. Lin, Y.-H. Chen,
S.-J. Yu, C.-H. Liu, H.-C. Ting, H.-H. Lu, L. Tsai, H.-S. Lin,
C.-Y. Chen, L.-H. Chang, Y.-H. Lin*

AU Optronics, Taiwan

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.

AMD2 - 2: Invited Flexible AMOLED Display Driven by Amorphous InGaZnO TFTs
11:05

K. Miura, T. Ueda, N. Saito, S. Nakano, T. Sakano, H. Yamaguchi, I. Amemiya

Toshiba, Japan

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.

AMD2 - 3 12.1-in. WXGA Plastic AMLCDs Driven by Low Temperature Amorphous IGZO TFTs
11:30

S.-Y. Sun, W.-C. Huang, W.-T. Lin, L.-Y. Lin, C.-C. Cheng, C.-Y. Liu, M.-F. Chiang

AU Optronics, Taiwan

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.

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

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

T. Kamiya^{}, K. Kimoto^{**}, N. Ohashi^{*,**}, K. Abe^{*}, Y. Hanyu^{*}, H. Kumomi^{*}, H. Hosono^{*}*

^{}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 -----

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

13:30

*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.

Oxide TFT

AMD3 - 2 Influence of Charge Trapping on Hysteresis in InGaZnO Thin-Film Transistors under Negative Bias and Illumination Stress

13:55

*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

14:15

*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 length TFT, the ΔV_{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

14:35

*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 ΔV_{th} less than 1 V under NBIS while the wavelength varied from 360 nm to 620 nm, whereas the unpassivated a-IGZO TFTs exhibits ΔV_{th} around -10 V.

----- Break -----

15:10 - 16:40

Main Hall B

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.

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.

Oxide TFT

AMD5 - 2 Solution-Processed Metal Oxide TFTs for AMOLED Applications

17:15

*L.-Y. Lin, C.-C. Cheng, C.-Y. Liu, M.-F. Chiang, S.-Y. Sun, P.-H. Wu, M.-T. Lee, H.-H. Wang**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 A High Mobility Metal Oxide Thin Film Transistor with Solution Coating Process

17:35

*K.-H. Su, D.-V. Pham, A. Merkulov, A. Hoppe, J. Steiger, R. Anselmann**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 $20 \text{ cm}^2/\text{Vs}$, solution-processed TFT is capable for AMOLED driving, high resolution and other high-end applications.

**AMD5 - 4L Effect of Annealing on Oxygen Content
17:55 in SiO₂/a-IGZO/SiO₂ Stacks**

*S. Oh, J.-H. Baeck, H. S. Shin, J. U. Bae, W. Shin,
I. Kang*

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.

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**

S. Yasuno, M. Inaba, S. Kosaka, S. Morita, A. Hino*,
K. Hayashi*, T. Kugimiya*, Y. Taniguchi**, I. Hirose***

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. Hirose, 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.

13:30 - 14:15

Conference Hall

FLX6: Flexible Oxide TFT

Chair: M. Ito, Toppan Printing, Japan
 Co-Chair: K. Uemura, Nippon Steel Sumitomo Metal, Japan

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

*H. S. Shin, S. M. Lee, S. Oh, J.-U. Bae, W. Shin,
 I. B. Kang*

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.

Oxide TFT

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

*C.-C. Chen, H.-C. Zang, S.-T. Huo, Z.-H. Ling, J. Ma,
 X.-F. Li*, L.-L. Chen*, J.-H. Zhang**

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

IGZO TFT array was fabricated on a Polyimide (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 **Low-Temperature IGZO TFT Backplane and Its Application in Flexible AMOLED Displays on Ultrathin Polymer Films**
14:00

*J.-L. P.J. van der Steen, A. K. Tripathi, J. Maas,
 K. van Diesen-Tempelaars, L. van Leuken, G. de Haas,
 B. van der Putten, I. Yakimets, F. Li, T. Ellis, T. van Mol,
 G. Gelinck, K. Myny*, P. Vicca*, S. Smout*, M. Ameys*,
 T. H. Ke*, S. Steudel*, M. Nag*, S. Schols*, J. Genoe*,
 P. Heremans*, Y. Fukui**, S. Green****

*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.

Author Interviews and Demonstrations

16:40 – 17:20

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
14:00 Future of Optical Technology**

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
14:20 Medicine**

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
14:40 Advanced Optical Features of Digital Projectors**

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 -----

15:40 - 17:20

Mid-sized Hall B

INP2/DES2: AR/VR Interactive Systems

Chair: N. Sakata, Osaka Univ., Japan

Co-Chair: N. Hashimoto, Citizen Holdings, Japan

INP2/ Invited Reality Beyond Its Physicality

DES2 - 1: *M. Inami*

15:40 *Keio Univ., Japan*

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.

INP2/ Invited A Tablet Interface for Laying Out AR Objects
DES2 - 2: -Outlook of Relationship with Smartphone and AR-

16:10 *N. Sakata, R. Nagashima, S. Nishida*

Osaka Univ., Japan

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.

INP2/ Invited The Possibility of the Eyeglass-Type Mobile
DES2 - 3: Phone

16:35 *T. Horikoshi*

NTT DoCoMo, Japan

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.

**INP2/
DES2 - 4** **A Cartoon-Character Costume with Active Facial
Expression**
17:00 *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 - 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
9:00 Standardization Effort in Korea**
 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**
 S. Cho, J. Kim, S. Jeong, H.-G. Choo, J. S. Choi, J. Kim
 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
9:40 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 -----

10:40 - 12:10

Mid-sized Hall B

DES3: Human Perceptions in Augmented 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

T. Kuroda, Y. Kuroda^{}, K. Hori^{**}, N. Ohboshi^{***}*

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.

DES3 - 4L Effectiveness of Freehand Modeling by BlueGrotto for CSCW in VR Space

11:55

*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.

11:55 - 12:25

Mid-sized Hall B

Short Presentation DESp: Display Electronics and systems

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

----- Lunch -----

13:30 - 14:45

Mid-sized Hall B

DES4/VHF1: Sensing Technologies for Virtual/Augmented 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
13:55** **Useful Field of View in Augmented Reality:
Comparison Between Distribution of Attention
under Binocular and Monocular Observation**

A. Kitamura, H. Naito, T. Kimura, K. Shinohara,
T. Sasaki**, H. Okumura***

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:
14:15** **Invited e-Heritage, Cyber Archaeology, and Cloud
Museum**

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.

14:50 - 17:50

Main Hall C

Poster DESp: Display Electronics and Systems

**DESp - 4 Eyeglass-Based Hands-Free Videophone Using
Fish-Eye Cameras and HMD**

S. Kimura, T. Horikoshi

NTT DoCoMo, Japan

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.

Author Interviews and Demonstrations

18:30 – 19:10

Special Topics of Interest on Lighting Technologies

Wednesday, December 4

13:40 - 16:40

Main Hall C

Poster OLEDp1: OLED Technologies

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 $\pm 5\%$ 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**PHp - 15 Wavelength Conversion Material Phosphor-Glass Composites for High Power Solid-State Lighting***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 CuInS₂/ZnS Quantum Dot-Polymer Plate-Based High-Color Rendering White Light-Emitting Diode*J.-H. Kim, W.-S. Song, J.-H. Lee, H.-D. Kang, H. Yang**Hongik Univ., Korea*

A free-standing double-layered composite plate, consisting of highly bright orange and greenish-yellow CuInS₂ 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*W.-S. Song, J.-H. Kim, K.-H. Lee, H.-S. Lee, S.-H. Lee, H. Yang**Hongik Univ., Korea*

Blue-to-yellow light-convertible CuInS₂/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 - 25L Improve the Stability of Quantum Dots with Silica and Applying Quantum Dot Film as a New Type White Light Packaging System

I. S. Sohn, W. B. Im

Chonnam Nat. Univ., Korea

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.

16:50 - 18:15

Conference Hall

OLED5: OLED for Lighting Applications

Chair: Y. Kijima, Sony, Japan

Co-Chair: T. Ikuta, JNC Petrochem., Japan

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

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 17:15 Diffractive Micro Lens Film

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

D. Kato, K. Sugi, T. Ono, A. Amano, T. Sawabe, T. Sugizaki, H. Kakizoe, Y. Mizuno, Y. Shinjo, S. Enomoto, I. Amemiya

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.

Author Interviews and Demonstrations

18:30 – 19:10

Friday, December 6

9:00 - 9:55

Main Hall A

PH3: Phosphors for Lighting

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

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

Niigata Univ., Japan

A novel red-emitting olivine-structure type phosphor $\text{NaMgPO}_4:\text{Eu}^{2+}$ was synthesized for the first time by the melt synthesis technique. The $\text{NaMgPO}_4:\text{Eu}^{2+}$ 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**
9:25

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

Nat. Chiao Tung Univ., Taiwan

**ITRI, Taiwan*

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

Unprecedented $\text{M}(\text{La}_{1-x}\text{Ce}_x)_2\text{Si}_2\text{S}_8$ (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.

PH3 - 3 9:40 Comparison of ACELs Formed on Copper, Silver and Gold Back Electrodes

J. Silver, G. Fern, P. G. Harris, P. Reip^{}, A. Kong^{*},
P. Bishop^{**}, A. Berzins^{**}, S. Jones^{***}*

Brunel Univ., UK

^{}Intrinsic 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***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.

13:30 - 15:05**Main Hall A****FMC8: Lighting Technologies**Chair: *K. Käläntär, Global Optical Solutions, Japan*Co-Chair: *Y. Yang, Japan Display, Japan***FMC8 - 1
13:30 Quantum Dot Enhancement of Color for LCD Systems***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.

FMC8 - 2 New LED Design Concept for High Color Gamut Application
13:50*S. J. Chang**AU Optronics, Taiwan*

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.

FMC8 - 3 Switchable Dual Directional Backlight for Energy Saving in Automotive Displays
14:10*A. Yuuki, K. Itoga, T. Satake**Mitsubishi Elec., Japan*

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.

FMC8 - 4 Optical Characteristics of Directional Backlight Unit for Field-Alternative Full Resolution Auto-Stereoscopic 3D LCD
14:30*K. Kälántár**Global Optical Solutions, Japan*

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 Optical Design of Novel Microstructure Film for Wide Viewing TN-LCD
14:50*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

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: 14:00 *Invited* **TFT-LCD Manufacturing Technology; Current Status and Future Prospects**

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: 14:35 *Invited* **IGZO Technology for the Innovative LCD**

*Y. Kataoka, H. Imai, Y. Nakata, T. Daitoh, T. Matsuo,
N. Kimura, T. Nakano, Y. Mizuno, T. Oketani,
S. Yamazaki*, J. Koyama*, M. Takahashi*, M. Tsubuku*,
H. Miyake*, T. Ishitani*, Y. Hirataka*, J. Koezuka**,
K. Okazaki***

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 -----

15:40 - 16:55

Mid-sized Hall A

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

Thursday, December 5

9:00 - 10:25

Mid-sized Hall A

LCT3: Display Mode (1)

Chair: M. Funahashi, Kagawa Univ., Japan

Co-Chair: S. H. Lee, Chonbuk Nat. Univ., Korea

LCT3 - 1: Invited Evolution of Super Fast Response VA-LCD

9:00

*M. Murata, Y. Iwata, K. Tanaka, H. Yoshida, K. Miyachi**Sharp, Japan*

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.

LCT3 - 2 Bidirectional Field Switching Mode for Fast Nematic LC Modulators

9:25

*A. R. Geivandov, M. I. Barnik, V. S. Palto, S. P. Palto**Inst. of Crystallography RAS, Russia*

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.

LCT3 - 3 Reflective Field Sequential Color Displays Based on Electrically Suppressed Helix FLC

9:45

*Y. Ma, A. Srivastava, V. G. Chigrinov, H. S. Kwok**Hong Kong Univ. of S&T, Hong Kong*

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.

LCT3 - 4 Viewing Angle Switchable LCD Based on 3-Electrode FFS Mode

10:05

*C.-H. Yang, C.-F. Fan, C.-W. Yeh, C.-H. Liao, W.-H. Hsu**AU Optronics, Taiwan*

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.

----- Break -----

10:40 - 12:00

Mid-sized Hall A

LCT4: LC Materials

Chair: K. Tarumi, Merck KGaA, Germany

Co-Chair: S. Komura, Japan Display, Japan

**LCT4 - 1
10:40 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
11:00 A New Patterning Technology with Polymerizable LCs***R. Goto, W. Hoshino, N. Iwahashi, K. Takahashi,
S. Morishima, N. Yanagihara, T. Yamaguchi, K. Takada,
Y. Ito, K. Oki**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
11:20 Comparison of Surface Characteristics on Rubbed Polyimide by Rubbing Condition with NEXAFS***M. Kwak, K. Kim, B. Kim, S. Choi, N. Kim, D. Kang,
Y. Choi, S. Jeon, J. Jeon, K. Kim*, B. Kim***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 α 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.

LCT

RECEPTION

Wednesday, December 4, 2013

18:30 – 20:30

Conference Hall (1F)

Sapporo Convention Center

See page 12 for details

LCTp1 - 3 Alignment and Electro-Optical Properties of Nematic LCs by Using Dendrimers

Y. Takahashi, T. Sakuma, O. Haba, T. Koda, K. Yonetake, M. Kwak, N. Kim*, S. Choi*, D. Kang*, Y. Choi*, S. Jeon*, Y. Momoi***

Yamagata Univ., Japan

**LG Display, Korea*

***LG Display, Japan*

Using liquid crystalline (LC) dendimer, 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

M. Uchida, T. Koda, A. Nishioka, O. Haba, K. Yonetake, M. Kwak, Y. Momoi*, S. An*, D. Kang*, Y. Choi*, S. Jeon**

Yamagata Univ., Japan

**LG Display, Korea*

Recent experiments disclosed that dendrimers in liquid crystal (LC) induce homeotropic alignment. In this study we tried to elucidate mechanism of alignment of dendrimer/LC mixture by Monte Carlo simulation of hard repulsive model molecules. We discuss alignment structure depending on density of dendrimers.

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

F. Fan, A. K. Srivastava, T. Du, M. C. Tseng, V. G. Chigrinov, H.-S. Kwok

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 - 8 Withdrawn

LCTp1 - 9 Enhancement of an Azimuthal Anchoring Energy in a Photo-Alignment Layer by Stacking Planar Alignment Layer

*Y. Kim, D.-H. Kim, Y.-J. Lee, C.-J. Yu, J.-H. Kim
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

*T.-H. Lin, C.-T. Wang, H.-C. Jau
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

Y. Nagataki, T. N. Oo, K. Miyashita, H. Hirata*,
M. Kimura, T. Akahane
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_A^* 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.

LCTp1 - 13L Observation of Dynamic Behavior of Liquid Crystal Molecules at the Alignment Surface*Y. Nishikawa, M. Sugimoto, S. Ishihara**Osaka Inst. of Tech., Japan*

We observed the very fast response (both the rise and decay time were about 200 μ 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***S.-K. Roh, J.-H. Kim, Y.-H. Choi, W.-Y. Choi, J.-H. Baek, M. Jun**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.

LCTp2 - 4 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.

LCTp2 - 5 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.

LCTp2 - 6 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 V_{gh} or V_{data}, CR attenuation will be 21.0%. Lessen the charging frequency from 60 Hz to 50 Hz, CR decreases about 26.9%.

LCTp2 - 7 The Reason of COG Mura in TFT-LCD to Explore

J. Long, Y. Song, H. Zhu, H. Yu, X. Dong, S. Sun, J. Wang, N. Quan, R. Li, H. Zhang, G. Yang, X. An

BOE Optoelect. 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.

LCTp2 - 8L 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

*J.-D. Yang, C.-A. Tseng, P.-C. Liao, W.-H. Hsu
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**

*Y. Xu, W. Chen, Z. Su, L. Jiang, X. Zhu, P. Liao
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 $\pm B$ plates.

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

*C. F. Fan, C. H. Yang, C. W. Yeh, C. H. Liao, W. H. Hsu
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 propose 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

J.-H. Cho, W. S. Kang, B.-J. Mun, J. H. Lee, B. K. Kim*,
H. C. Choi*, G.-D. Lee
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

S.-W. Oh, B. W. Park, J.-H. Lee, T.-H. Yoon*

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

T.-H. Choi, J.-W. Kim, S.-T. Shin, T.-H. Yoon*

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.

LCTp3 - 12L Surface-Stabilized Single-Domain Fringe-Field-Switching Liquid Crystal Mode with Zero Pretilt Alignment Property

S.-W. Oh, M.-K. Park, H. J. Lee, S.-H. Yoo, K. H. Park, J.-H. Lee*, B. K. Kim*, H.-R. Kim*

Kyungpook Nat. Univ., Korea

**LG Display, Korea*

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).

14:50 - 17:50

Main Hall C

Poster LCTp4: LC Applications

LCTp4 - 1 Planar Polymeric LC Lens for 2D/3D Image Switching in Auto-Stereoscopic Display

B.-J. Mun, J.-H. Baek, J. H. Lee**, B. K. Kim**, H. C. Choi**, J.-H. Kim*, G.-D. Lee*

Dong-A Univ., Korea

**Hanyang Univ., Korea*

***LG Display, Korea*

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.

LCTp4 - 2 Optically Rewritable LC Fresnel Zone Lens with Fast Response

X. Wang, A. Srivastava, V. Chigrinov, H. S. Kwok

Hong Kong Univ. of S&T, Hong Kong

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.

LCTp4 - 3 The Application of LC Q-Plates for Modulating Gaussian Beam

Y.-H. Huang, M.-S. Li, A. Y.-G. Fuh

Nat. Cheng Kung Univ., Taiwan

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

*C.-T. Hsieh, C.-W. Chung, C.-H. Liao, P.-R. Ding,
W.-C. Su, C.-Y. Huang, C.-H. Lin^{*}, K.-Y. Lo^{**}, C.-J. Tien^{***}
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 ℓ of the plate.

LCTp4 - 8 Withdrawn

LCTp4 - 9 A Novel Imaging Method for Cholesteric LCD

*M.-H. Yang, B.-W. Xiao, S.-W. Lai, Y.-S. Tsai, J.-L. Chen,
M.-H. Yeh, Y.-Z. Lee
ITRI, Taiwan*

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.

LCTp4 - 10 An Issue of RA Bright Spot in TN-LCD

*Y. J. Tang, X. Huang, S. Li, F. Lin
Infovision Optoelect., China*

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.

LCTp4 - 11 Method of Recycling LC from Waste LCD Panel

*C.-W. Lu, H.-Y. Huang
ITRI, Taiwan*

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.

LCTp4 - 12L Fast Switchable Ferroelectric Liquid Crystal Fresnel Zone Lens

*X. Wang, Q. Guo, F. Fan, J. Sun, A. Tam, Y. Ma,
A. K. Srivastava, V. G. Chigrinov, H. S. Kwok
Hong Kong Univ. of S&T, Hong Kong*

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.

LCTp4 - 13L All-Optically Controllable Scattering Mode Light Modulator Based on Azobenzene Liquid Crystals and Poly(N-Vinylcarbazole) Films

Y.-C. Liu^{}, K.-T. Cheng^{**}, Y.-D. Chen^{*}, A. Y.-G. Fuh^{*,***}*

^{}Nat. Cheng Kung Univ., Taiwan*

*^{**}Nat. Central Univ., Taiwan*

*^{***}Advanced Optoelect. Tech. Ctr., Taiwan*

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.

LCTp4 - 14L Optical Switch Using Dye-Doped Chiral Nematic Liquid Crystals

J.-W. Huh, B.-H. Yu, K.-H. Kim, T.-H. Yoon

Pusan Nat. Univ., Korea

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.

LCTp4 - 15L Dependence of Cell Thickness on Scattering Property in Reverse Mode Liquid Crystal Cells with Different Morphologies

S. Sakurai, R. Yamaguchi

Akita Univ., Japan

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.

LCTp4 - 16L Switchable Liquid Crystal Window for Daylight Control with Asymmetrical Incident Angle

T. Takasu, R. Yamaguchi

Akita Univ., Japan

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.

LCTp4 - 17L Top-down Aligned Reactive Mesogen Layer for Polarization-dependent Lenticular Lens in 2D/3D Switchable Display

C. Lee, S.-H. Yoo, M. Kim, H.-R. Kim

Kyungpook Nat. Univ., Korea

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.

LCTp4 - 18L Terahertz Liquid Crystal Grating Fabricated by Using Microrubbing Process

R. Ito, M. Honma, T. Nozokido, T. Nose*

Akita Prefectural Univ., Japan

**Univ. of Toyama, Japan*

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.

14:50 - 17:50

Main Hall C

Poster LCTp5: Blue Phase

LCTp5 - 1 Effect of Surface Alignment on the Stability and Electro-Optical Properties of Blue Phase LC

I. Yamana, T. N. Oo, H. Kikuchi, M. Kimura, T. Akahane*

Nagaoka Univ. of Tech., Japan

**Kyushu Univ., Japan*

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 - 2 Withdrawn

LCTp5 - 3 Withdrawn

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. Dubruel^{*},
H. D. Smet^{*,**}*

^{}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

S.-B. Ni, J.-L. Zhu, H.-J. Huang^{}, K.-C. Lee^{*}, J.-G. Lu*

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.

Friday, December 6

9:00 - 10:20

Mid-sized Hall A

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.

LCT5 - 4 **Low Operating Voltage and Good Contrast Ratio**
10:00 **Cholesteric LC Applied in Active-Matrix TFT**
Transparent Display

J.-H. Chen, C.-W. Su, J.-T. Lien

Chunghwa Picture Tubes, Taiwan

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 -----

10:40 - 12:15

Mid-sized Hall A

LCT6: Evaluation

Chair: M. Inoue, Apple, Japan

Co-Chair: A. Kubono, Shizuoka Univ., Japan

LCT6 - 1 **Improving the Image Sticking of Photo-Alignment**
10:40 **LCD Panel by Polymer Stabilization Technology**

H.-M. Fu, C.-S. Hsieh, J.-T. Lien

Chunghwa Picture Tubes, Taiwan

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).

LCT6 - 2 **Image Sticking Improvement by Optimizing Gamma**
11:00 **Voltages of Low Grey Levels**

X. Zhong, H. J. Huang, X. Ma, K.-C. Lee

Shenzhen China Star Optoelect. Tech., China

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.

LCT6 - 3 **Electric Field Interference among Vertically Aligned**
11:20 **In-Plane-Switching Mode**

*Y.-Y. Kung, S.-W. Tsao, M.-J. Lu, C.-Y. Chen, T.-L. Ting,
W.-H. Hsu, J.-J. Su*

AU Optronics, Taiwan

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.

**LCT6 - 4 Pursuing Peak Performance LCD of Mobile
11:40 Application**

*S. L. Yang, J.-P. Yu
AU Optronics, Taiwan*

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.

**LCT6 - 5L Novel Microstructure Film for Improving Viewing
12:00 Angle Characteristics of LCD**

*E. Yamamoto, T. Kanno, S. Katsuta, Y. Asaoka, T. Maeda,
T. Kamada, H. Yoshida, Y. Tsuda, K. Kondo
Sharp, Japan*

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 -----

13:30 - 14:30

Mid-sized Hall A

LCT7: Photo Alignment

Chair: K. Ono, Panasonic, Japan
Co-Chair: T. Nose, Akita Pref. Univ., Japan

**LCT7 - 1 LC Alignment on a New Photo-Alignment
13:30 Material with Liquid Crystalline Properties**

*S. Inoue, K. Obayashi, Y. Iimura
Tokyo Univ. of A&T, Japan*

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.

**LCT7 - 2 Polarization Mask by Patterned Rubbing Alignment
13:50 Technology for Azodye Photoalignment**

*A. A. Muravsky, A. A. Murauski, V. E. Agabekov
Inst. of Chem. of New Materials NAS Belarus, Belarus*

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.

LCT7 - 3
14:10

Light-Control of LC Alignment from Vertical to Planar

A. A. Rasha, G. Hegde, L. Komitov*

Univ. of Gothenburg, Sweden

**Univ. Malaysia Pahang, Malaysia*

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

*Y. H. Jang, H. N. Cho, W. S. Choi, K. I. Chun, M.-G. Kang,
K. Choo, B. Cho, J. U. Bae, W. Shin, I. Kang
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

*S.-C. Liu, C.-Y. Su, W.-H. Li, L.-Q. Shi, X.-W. Lv, Y.-T. Hu,
H.-J. Zhang, C.-Y. Tseng, Y.-F. Wang, C.-C. Lo, A. Lien*
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 cm²/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 H₂O molecules into films and terminate the traps in films by the oxidization.

AMDp1 - 4 New a-IGZO TFT Gate Driver Circuit with AC-Driven Pull-Down Circuit

*C.-E. Wu, F.-H. Chen, M.-H. Cheng, C.-L. Lin
Nat. Cheng Kung Univ., Taiwan*

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.

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*

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

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*

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.

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*

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 $0.05 \text{ cm}^2/\text{Vs}$ and an on/off current ratio over 10^3 .

AMDp1 - 8 Process Improvement for Reliability of Oxide TFT Display

M. Zhang, Y. Zhang, J. Hu, Y. Shi, X. Zhang, Y.-C. Chung, J.-K. Kim, G. Tian, Y. Xu

Hefei BOE Optoelect. Tech., China

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.

AMDp1 - 9 Self-Aligned Top-Gate a-IGZO Thin-Film Transistor with N₂ Plasma-Treated Source/Drain Regions

S. Chi, X. Xiao, X. He, S. Zhang

Peking Univ., China

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.

AMDp1 - 10 Influence of Temperature Annealing on Electrical Performances of Oxide TFT

B.-L. Yeh, C.-N. Lin, C.-C. Wu, C.-M. Chang, W.-B. Wu, C.-Y. Chen

AU Optronics, Taiwan

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.

AMDp1 - 11L High Mobility Atmospheric-Pressure-Processed IGZO TFT with AlO_x/IGZO Stack Fabricated by Mist Chemical Vapor Deposition

M. Furuta, T. Kawaharamura, T. Kaida, D. Wang

Kochi Univ. of Tech., Japan

High-mobility IGZO TFTs were demonstrated at 360°C with an IGZO channel and AlO_x 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.

13:40 - 16:40

Main Hall C

Poster AMDp2: Active-Matrix Devices**AMDp2 - 1 Temperature Sensor Using Poly-Si TFT and 1T1C Circuit with Gate Bias Control**

*J. Taya, K. Kojima, T. Mukuda, A. Nakashima, Y. Sagawa,
T. Matsuda, M. Kimura*

Ryukoku Univ., Japan

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.

AMDp2 - 2 Operational Amplifier Using Poly-Si TFTs - Characteristic Comparison between Multiple Output Stage Numbers -

*Y. Ito, S. Terada, Y. Imuro, K. Setsu, T. Matsuda,
M. Kimura*

Ryukoku Univ., Japan

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.

AMDp2 - 3 Bias-Temperature Instability Modeling for On-Glass-Integrated Shift Resistor Circuit Design Using Amorphous Silicon TFTs

M. Shin, J. Kang, K. Kim, Y. Choi, H. Bang, K. Lee

LG Display, Korea

We introduce ΔV_{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.

AMDp2 - 4 Optimized Pixel Design to Improve Oblique Picture Quality for 12-Domain Polymer Stabilized Vertical Alignment Display

C.-H. Chen, Z. Liao

Shenzhen China Star Optoelect. Tech., China

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.

AMDp2 - 5 PMOS LDD Structure and Conditions for Wide Driving Range of Driving TFT*H. Jeon^{*,**}, S. Lee^{**}, Y. Lee^{**}, K. Jang^{*}, Y.-J. Lee^{*}, J. Yi^{*}**^{*}Sungkyunkwan Univ., Korea**^{**}Samsung Display, Korea*

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 $1 \times 10^{13} / \text{cm}^2$.

AMDp2 - 6 A Cascaded Type Level Shifter for High-Voltage Generators*M. Yamashita, M. Fukuhara, M. Yoshida**Tokai Univ., Japan*

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.

AMDp2 - 7 An Integrated a-Si:H Gate Driver Circuit Design for Low Power Consumption TFT-LCD Application*Y. Qiao^{*,**,**}, Y. Li^{**,**}, H. Zheng^{**,**}, C.-T. Liao^{**,**}, X. Guo^{*}, T.-S. Jen^{*,**}**^{*}Shanghai Jiao Tong Univ., China**^{**}Infovision Optoelect., China**^{**}Inst. of Jiangsu Flat-Panel-Display Tech., China*

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.

AMDp2 - 8 An AMOLED Pixel Circuit with Negative V_{TH} Compensation Function*C. Leng, L. Wang, S. Zhang**Peking Univ., China*

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.

AMDp2 - 9 Formation of SiO₂ Thin Films on Polycrystalline Silicon Thin Films from Polysilazane Solution by CO₂ Laser Annealing

D. Hishitani^{}, M. Horita^{*,**}, Y. Ishikawa^{*,**}, Y. Watanabe^{***},
H. Ikenoue^{***}, Y. Uraoka^{*,**}*

^{}Nara Inst. of S&T, Japan*

*^{**}CREST, Japan*

*^{***}Kyushu Univ., Japan*

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.

AMDp2 - 13L Inkjet Printing Technique for Manufacturing Single-Crystal Films for Organic Thin-Film Transistors

H. Minemawari, T. Yamada, M. Tanaka, T. Hasegawa
AIST, Japan

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 $9 \text{ cm}^2/\text{V}\cdot\text{s}$.

AMDp2 - 14L Elevated-Electrode Structure in Organic Thin-Film Transistors

S. K. Kim, C.-H. Shim, T. Edura, K. Tsugita, S. Yukiwaki,
C. Adachi, R. Hattori
Kyushu Univ., Japan

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 DNNT.

13:40 - 16:40

Main Hall C

Poster AMDp3/OLEDp2: AMOLED**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.

**AMDp3/
OLEDp2 - 4 Low Voltage Operation of Organic Field-Effect
Transistors with Embedded Electrodes**

Y. Kimura, T. Nagase, T. Kobayashi, K. Takimiya,
M. Ikeda**, H. Naito
Osaka Pref. Univ., Japan
*Hiroshima Univ., Japan
**Nippon Kayaku, Japan*

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.

Thursday, December 5**9:00 - 10:25****Main Hall B****AMD1: Advanced Si TFT**

Chair: K. Miura, Toshiba, Japan
Co-Chair: T. Noguchi, Univ. of the Ryukyus, Japan

**AMD1 - 1: Invited The Physics and Technology of Bridged-
Grain Polycrystalline Silicon Thin-Film Transistor**

*M. Wong, H. S. Kwok, W. Zhou, R. Chen, M. Zhang,
S. Chen, T. Chow*
Hong Kong Univ. of S&T, Hong Kong
Sinodisplay Tech., China

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.

AMD1 - 2 **Degradation Behaviors of Bridged-Grain Polycrystalline Silicon Thin Film Transistors under DC Bias Stresses**
9:25

*M. Zhang, W. Zhou, R. Chen, M. Wong, H.-S. Kwok
Hong Kong Univ. of S&T, Hong Kong*

Device degradation behaviors of bridged-grain (BG) polycrystalline silicon thin films 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.

AMD1 - 3: *Invited* Low-Temperature Formation of Single-Crystalline Silicon on Glass and Plastic Substrates and Its Application to MOSFET Fabrication
9:45

*S. Higashi, K. Sakaike, S. Hayashi, S. Morisaki,
M. Akazawa, S. Nakamura, T. Fukunaga
Hiroshima Univ., Japan*

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.

AMD1 - 4L **Four-Terminal Planar Metal Double-Gate Low-Temperature Poly-Si TFTs for System-on-Glass**
10:10

R. Kurosu, S. Kamo, T. Sato, A. Hara
Tohoku Gakuin Univ., Japan
Hiroshima Univ., Japan

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.

----- Break -----

10:40 - 12:25

Main Hall B

AMD2: Oxide TFT: Applications
Special Topics of Interest on Oxide TFT

Chair: M. Wong, Hong Kong Univ. of S&T, Hong Kong

Co-Chair: N. Morosawa, Sony, Japan

AMD2 - 1: *Invited* 65-in. OLED TV Developed by Oxide TFT and Fine Metal Mask Technologies

10:40

L.-F. Lin, T.-H. Shih, J.-Y. Lee, W.-H. Wu, S.-C. Wang, Y.-H. Chen, C.-C. Chen, C.-L. Chen, P. P. Lin, Y.-H. Chen, S.-J. Yu, C.-H. Liu, H.-C. Ting, H.-H. Lu, L. Tsai, H.-S. Lin, C.-Y. Chen, L.-H. Chang, Y.-H. Lin

AU Optronics, Taiwan

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.

AMD2 - 2: *Invited* Flexible AMOLED Display Driven by Amorphous InGaZnO TFTs

11:05

K. Miura, T. Ueda, N. Saito, S. Nakano, T. Sakano, H. Yamaguchi, I. Amemiya

Toshiba, Japan

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.

AMD2 - 3 12.1-in. WXGA Plastic AMLCDs Driven by Low Temperature Amorphous IGZO TFTs

11:30

S.-Y. Sun, W.-C. Huang, W.-T. Lin, L.-Y. Lin, C.-C. Cheng, C.-Y. Liu, M.-F. Chiang

AU Optronics, Taiwan

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.

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

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

T. Kamiya^{}, K. Kimoto^{**}, N. Ohashi^{*,**}, K. Abe^{*},
 Y. Hanyu^{*}, H. Kumomi^{*}, H. Hosono^{*}*
^{*}*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 -----

13:30 - 14:55

Main Hall B

AMD3: Oxide TFT: Reliability (1)
Special Topics of Interest on Oxide TFT

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**
13:30

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
13:55** **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
14:15** **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 ΔV_{TH} had shown very smaller shift than shorter channel length TFT.

AMD3 - 4 **Photo-Response Elimination of Amorphous
14:35** **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 ΔV_{th} less than 1 V under NBIS while the wavelength varied from 360 nm to 620 nm, whereas the unpassivated a-IGZO TFTs exhibits ΔV_{th} around -10 V.

----- Break -----

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

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.

----- Break -----

16:50 - 18:10

Main Hall B

AMD5: Oxide TFT: Modeling & Devices
Special Topics of Interest on Oxide TFT

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 Solution-Processed Metal Oxide TFTs for AMOLED Applications
17:15

L.-Y. Lin, C.-C. Cheng, C.-Y. Liu, M.-F. Chiang, S.-Y. Sun, P.-H. Wu, M.-T. Lee, H.-H. Wang

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 A High Mobility Metal Oxide Thin Film Transistor
17:35 with Solution Coating Process**

*K.-H. Su, D.-V. Pham, A. Merkulov, A. Hoppe, J. Steiger,
R. Anselmann*

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.

**AMD5 - 4L Effect of Annealing on Oxygen Content
17:55 in SiO₂/a-IGZO/SiO₂ Stacks**

*S. Oh, J.-H. Baeck, H. S. Shin, J. U. Bae, W. Shin,
I. Kang*

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.

Author Interviews and Demonstrations

18:30 – 19:10

Friday, December 6

9:00 - 10:20

Main Hall B

AMD6: Novel Applications

Chair: A. Facchetti, Polyera, USA

Co-Chair: M. Inoue, Innolux, Japan

**AMD6 - 1: Invited Printed Organic TFTs for Interfacing Circuits
9:00 and Active Matrix**

*M. Charbonneau, S. Jacob, M. Benwadih, J. Bablet,
V. Fischer, D. Boutry, R. Coppard, I. Chartier, S. Abdinia^{*},
E. Cantatore^{*}, G. Maiellaro^{**}, E. Ragonese^{**},
G. Palmisano^{***}, R. Gwoziecki,*

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.

AMD6 - 2: Invited Device Characterizations and Novel Applications of Thin-Film Transistors
9:25

*M. Kimura, T. Matsuda
 Ryukoku Univ., Japan*

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.

AMD6 - 3L 3-D Stacked Complementary TFT Devices Using n-Type α -IGZO and p-Type F8T2 TFTs - Comparison between Stacked and Sided Configurations -
9:50

*T. Hasegawa, M. Inoue, T. Matsuda, M. Kimura,
 K. Nomura*, T. Kamiya*, H. Hosono*
 Ryukoku Univ., Japan
 Tokyo Inst. of Tech., Japan

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.

AMD6 - 4L 512PPI High Resolution Mobile Displays with High Aperture Ratio and Slim Border
10:05

*M.-H. Lee, H.-W. Wang, Y.-W. Chang, C.-H. Wu, J.-H. Ye,
 H.-H. Su, S.-H. Lu, A.-J. Tsai, W.-T. Pai, A. Huang,
 S.-H. Huang
 AU Optronics, Taiwan*

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.

----- Break -----

10:40 - 12:20

Main Hall B

AMD7: Printed TFT

Chair: M. Kimura, Ryukoku Univ., Japan

Co-Chair: Y. Fujisaki, NHK, Japan

AMD7 - 1: Invited Metal Oxides and Organic Materials for Flexible Displays

*Y. Xia, P. Tan, W. Zhao, H. Yan, D. Boudinet, Z. Chen,
Y. Zheng, H. Usta, M. Chen, J. Fang, S. W. Huang,
C. C. Hsiao, T. J. Marks, A. Facchetti^{*,**}*

^{*}*Polyera, USA*

^{**}*Northwestern Univ., USA*

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 $2\text{-}5\text{ cm}^2\text{ V}^{-1}\text{s}^{-1}$ and $\text{Ion}:\text{Ioff} > 10^6$ and oxide/IGZO TFTs with mobilities $> 20\text{ cm}^2\text{ V}^{-1}\text{s}^{-1}$.

AMD7 - 2 Low Process Temperature Organic TFT on PEN Substrate

11:05

*Y.-Y. Huang, S.-C. Chiang, Y.-H. Chen, I.-H. Lin,
H.-M. Chang, E. Hsu*

Chunghwa Picture Tubes, Taiwan

In this study, p-type organic TFTs were fabricated by spin coating method and ink-jet printing method, respectively. The $\text{Ion}:\text{Ioff}$ 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.

AMD7 - 3 Flexible Single-Grain Si TFTs Fabricated from Doctor-Blade Coated Cyclopentasilane on Polyimide Substrate

11:25

*J. Zhang, M. Trifunovic, M. van der Zwan, B. Mimoun,
H. Takagishi^{*}, T. Shimoda^{*,**}, K. Beenakker, R. Ishihara*

Delft Univ. of Tech., the Netherlands

^{*}*JST, Japan*

^{**}*JAIST, Japan*

Single grain Si TFTs have been fabricated on a polyimide substrate with mobilities of $378\text{ cm}^2/\text{Vs}$ and $129\text{ cm}^2/\text{Vs}$ for electrons and holes, respectively. Pure CPS has been doctor-blade coated, and an excimer laser-crystallization step lead to grains of $3\text{ }\mu\text{m}$. Transfer to a PEN foil resulted in flexible TFTs and CMOS inverters.

AMD7 - 4L Invited Self-Aligned Imprint Lithography (SAIL) for Manufacturing High Performance Flexible Display Electronics

11:45

H.-J. Kim, E. Holland, J. Maltabes, R. Elder, A. Jeans, C. Perlov*, O. Kwon**, C. Taussig***, N. Morrison*****

Phicot, USA

**Hewlett Packard, USA*

***Apple, USA*

****e-Inc, USA*

*****Appl. Materials, Germany*

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.

AMD7 - 5L A Flexible AMOLED Display Driven by Organic TFTs with an Inkjetted Semiconductor Layer

12:05

A. Miyamoto, Y. Okumoto, K. Sasai, K. Morita

Panasonic, Japan

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 ± 0.45 V.

----- Lunch -----

Author Interviews and Demonstrations

16:40 – 17:20

Supporting Organization:

Thin Film Materials & Devices Meeting

Workshop on FPD Manufacturing, Materials and Components

Wednesday, December 4

FMC

14:00 - 15:20

Main Hall A

FMC1: The 20th Anniversary: Past, Present, and Future (1)

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 (diazonaphtoquinone) 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.

**FMC1 - 4 Past, Present, and Future: Large Size Photo-Mask
15:00 for Fine Patterning at FPD Manufacturing**

*T. Hirano, H. Ihara, Y. Iwanaga, Y. Yoshikawa,
N. Imashiki, K. Yoshida*

HOYA, Japan

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 -----

15:40 - 17:00

Main Hall A

FMC2: The 20th Anniversary: Past, Present, and Future (2)

Chair: K. Käläntär, Global Optical Solutions, Japan

Co-Chair: R. Yamaguchi, Akita Univ., Japan

FMC2 - 1 Past, Present, and Future: Polarizing Film

15:40

M. Miyatake, Y. Saiki

Nitto Denko, Japan

Nitto Denko has been enhancing properties and adding a number of functions to polarizing films, in line with evolution of LCDs. Here we review our progress of development of polarizing films, and report future direction of the development including accuracy improvement for absorption axis and approaches for thinner polarizing film.

**FMC2 - 2 Past, Present, and Future: Retardation Films and
16:00 Plastic Base Films**

T. Toyoshima

ZEON, Japan

ZeonorFilm is a high-performance optical film for FPD. The FPD market has grown rapidly together with LCD technology. Recently, high-resolution display panels and high-performance touch sensors have gained favor. In those areas, ZeonorFilm exhibits excellent optical performance. This paper details Zeon's research focus areas for enabling next-generation displays via ZeonorFilm.

**FMC2 - 3 Past, Present, and Future: Evolution of Mobile
16:20 Phone LED Backlight Unit**

*K. Käläntär, M. Shinohara**

Global Optical Solutions, Japan

**Omron, Japan*

In this paper we review the BLU technology trends that supported the significant advancement of the LCD especially in the mobile phones within past 20 years. The light controlling technologies applied to BLU during this period are discussed and the future image of BLU is portrayed.

FMC2 - 4: *Invited* Past, Present, and Future: Transport of Gas Molecules through Plastic Films and Organic Adhesives for Electronic Devices

K. Nagai

Meiji Univ., Japan

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.

FMC

Author Interviews and Demonstrations

17:20 – 18:00

Thursday, December 5

9:00 - 10:20

Main Hall A

FMC3: Oxide TFT: Process Technologies
Special Topics of Interest on Oxide TFT

Chair: T. Kamiya, Tokyo Inst. of Tech., Japan

Co-Chair: T. Arikado, Tokyo Electron, Japan

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

9:00

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

9:20

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 **In-Line Process Monitoring for Amorphous Oxide Semiconductor TFT Fabrication Using Microwave-Detected Photoconductivity Decay Technique**

9:40

H. Goto, H. Tao, S. Morita, Y. Takahashi, A. Hino, T. Kishi, M. Ochi, K. Hayashi, T. Kugimiya*

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 **Manufacturing Process of Oxide TFT Using Solution-Processed Photosensitive Passivation Layer**

10:00

M. Takeshita, S. Abe, T. Kojiri, M. Hanmura, 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 -----

10:40 - 12:00

Main Hall A

FMC4: Materials

Chair: R. Yamaguchi, Akita Univ., Japan

Co-Chair: T. Tomono, Toppan Printing, Japan

FMC4 - 1: *Invited* Potential of Nonlinear Optical Organic Material for Green Light Source in Laser Projector

10:40

T. Tomono

Toppan Printing, Japan

Potential of Nonlinear optical (NLO) organic material for green light source in laser display was discussed. Organic device design guideline for second harmonic generation (SHG) was described from nonsymmetrical point of view by using some model material.

FMC4 - 2: Invited Novel Non-Alkaline Glass Substrate with Ultra-Low Thermal Shrinkage for Higher Resolution Active Matrix Displays
11:00

*A. Koike, M. Nishizawa, H. Tokunaga, J. Akiyama,
 T. Tsujimura, K. Hayashi
 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 slimming rate, lower sag and lower photoelastic constant.

FMC

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 -----

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>

13:30 - 14:30

Main Hall A

FMC5/FLX1: Flexible Materials

Chair: Y. Mizushima, Corning, Japan
 Co-Chair: M. Kimura, Nagaoka Univ. of Tech., Japan

**FMC5/
 FLX1 - 1:
 13:30** *Invited* **Highly Transparent and Conductive Carbon
 Nanotube Film on Plastic: Cellulose-Assisted Film
 Deposition Followed by Solution and Photonic
 Processing**

*Y. Kim, Y. Yokota, S. Shimada, R. Azumi, T. Saito,
 N. Minami
 AIST, Japan*

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 Ω /sq at transmittance of 89 - 98%.

**FMC5/
 FLX1 - 2:
 13:50** *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/m²/day in water vapor transmission rate (WVTR) were developed. Using them, consistency between two WVTR measurement systems was successfully achieved to 10^{-4} g/m²/day level. Furthermore, CEREBA's strategy to achieve a reliable WVTR evaluation technology to 10^{-6} g/m²/day is presented.

**FMC5/
 FLX1 - 3:
 14:10** *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, SiO₂ dielectric layer and photoluminescence treated Si nanoparticles with application in FPDs and LEDs are introduced.

----- Break -----

15:10 - 16:30

Mid-sized Hall A

FMC6: Optical Films

Chair: T. Ishinabe, Tohoku Univ., Japan

Co-Chair: I. Amimori, A51 Tech, Japan

**FMC6 - 1
15:10 Analysis of 3D Viewing Angle Characteristics for Film Type Patterned Retarder Panel Using Extended Jones Calculus***H.-H. Son^{*,**}, J.-U. Park^{*}, W.-N. Jeong^{*}, K.-M. Lim^{*}, K. Oh^{**}**^{*}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
15:30 Novel Film Patterned Retarder for Improving Viewing Angle Properties in 3D-LCDs***K. Takada, T. Otani, M. Nakao, K. Ohmuro, K. Amemiya, R. Goto, A. Matsumoto, T. Katagiri, H. Kagawa, Y. Suga, Y. Ito**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
15:50 Analysis of Grayscale Inversion and Image Quality Improvement of TN-LCDs Using New Wide View Film***H. Sato, A. Yamamoto, Y. Yanai, Y. Saitoh, T. Arai, Y. Ito**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.

**FMC6 - 4 Ellipsoidal Light Diffusing Film by Controlling
16:10 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
16:50 Organic Electron Devices**

*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
17:10 Mobile Devices**

*R. Hattori, K. Miyamoto, H. Kanaya, S. Tsukamoto,
H. Ishinishi**
Kyushu Univ., Japan
**Network Appl. Eng. Lab., 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.

FMC7 - 3 **Influence of Heating on the Direct Imprinting of ZrO₂ and an Idea to Improve Heating Condition for High Throughput**
17:30

K. Fukada^{}, H. Koyama^{*,**}, S. Inoue^{*}, T. Shimoda^{*,***}*

^{}JAIST, Japan*

*^{**}Toppan Printing, Japan*

*^{***}JST-ERATO, Japan*

We simulated the thermal conduction of a roll-to-sheet imprinting system. ZrO₂ 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.

FMC

FMC7 - 4 **Single Crystalline ZnO Nanorods Fabricated by Mist Chemical Vapor Deposition for Optical Applications**
17:50

C. Li, X. Li, D. Wang, T. Kawaharumura, M. Furuta, A. Hatta

Kochi Univ. of Tech., Japan

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.

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 - 1 **Evaluations of Reduced Graphene Oxide and Nano Graphene for Printable Transparent Conductors**

M. Hasegawa, Y. Hirayama

Merck, Japan

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.

FMCP - 2 Transparent Polyimides with Low Coefficient of Thermal Expansion and Low Birefringence for Flexible Display

M. Okazaki, K. Fukukawa, T. Urakami, Y. Sakata, A. Okubo

Mitsui Chems., Japan

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.

FMCP - 3 Low Thermal Shrinkage Glass Substrate for High Definition Display

M. Hayashi, S. Miwa, M. Ohji

Nippon Elec. Glass, Japan

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.

FMCP - 4 Refractive Index Control by Siloxane/Nano Particle Hybrid

N. Yoshida, Y. Tashiro, T. Nonaka

AZ Elect. Materials Manufacturing Japan, Japan

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.

FMCP - 5 A Novel Primer for Cycloolefin Polymer with Strong Adhesion and High Durability

T. Yamate, K. Kumazawa, S. Yamada, H. Suzuki

Nippon Soda, Japan

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

*C. H. Park, Y. S. Na, M. C. Sakong, M. S. Kwak,
M. W. Nam, S. J. Yu, K. D. Jeong*

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 mJ/cm²) & good straightness (1.9 μm L/S). It was demonstration of high resolution at 2.4 μm pattern at the 6th generation LCD Plant.

FMCP

FMCP - 7 Withdrawn

FMCP - 8 Roll-to-Roll Deposition on 100 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 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 ΩSq 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.

IDW '14

The 21st International Display Workshops

December 3 – 5, 2014

Toki Messe Niigata Convention Center
Niigata, Japan

<http://www.idw.ne.jp>

FMCp - 10 Improvement of Stamping Mura for Overcoat Layer and Column Spacer Fabricated by Imprint Lithography

*H.-S. Cho, D. Kwon, D.-H. Jang, Y.-S. Choi, S.-H. Jeon
LG Display, Korea*

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.

FMCp - 11 Development of High Optical Density Black Column Space for Black Matrix-Less Color Filter on TFT

*Y. Na, Y. Kim, C. Park, M. Kwak, D. Kang, Y. Choi,
S. Jeon
LG Display, Korea*

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

FMCp - 12 Optimization of Heat Treatment Profile Prior to Low Temperature Poly-Si TFT Fabrication Process

*J. Akiyama, K. Hayashi, M. Nishizawa, A. Koike
Asahi Glass, Japan*

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 alloy fabrication process was investigated.

FMCp - 13 Triple-View and Secure Dual-View Display by Use of Three-Layered LCD Panels

*K. Uchida, S. Suyama, H. Yamamoto
Univ. of Tokushima, Japan*

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 Optoelect. 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*S. Yasuno, M. Inaba, S. Kosaka, S. Morita*, A. Hino*, K. Hayashi*, T. Kugimiya*, Y. Taniguchi**, I. Hirose****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***C. Yan, K. Lu, Z. Xie, J. Guo, X. Chen, W. Wang, T. Y. Min, X. Dong, D. Sha, J. Zhang, X. Chen, L. Shi, Y. Xue,**W. Zhang, S. Xu, T. Li, Z. Tian, J. Li, H. Xiao, G. Zhang**BOE Optoelect. 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 lower 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

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

I. Hirose, 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.

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

T. Imamura, Y. Ikeda*, Y. Tomizawa*, T. Daidou*,*

*T. Shiro**,*

**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-Stabilized 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**

*Y. Asaoka, T. Kanno, D. Shinozaki, S. Ochi, S. Katsuta,
E. Yamamoto, T. Maeda, Y. Tsuda, Y. Shimada*

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

**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 adopted 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**

S. J. Choi, Y. J. Song, J. Niu, J. H. Kim*, B. K. Jung*,
Z. F. Cao, F. Z. Zhang, S. Sun, G. B. Hui, J. S. Xue*

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 -----

13:30 - 15:05

Main Hall A

FMC8: Lighting Technologies
Special Topics of Interest on Lighting Technologies

Chair: K. Kälantär, Global Optical Solutions, Japan

Co-Chair: Y. Yang, Japan Display, Japan

**FMC8 - 1 Quantum Dot Enhancement of Color for LCD
13:30 Systems**

*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.

**FMC8 - 2 New LED Design Concept for High Color Gamut
13:50 Application**

*S. J. Chang
AU Optronics, Taiwan*

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.

**FMC8 - 3 Switchable Dual Directional Backlight for Energy
14:10 Saving in Automotive Displays**

*A. Yuuki, K. Itoga, T. Satake
Mitsubishi Elec., Japan*

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.

**FMC8 - 4 Optical Characteristics of Directional Backlight Unit
14:30 for Field-Alternative Full Resolution Auto-
Stereoscopic 3D LCD**

*K. Kälantär
Global Optical Solutions, Japan*

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 Optical Design of Novel Microstructure Film for Wide Viewing TN-LCD
14:50

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.

FMC
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



–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 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 14:00 Powders for BUS Electrodes of AC PDPs

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 14:20 Calcium Magnesium Oxide Protective Layer for High Luminous Efficacy PDP

*Q. F. Yan, K. Kotera, H. Liu, H. Zhou, H. Zhao, X. Deng,
P. Wang*

Sichuan COC Display Devices, China

New combination layer of $\text{Ca}_x\text{Mg}_{1-x}\text{O}$ (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 14:40 Discharge Characteristics of AC PDPs in Xe/Ne Gas Mixture

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.

**PDP1 - 4L Electron Traps Formed by Photochromic Transition
15:00 of ZnSiO Nanoparticle**

H. Kajiyama^{}, Y. Matsuura^{*}, H. Tanaka^{*}, A. Otomo^{**},
S. Inoue^{**}, K. Takata^{***}, K. Uchino^{****}*

^{}Tokushima Bunri Univ., Japan*

*^{**}Hiroshima Univ., Japan*

*^{***}Kansai Univ., Japan*

*^{****}Kyushu Univ., Japan*

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 -----

PDP

15:50 - 17:00

Meeting Room 206

PDP2: Large Screen and Discharge Applications

Chair: Y.-S. Kim, Hongik Univ., Korea

Co-Chair: H. Kajiyama, Tokushima Bunri Univ., Japan

**PDP2 - 3L Application of AC Plasma Display Panels to
15:50 Radiation Detectors**

Y. Shintani, M. Murata, R. Murai

Panasonic, Japan

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.

**PDP2 - 4L Address While Display Method with Grouped
16:05 Subfield Arrangement for Increasing Light Emission
Duty Ratio of UHD PDPs**

Y. Saito, K. Komatsu, T. Shiga

Univ. of Electro-Commun., Japan

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 μ s.

**PDP2 - 1: *Invited* Reproduction of 22.2 Multichannel Sound
16:20 with FPD-Integrated Loudspeakers for Home Use**

*K. Matsui, S. Oishi, S. Oode, T. Sugimoto, Y. Nakayama,
H. Okubo, A. Ando, H. Sato*, K. Mizuno*, Y. Morita**

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
16:40 Display with LAFi Technology**

*K. Shinohe, T. Hidaka, T. Kosako, H. Hirakawa,
K. Awamoto, T. Shinoda*

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

The 20th Anniversary 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



Room 108, 1F
Sapporo Convention Center

Workshop on EL Displays and Phosphors

Thursday, December 5

9:00 - 12:00

Main Hall C

Poster PHp: Phosphors

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 (Ba_{1.98-x}Sr_xEu_{0.02}SiO₄) 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.

**PHp - 4 Eco-Friendly AC Electroluminescent Lamps II:
Comparison of Biodegradable, Rigid Substrates for
Electronics**

*J. Silver, G. R. Fern, P. G. Harris
Brunel Univ., UK*

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.

**PHp - 5 Femtosecond Laser Irradiation to ZnS Phosphor for
Inorganic Electroluminescent Displays**

K. Nabesaka, Y. Ishikawa^{*,***}, T. Doe*, N. Taguchi^{**},
Y. Hosokawa*, Y. Uraoka^{*,***}*

**Nara Inst. of S&T, Japan*

***Image Tech, Japan*

****CREST, Japan*

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.

**PHp - 6 Effect of Manganese on the Crystal Structure of
Colloidal Zinc Sulfide in the Presence of Sodium
Chloride**

*N. Sergeeva, M. Tsvetkova, A. Abizov, S. Bogdanov
Saint-Petersburg State Tech. Inst., Russia*

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.

**PHp - 7 Electroluminescence from DC Biased ZnS:TbF₃
Phosphor Layers Having Oxide Semiconductor**

*K. Yanagihara, N. Miura, H. Matsumoto
Meiji Univ., Japan*

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, copper aluminate was investigated. Phosphor deposited on the n-p-n structure, stable electroluminescence was observed.

PHp - 8 Development of ZnO Luminescent Thin Films for Electron Beam Excitation Assisted Optical Microscope

*S. Kanamori**, *A. Miyake* ***, *W. Inami* ***, *H. Kominami**,
Y. Kawata ***, *Y. Nakanishi**

**Shizuoka Univ., Japan*

***JST-CREST, Japan*

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.

PHp - 9 Synthesis of Eu³⁺ Doped Fluoride Phosphors Using PTFE

H. Mizobuchi, K. Uematsu, S. W. Kim, T. Ishigaki,
K. Toda, M. Sato

Niigata Univ., Japan

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.

PHp - 10 Synthesis and Luminescent Properties of Eu-Doped Sc-Based Phosphors with Perovskite Related Structures

*Y. Fujita, T. Kunimoto, T. Honma**, *M. Mikami***,
*Y. Shimomura***

Tokushima Bunri Univ., Japan

**JASRI, Japan*

***Mitsubishi Chem., Japan*

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.

PHp - 11 Synthesis and Luminescence Properties of Novel Blue-Emitting Sr₆(Y,Ce)₂Al₄O₁₅ Phosphors

Y. Kawano, K. Seki, K. Uematsu, S. W. Kim, T. Ishigaki,
M. Sato, K. Toda

Niigata Univ., Japan

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 4f¹ 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

$\text{Ca}_3\text{Y}_3\text{Ge}_2\text{BO}_{13}:\text{Ln}^{3+}$ (Ln = Eu, Tb and Sm) phosphors were synthesized by the conventional solid-state reaction method. Eu^{3+} - or Tb^{3+} -doped $\text{Ca}_3\text{Er}_3\text{Ge}_2\text{BO}_{13}$ phosphors showed strong red or green emission under the excitation at 254 nm. Sm^{3+} -doped $\text{Ca}_3\text{Er}_3\text{Ge}_2\text{BO}_{13}$ 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 $[(\text{Ca}_{0.97}\text{Mg}_{0.03})_{0.98}\text{Tb}_{0.02}]\text{SnO}_3$ thin films. On a glass substrate with the seed layer prepared by spin-coat technique, oriented thin films of $[(\text{Ca}_{0.97}\text{Mg}_{0.03})_{0.98}\text{Tb}_{0.02}]\text{SnO}_3$ 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

$\text{YVO}_4:\text{Eu}$ and $\text{YVO}_4:\text{Bi}$ nanophosphors were synthesized by microemulsion-mediated solvothermal and polyol methods. $\text{YVO}_4:\text{Bi}$ 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.

PHp - 15 Wavelength Conversion Material Phosphor-Glass Composites for High Power Solid-State Lighting

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 CuInS₂/ZnS Quantum Dot-Polymer Plate-Based High-Color Rendering White Light-Emitting Diode

*J.-H. Kim, W.-S. Song, J.-H. Lee, H.-D. Kang, H. Yang
Hongik Univ., Korea*

A free-standing double-layered composite plate, consisting of highly bright orange and greenish-yellow CuInS₂ 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

*W.-S. Song, J.-H. Kim, K.-H. Lee, H.-S. Lee, S.-H. Lee,
H. Yang
Hongik Univ., Korea*

Blue-to-yellow light-convertible CuInS₂/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.

PH

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-Nsp³ bond increased by irradiating He-Cd laser.

PHp - 22L Cathodoluminescent Properties of UV Emitting (Zn_{1-x}Mg_x)Al₂O₄ Phosphor

T. Ishinaga, H. Kominami, Y. Nakanishi, K. Hara

Shizuoka Univ., Japan

ZnAl₂O₄ which shows UV emission under EB excitation has been investigated. The luminescent properties of (Zn_{1-x}Mg_x)Al₂O₄ 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

K. Yamashina, H. Okura, R. Sakata, R. Komiyama, H. Miyashita, S.-S. Lee, K. Ohmi*

Tottori Univ., Japan

**Merck, Japan*

A novel microreactor system combining with the Y-branch glass mixer cell has been proposed. YVO₄: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.

PHp - 25L Improve the Stability of Quantum Dots with Silica and Applying Quantum Dot Film as a New Type White Light Packaging System

I. S. Sohn, W. B. Im

Chonnam Nat. Univ., Korea

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 Eu²⁺ Doped Phosphors for Light-Emitting Diodes by Computational Chemistry

15:10

H. Takaba, R. Matsui

Kogakuin Univ., Japan

Theoretical screening of host materials of Eu²⁺ 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 Analysis of Luminescence Centers in Phosphor Materials by X-ray Absorption Spectroscopy

15:35

T. Honma, T. Kunimoto, K. Ohmi***

JASRI, Japan

**Tokushima Bunri Univ., Japan*

***Tottori Univ., Japan*

We have reviewed the XAFS studies on BaMgAl₁₀O₁₇:Eu, CuAlS₂:Mn and Y₃Al₅O₁₂: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

16:00

Y. Kawata^{,**}, Y. Nawa^{*}, S. Kanamori^{*}, A. Miyake^{*,**},
W. Inami^{*,**}, Y. Nakanishi^{*}*

^{}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

16:50

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

17:15

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

17:40

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.

PH2 - 4 **Nematic Liquid Crystalline Phase of Red-Emitting**
18:05 **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

PH

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

PH3 - 1: ***Invited* New Blue Light Excitable Red-Emitting**
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**
9:25 **New Thiosilicates Phosphors for LED Lighting**

S.-P. Lee, T.-M. Chen, C.-H. Huang, T. S. Chan***
Nat. Chiao Tung Univ., Taiwan
**ITRI, Taiwan*
***Nat. Synchrotron Radiation Res. Ctr., Taiwan*

Unprecedented M(La_{1-x}Ce_x)₂ Si₂S₈ (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.

PH3 - 3 **Comparison of ACELs Formed on Copper, Silver and Gold Back Electrodes**

9:40

J. Silver, G. R. Fern, P. G. Harris, P. Reip^{}, A. Kong^{*}, P. Bishop^{**}, A. Berzins^{**}, S. Jones^{***}*

Brunel Univ., UK

^{}Intrinsic 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 -----

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

Y. Neo, A. Koike, H. Mimura, H. Murata^{}, T. Yoshida^{**}, T. Nishi^{**}, M. Nagao^{**}*

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.

FED2/
PH4 - 3
11:30

**Cathodoluminescence Spectra of Single
Gd₂O₂S:Tb³⁺ Nanometer Sized Phosphor Crystals
Excited in a Field Emission Scanning Transmission
Electron Microscope**

G. R. Fern, X. Yan, N. Wilkinson, J. Silver*

Brunel Univ., UK

**Gatan UK, UK*

Cathodoluminescence spectra have been collected from eight nanometer-sized crystals of Gd₂O₂S:Tb³⁺ 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.

FED2/
PH4 - 4
11:50

**Cathodoluminescence Spectra of Single Y₂O₂S:Tb³⁺
Nanometer Sized Phosphor Crystals Excited in a
Field Emission Scanning Transmission Electron
Microscope**

J. Silver, X. Yan, N. Wilkinson, G. Fern*

Brunel Univ., UK

**Gatan UK, UK*

Cathodoluminescence (CL) spectra have been collected from single nanometer-sized crystals of Y_{1.9}Tb_{0.1}O₂S 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 -----

Author Interviews and Demonstrations

16:40 – 17:20

Supporting Organizations:

Phosphor Research Society. The Electrochemical Society of Japan
The 125th Research Committee on Mutual Conversion between
Light and Electricity, JSPS

**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

Workshop on Field Emission Display and CRT

Friday, December 6

9:00 - 9:10

Meeting Room 206

Opening

Opening Remarks

9:00

H. Mimura, Shizuoka Univ., Japan

9:10 - 10:30

Meeting Room 206

FED1: Novel Devices & Applications

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.

FED1 - 3 **Highly Reliable MIM-Cathode-Arrays for Large-Size**
10:10 **FED**

*M. Ikeda, T. Kusunoki, M. Sagawa, M. Suzuki,
 E. Nishimura, T. Hirano
 Hitachi, Japan*

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/ **Invited Performance of Microcolumn for Fine**
PH4 - 1: **Electron Beam Applications**
10:40

Y. Neo, A. Koike, H. Mimura, H. Murata, T. Yoshida**,
 T. Nishi**, M. Nagao**
 Shizuoka Univ., Japan
 *Meijo Univ., Japan
 **AIST, Japan*

FED

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/ **Cathodoluminescence in Transparent Perovskite**
PH4 - 2 **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.

**FED2/
PH4 - 3
11:30** **Cathodoluminescence Spectra of Single
Gd₂O₂S:Tb³⁺ Nanometer Sized Phosphor Crystals
Excited in a Field Emission Scanning Transmission
Electron Microscope**

G. R. Fern, X. Yan, N. Wilkinson, J. Silver*

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Cathodoluminescence spectra have been collected from eight nanometer-sized crystals of Gd₂O₂S:Tb³⁺ 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.

**FED2/
PH4 - 4
11:50** **Cathodoluminescence Spectra of Single Y₂O₂S:Tb³⁺
Nanometer Sized Phosphor Crystals Excited in a
Field Emission Scanning Transmission Electron
Microscope**

J. Silver, X. Yan, N. Wilkinson, G. R. Fern*

Brunel Univ., UK

**Gatan UK, UK*

Cathodoluminescence (CL) spectra have been collected from single nanometer-sized crystals of Y_{1.9}Tb_{0.1}O₂S 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 -----

13:30 - 15:00

Meeting Room 206

FED3: Fabrication Process & CNT Emitters

Chair: H. Mimura, Shizuoka Univ., Japan

Co-Chair: H. Shimawaki, Hachinohe Inst. of Tech., Japan

**FED3 - 1: *Invited* Fabrication of Spindt-Type FEAs with
13:30 Volcano-Structured Focusing Electrode**

M. Nagao, T. Yoshida

AIST, Japan

A new fabrication method of Spindt-type emitters is presented. In our method, double-layered photoresist is used as a lift-off layer, and gate hole is formed after emitter-tip formation. As a result, volcano-structured focusing electrodes can be easily formed on the Spindt-type metal emission tip.

**FED3 - 2 Evaluations for Graphene Flower Cloth as a Field
14:00 Emitter and Its Applications**

Y. Iwai^{,***}, K. Muramatsu^{**}, A. Jyouzuka^{*}, T. Nakamura^{*},
Y. Onizuka^{*}, H. Mimura^{***}*

**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.

**FED3 - 3 Fabrication of Carbon Nanotube Field Emitter with
14:20 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.

**FED3 - 4 Microscopic Properties of Carbon Films That
14:40 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.

----- Break -----

FED

15:10 - 16:30

Meeting Room 206

FED4: FE Materials & Mechanisms

Chair: M. Sasaki, Univ. of Tsukuba, Japan

Co-Chair: F. Wakaya, Osaka Univ., Japan

**FED4 - 1 Work Function Measurements of W(100) Surface
15:10 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.

**FED4 - 2 Measurement of Work Function of Hafnium Nitride
15:30 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.

**FED4 - 3 Evaluation of Radiation Tolerance of Hafnium Nitride
15:50 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 .

**FED4 - 4 Photoresponse of MOS Cathodes Based on
16:10 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.

Author Interviews and Demonstrations

16:40 – 17:20

Sponsor:

158th Committee on Vacuum Nanoelectronics, JSPS

Workshop on OLED Displays and Related Technologies

Wednesday, December 4

13:40 - 16:40

Main Hall C

Poster OLEDp1: OLED Technologies

OLEDp1 - 1 Optical and Electrical Properties of $\text{MoO}_3/\text{Ag}/\text{MoO}_3$ 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 $\text{MoO}_3/\text{Ag}/\text{MoO}_3$ (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 $6.1 \Omega/\square$). 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 $3,540 \text{ cd/m}^2$ 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. Oishi, 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.

OLEDp1 - 4 Efficiency Control of Organic Light-Emitting Diodes for High Contrast Ratio

*M. J. Park, Y. H. Son, Y. J. Kim, J. H. Kwon
Kyung Hee Univ., Korea*

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.

OLEDp1 - 5 Withdrawn**OLEDp1 - 6 High Efficiency Orange-Red Phosphorescent Iridium(III) Complexes for Solution-Processable Organic Light-Emitting Diode Based on Small-Molecule Mixed Host**

W.-C. Su, C.-H. Yuan, A.-K. Cheng, S.-B. Chen, C.-F. Lin,
Y.-C. Chiu*, Z.-Y. Lin*, S.-W. Liu*, C.-C. Lee
Nat. Taiwan Univ. of S&T, Taiwan
Ming Chi Univ. of Tech., Taiwan

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.

OLEDp1 - 7 Flexible OLEDs on Polyimide-Graphene Composite Film and Properties

*W. S. Cho, M. Y. Lee, H. H. Kim, G. S. Kwak, S. Y. Park,
L. S. Park
Kyungpook Nat. Univ., Korea*

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.

OLEDp1 - 8 Highly Efficient Phosphorescent White Organic Light-Emitting Devices with Theoretical Efficiency Using Single Host Structure

*J.-M. Do, J.-H. Jung, J.-G. Choi, D.-G. Moon
Soonchunhyang Univ., Korea*

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-(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

J.-A. Yoon, N. H. Kim*, S. I. Yoo*, J. W. Kim*, C.-B. Moon*, A. Turak**, W. Y. Kim****

**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 BAiq and DPVBi. Luminous efficiency and CIE_{xy} 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 $\pm 5\%$ 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

*J.-Y. Liao, H.-C. Yeh, T.-C. Chao, J.-S. Lin, C.-H. Chou,
M.-R. Tseng*

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

13:40 - 16:40

Main Hall C

Poster AMDp3/OLEDp2: AMOLED**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.

**AMDp3/
OLEDp2 - 4 Low Voltage Operation of Organic Field-Effect Transistors with Embedded Electrodes**

Y. Kimura, T. Nagase, T. Kobayashi, K. Takimiya,
M. Ikeda**, H. Naito*

Osaka Pref. Univ., Japan

**Hiroshima Univ., Japan*

***Nippon Kayaku, Japan*

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

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

9:00

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

9:25

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.

**OLED1 - 3 Development of Highly Efficient and Long-Lived
9:50 Light-Blue Phosphorescent Material Technology**

H. Ito, K. Hiyama, H. Kita

Konica Minolta, Japan

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.

**OLED1 - 4L: *Invited* Improving Efficiency of Blue Fluorescent
10:10 OLED by Controlling Molecular Shape of Dopant**

*K. Okinaka, T. Ogiwara, H. Ito, Y. Mizuki, R. Naraoka,
M. Funahashi, H. Kuma*

Idemitsu Kosan, Japan

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.

----- Break -----

IDW '14

The 21st International Display Workshops

December 3 – 5, 2014

Toki Messe Niigata Convention Center
Niigata, Japan

<http://www.idw.ne.jp>

10:40 - 12:00

Conference Hall

OLED2: Display Technologies

Chair: H. Kuma, Idemitsu, Japan

Co-Chair: S. Enomoto, Toshiba Lighting & Tech., Japan

OLED2 - 1 Active Matrix OLED Microdisplay for Augmented Reality Applications with Improved Color Space**10:40***M. Thomschke, K. Fehse, B. Richter, P. Wartenberg, 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 Improved Bi-Directional Illumination Transparent White Organic Light-Emitting Diodes with Asymmetric Multilayer Electrode**11:00***C.-H. Yuan, Y.-H. Liu*, K.-T. Chen*, W.-C. Su, A.-K. Cheng, S.-B. Chen, C.-F. Lin*, S.-W. Liu*, C.-C. Lee**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 Wide View-Angle Top-Emitting Organic Light-Emitting Diodes Based on Green Fluorescent Dopant: Research on Transparent Electrode and Angular Characteristic**11:20***C.-F. Lin, C.-H. Yuan*, Y.-C. Chiu, Y.-H. Liu, K.-T. Chen, Z.-Y. Lin, W.-C. Su*, S.-W. Liu, C.-C. Lee***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 MoO₂/Ag/WO₃ (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.

OLED2 - 4L Enabling Dark Injection SCLC to Characterize Trapping in OLED Charge Transport Layers
11:40

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.

----- Lunch -----

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
13:30

M. James, I. Afonina, T. Backlund, R. Bhintade, S. Bain, T. Cull, G. Lloyd, D. Sparrowe, L.-W. Tan, P. Wierzchowicz, M. Verrall
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
13:55

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.

OLED3 - 3 Flexible AM-OLED Display on Ultra-Thin Glass

14:15

*C. C. Kuo, J.-Y. Chiou, S.-F. Liu, C.-H. Chiu, C.-H. Lin,
Y.-C. Sun, M.-C. Chen, Y.-W. Chiu*

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.

OLED3 - 4L: Invited Flexible and Printed Organic TFT Devices and Integrated Circuits

14:35

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 -----

15:10 - 16:30

Conference Hall

OLED4: Process Technologies

Chair: S. Naka, Univ. of Toyama, Japan

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

OLED4 - 1 Surface Morphology Control of Organic Semiconductor Layers Using Surface Control Additives on Solution Processes

15:10

K. Sakanoue, H. Harada, K. Ando, J. Fukai, M. Aonuma,
C. Adachi*

Kyushu Univ., Japan

**Panasonic, Japan*

We investigated novel organic semiconductor ink formulation including siloxane and acryl based surface control additives to form uniform film morphologies on stripe patterned bank structured substrates. These additives reduced contact angles, resulting in higher pinning position than pristine inks. Accordingly, improved film uniformities were obtained.

**OLED4 - 2 Polymer Light Emitting Diodes with PEDOT:PSS
15:30 Anode Deposited by Inkjet Printing**

*J. Ha, J. Park, J. Ha, D. Kim, C. Lee, Y. Hong
Seoul Nat. Univ., Korea*

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.

OLED4 - 3 Withdrawn**OLED4 - 4L Vacuum Based Fine Patterning of Organic Emissive
15:50 Layers for AMOLED Displays**

*M. Burghart, A. Dutkowiak, G. Haasemann, L. Tandler,
R. Seifert, J. Richter, F. Schröter, U. Seifert
Von Ardenne, Germany*

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.

**OLED4 - 5L: *Invited* New Transparent Liquid Desiccant for OLED
16:10 Application**

*Y. Hoshina, T. Niyama, S. Tanaka, M. Miyagawa
Futaba, Japan*

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.

----- Break -----

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>

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
16:50 Lighting Application**

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
17:15 Diffractive Micro Lens Film**

*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
17:35 Panel with Solid Encapsulation and Peripheral Grid Electrode**

*D. Kato, K. Sugi, T. Ono, A. Amano, T. Sawabe,
T. Sugizaki, H. Kakizoe, Y. Mizuno, Y. Shinjo, S. Enomoto,
I. Amemiya*

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.

OLED5 - 4L A 56-in. High Mobility Metal Oxide Thin Film Transistors Active-Matrix Organic Light-Emitting Diode Television

17:55

T.-H. Shih, P.-L. Lin, L.-F. Lin, H.-C. Ting, C.-L. Chen, S.-J. Yu, L. Tsai, C.-H. Liu, H.-S. Lin, C.-Y. Chen, L.-H. Chang, Y.-H. Lin

AU Optronics, Taiwan

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.

Author Interviews and Demonstrations

18:30 – 19:10

The 20th Anniversary Address

Shunsuke Kobayashi

Tokyo Univ. of Sci. Yamaguchi

Wednesday, December 4, 2013

12:00 – 12:30

Conference Hall, 1F



The 20th Anniversary 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

Room 108, 1F

Sapporo Convention Center



Workshop on 3D/Hyper-Realistic Displays and Systems

Wednesday, December 4

13:40 - 16:40

Main Hall C

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,
Z. M. Meng, L. Liu, J. M. Wang, R. Guo, W. G. Su
Beijin 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. Matsuhira^{,**}
*Arisawa Manufacturing, Japan
**Asuna, 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.

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

W. H. Hu, L. Liu, L. Zhang, Y. P. Liao, X. B. Shao, D. K. Yoon, D. Wang, L. Q. Guo, Y. F. Du, Z. Z. He, Y. B. Yu, Z. M. Meng, J. M. Wang, R. Guo, W. G. Su

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

Y.-J. Li, H.-F. Wang, H.-S. Chen, C.-H. Tsao, N.-W. Chang**

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.

3Dp - 8 The Effects of Environmental Illumination and Screen Brightness on Accommodation and Convergence in Handheld 3D Game Console

*Y. Okada, T. Kojima, K. Yoshikawa, T. Ohashi, M. Miyao
Nagoya Univ., Japan*

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 the how accommodation and convergence were dependent on pupil diameter.

3Dp - 9 Withdrawn

3Dp - 10 Scent Presentation to Food Image and Its Psychological Effect

*K. Tomono, M. Tanaka, R. Shu, A. Tomono
Tokai Univ., Japan*

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.

3Dp - 11 Depth-Fused 3D (DFD) Display with Non-Overlapped Pixels Using Layered LED Displays

*J. Kawakami, A. Tsunakawa, S. Suyama, H. Yamamoto
Univ. of Tokushima, Japan*

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.

3Dp - 12 DFD Viewer Composed of Two DFD Images with a Large Gap for Estimating Background Effect on Perceived Depth of 2D/3D Image

*M. Takahashi, H. Yamamoto, S. Suyama
Univ. of Tokushima, Japan*

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.

3Dp - 13 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.

3Dp - 14 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.

3Dp - 15 One-Colored Time-Division Electroholography Using a NVIDIA GeForce GTX TITAN

H. Niwase, H. Araki, N. Takada, H. Nakayama, A. Sugiyama**, T. Kakue**, T. Shimobaba**, T. Ito***

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.

3Dp - 16 Large-Scale Digital Holographic Display with Wide Viewing Angle

M. Park, H. Kim, B. G. Chae, J. Hahn, H. Kim**, C. H. Park***, K. Moon, J. Kim*

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.

3Dp - 17L Semi-Portable Full-Color Electro-Holographic Display with See-Through Vision

*T. Yoneyama, T. Ichikawa, Y. Sakamoto
Hokkaido Univ., Japan*

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.

3Dp - 18L Computer-Generated Hologram on GRAPE-DR

*A. Sugiyama, M. Oikawa, N. Okada, H. Nakayama,
N. Masuda*, T. Fukushige**, T. Shimobaba, T. Ito
Chiba Univ., Japan
*Nagaoka Univ. of Tech., Japan
**K&F Computing Res., Japan*

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.

3Dp - 19L Parallel Algorithm for Computer-Generated Hologram Calculation Using Multi-GPU Cluster System with a Single Display Device and Infiniband Network

N. Takada, H. Niwase, H. Araki, H. Nakayama,
A. Sugiyama**, T. Kakue**, T. Shimobaba**, T. Ito**
Kochi Univ., Japan
*VASA Entertainment, Japan
**Chiba Univ., Japan*

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.

3Dp - 20L Real-Time Time-Division Color Electroholography Using Message Passing Interface

H. Araki, H. Niwase, N. Takada, H. Nakayama,
A. Sugiyama**, T. Kakue**, T. Shimobaba**, T. Ito**
Kochi Univ., Japan
*VASA Entertainment, Japan
**Chiba Univ., Japan*

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 proposed 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

K. Tatehata, K. Sato, S. Yamada, S. Suyama, I. Ishii^{}, H. Yamamoto*

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 Based on MPEG-2 and HEVC**9:20***S. Cho, J. Kim, S. Jeong, H.-G. Choo, J. S. Choi, J. Kim**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
9:40 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
10:00 Inpainting Embedded Virtualized-Reality Indoor Modeler**

*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 -----

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: 3DTV**
15:10 *Invited Evaluation of Fatigue Caused by Watching*
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
15:30** **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.

**3D2/
VHF2 - 3
15:50** **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.

**3D2/
VHF2 - 4
16:10** **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.

----- Break -----

16:50 - 18:10

Mid-sized Hall B

3D3: Holography

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

3D3 - 1: 16:50 Invited New Multi-Color and Rewritable Holographic Polymer Film for 3D Holographic Display

*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 17:10 Display Chips for Electro-Holographic Display

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 be made smaller and brighter.

3D3 - 3 17:30 Enlargement of Viewing Zone of a Holographic Image Generated from an Image Captured by Integral Photography

*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/>

3D3 - 4 **Initial Study of Vision Training Used CGH Book with Head-Mounted Display**

17:50

*Q.-L. Deng, B.-S. Lin, H.-T. Chang**, *P.-L. Fan***,
*C.-Y. Chen**

Nat. Chiao Tung Univ., Taiwan

**Nat. Yunlin Univ. of S&T, Taiwan*

***Nat. Taipei Univ. of Education, Taiwan*

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

9:00 - 10:20

Mid-sized Hall B

3D4: 3D Display (1)

Chair: H. Y. Lin, Nat. Taiwan Univ., Taiwan

Co-Chair: M. Tsuchida, NTT, Japan

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.

3D4 - 3 **A Time-Division Multiplexing Parallax Barrier System with Wider Viewing Zone**

9:40

Q. Zhang, H. Kakeya

Univ. of Tsukuba, Japan

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.

3D4 - 4 **Optimized 3D Still-Gamma to Perform Better 3D Quality in a 120 Hz Frame Rate Display**

10:00

C. Ho, Y. Jin, S. Syu, Y. Chen, C. Li

Shenzhen China Star Optoelect. Tech., China

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 -----

10:40 - 11:55

Mid-sized Hall B

3D5: 3D Display (2)

Chair: S. Miura, Toyo Kohan, Japan

Co-Chair: H. Yamamoto, Tokushima Univ., Japan

3D5 - 1: ***Invited* Study of Designated Eye Position and Viewing Zone for Two-View Autostereoscopic 3D Displays**

10:40

K.-C. Huang^{,**}, Y.-H. Chou^{**}, L.-C. Lin^{**}, H. Y. Lin^{*},
F.-H. Chen^{**}, C.-C. Liao^{**}, Y.-H. Chen^{**}, K. Lee^{**},
W.-H. Hsu^{*}*

^{}Nat. Taiwan Univ., Taiwan*

*^{**}ITRI, Taiwan*

Designated eye position and viewing zone are important optical parameters in designing two-view autostereoscopic displays. We propose novel evaluation metrics based on equivalent luminance and binocular luminance to figure out both parameters. Simulation results prove the usefulness of our proposed metrics in effectiveness and accuracy of 3D metrology.

**3D5 - 2 Modification of Lenslet Shape of Lenticular Lens
11:00 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.

**3D5 - 3 A Novel Electrode Structure of LCL Lens Designed
11:20 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.

**3D5 - 4L Super Multi-View Display with 1-mm-pitch
11:40 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.

----- Lunch -----

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 daylight. 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**

*T. Shizume, G. Ohashi, Y. Onuki, H. Takamatsu**

Y. Shimodaira

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.

VHFp2 - 3 Evaluation of Color Channels and Gamut in OLED RGB to RGBW Conversions*J.-W. Huang, C.-J. Chou, H.-S. Chen, R. Luo***Nat. Taiwan Univ. of S&T, Taiwan***Univ. of Leeds, UK*

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.

VHF

VHFp2 - 4 Evaluation of Brightness and Visual Comfort of LED Light Fixtures*T.-X. Lee, H.-Y. Sung, C.-H. Wen, S.-W. Hsu*, C.-H. Chen***Nat. Taiwan Univ. of S&T, Taiwan***ITRI, Taiwan*

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.

VHFp2 - 5 Evaluation of Motion Artifacts on OLED TVs*J.-H. Bae, C.-M. Yang, K.-S. Shin, H.-S. Jang, C.-W. Kim**Univ. of Inha, Korea*

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.

VHFp2 - 6 Effects of 3D Display on Change Detection Task and Subjective Task Difficulty*Y. Masakura, T. Tamura*, S. Ohno**Tokyo Univ. of Tech., Japan***Tokyo Polytechnic Univ., Japan*

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

M. W. Lee, S. A. K. Ha, H. H. Park, J. H. Kim

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 Under Binocular and Monocular Observation
13:55
A. Kitamura, H. Naito, T. Kimura, K. Shinohara, T. Sasaki**, H. Okumura***
*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 -----

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

15:50 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.

**3D2/
VHF2 - 4** **Assessing the Impact of Crosstalk on 3D Image
Quality Using EEG**

16:10

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.

VHF

Author Interviews and Demonstrations

18:30 – 19:10

Friday, December 6

9:00 - 10:15

Meeting Room 204

VHF3: Improving Visual Experience

Chair: T. Kurita, NHK, Japan

Co-Chair: A. Yoshida, Sharp, Japan

**VHF3 - 1: *Invited* Using Image Dimension Dissection to Study
9:00 Viewer Preferences of Luminance Range in
Displayed Imagery**

*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
9:30 Reproduction**

*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.

**VHF3 - 3L Real-Time Virtual Fitting System by Using Morphing
10:00 with Skeletal Tracking**

*W. Naya, K. Fukumoto, T. Yamamoto, Y. Dobashi
Hokkaido Univ., Japan*

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 -----

10:40 - 12:10

Meeting Room 204

VHF4: Visual Perception

Chair: S. Daly, Dolby Labs., USA
Co-Chair: K. Masaoka, NHK, Japan

VHF4 - 1: Invited Surface Quality and Material Perception

10:40

*S. Nakauchi
Toyohashi Univ. of Tech., Japan*

This article reviews recent research on surface quality and material perception which attempt to reveal how the visual system identify the material properties and infer the surface quality of various materials including glossiness and translucency. Also pearl quality measurement is also mentioned as one of the technological applications.

**VHF4 - 2 Higher Resolution Stimulus Enhances Depth
11:10 Perception Even When the Resolution Difference is
Undetectable**

*Y. Tsushima, K. Komine, Y. Sawahata, N. Hiruma
NHK, Japan*

We recently make remarkable progress in spatial resolution of a computer display. However, it is unclear how high resolution stimulus affects our perception. Here, we examined the relationship between the resolution and depth perception. We found that higher resolution stimulus facilitates depth perception even when the resolution difference is undetectable.

**VHF4 - 3 Evaluating CIE Unified Glare Rating of a Scene
11:30 Using a Panoramic Camera**

*P.-L. Sun, H.-C. Li, P. Green
Nat. Taiwan Univ. of S&T, Taiwan*

A camera-based system was developed to estimate CIE Unified Glare Rating (UGR) in a panoramic scene. It consists of a geometric calibration, a color characterization model for multi-exposure images and a modified watershed image segmentation to determine the contribution of each light sources and reflected objects.

VHF4 - 4 Simulation of Ambient Light Impact on Public Displays
11:50

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 -----

VHF

13:30 - 15:00

Meeting Room 204

VHF5: Color

Chair: Y. Tani, Toyohashi Univ. of Tech., Japan
 Co-Chair: Y. Shimodaira, Shizuoka Univ., Japan

VHF5 - 1: *Invited* Quantifying Observer and Display Metamerism Effects When Evaluating Accuracy of Spot Color Matching in Mixed Media Presentations
13:30

T. Lianza
X-rite, USA

The growth of the mobile display market naturally leads to the migration of critical color viewing applications on the mobile platform. Differences in geometry and spectral characteristics of displays complicate the critical evaluation of color. This paper examines some of the factors that affect evaluation.

VHF5 - 2 New Generation of Optics for Imaging Video-colorimetry: Application to OLED Displays
14:00

P. Boher, T. Leroux, T. Bignon, V. Collomb-Patton
ELDIM, France

OLED displays are not perfect and require additional color calibration to improve their performances. Indeed OLED technology suffers from homogeneity problems with variations of the emissive properties within the same display or from on display to the other. We present new imaging optics dedicated to this type of calibration.

VHF5 - 3 Color Treatment Index: A New Metric for Mobile Displays
14:20

S. L. Yang
AU Optronics, Taiwan

We develop a Color Treatment Index (CTI) to define the level of color treatment. This index can judge the effective color gamut under different color treatment base on the locus the 24 color checker and the mapping to effective color gamut value.

**VHF5 - 4 A Self-Adaptive Method for Image Enhancement
14:40 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 ΔE^*ab matrix. With a special threshold of ΔE^*ab and a median filter, the enhancement can be achieved.

----- Break -----

15:10 - 16:10

Meeting Room 204

VHF6: Display Parameters and Human Performance

Chair: T. Lianza, X-rite, USA

Co-Chair: Y. Hisatake, Japan Display, Japan

**VHF6 - 1 Visual Search of Colour Patches Shown on a Tablet
15:10 Computer**

J.-Y. Wu, L.-C. Ou

Nat. Taiwan Univ. of S&T, Taiwan

This study found that the following factors may affect reaction time for locating a target colour surrounded by 23 colour chips shown on a tablet computer: (a) mean colour difference between target and surrounding colours, (b) colour variation between surrounding colours, and (c) location of target shown among surrounding colours.

**VHF6 - 2 Theoretical Derivation of Accommodation-
15:30 Optimized Line Space for Actual Documents in
Kanji Characters**

N. Ishikawa, T. Miyata, T. Matsui

Gunma Univ., Japan

The already-proposed framework, which estimates the optimal line space length to make documents the most legible in terms of accommodation, is applied to actual documents in which identical Kanji characters form sentences. Consequently, it is shown that the theoretical optimal line space lengths are nearly equal to the psychological ones.

VHF6 - 3 Characterization of Methods for Resolution and Noise in Medical Displays
15:50

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.

VHF

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

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 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 -----

15:40 - 17:20

Small Hall

PRJ2: Projection Components

Chair: T. Suzuki, JVC Kenwood, Japan
 Co-Chair: Y. Asakura, Nittoh Kogaku, Japan

PRJ2 - 1 **Surface Structure Light Guide for See-Through High Performances True AR Glasses**
15:40

K. Sarayeddine, K. Mirza
Optinvent, France

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.

PRJ

PRJ2 - 2 **Demonstration of a Compact See-Through Head-Mounted Display with Light Guide Plate**
16:00

H.-C. Hung, C.-W. Chiang*, Y.-K. Hsu*, Y.-J. Chen*,
 Y.-C. Huang*, J.-W. Pan***

**Nat. Chiao Tung Univ., Taiwan*
***Chi Mei Medical Ctr., Taiwan*

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.

PRJ2 - 3 **Reducing the Fringing Field Effect of Phase-Only Spatial Light Modulator for Holographic Display**
16:20

L. Yang, J. Xia, X. Zhang, B. Wang
Southeast Univ., China

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.

PRJ2 - 4 **Beam-Steering in Hollow Distributed Bragg Reflector Waveguides for RGB Imaging**
16:40

M. Nakahama, X. Gu, H. Sumimoto, F. Koyama
Tokyo Inst. of Tech., Japan

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.

**PRJ2 - 5 Suppression of Flicker in Analog LCOS Panels
17:00 Using Al₂O₃/SiO₂ Alignment Layers**

D. Cuypers^{,**}, H. D. Smet^{*,**}*

**imec, Belgium*

***Ghent Univ., Belgium*

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

9:00 - 10:20	Small Hall
PRJ3: Projection Technologies	

Chair: F. P. Shevlin, DYOPTYKA, Ireland

Co-Chair: H. Kanayama, Panasonic, Japan

**PRJ3 - 1: *Invited* How the Environmental Changes in
9:00 Projection Display Market?**

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
9:20 Business Projector Architectures**

B. Maximus, M. Tarpan, H. Nakano^{}*

Barco, Belgium

**Barco, Japan*

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.

PRJ3 - 3 **Interactive Laser Pico-Projection System Using a
9:40** **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.

PRJ3 - 4 **Liquid Cooling High Power Laser Phosphor Light
10:00** **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 -----

PRJ

10:40 - 12:20

Small Hall

PRJ4: Laser & Speckle Reduction

Chair: B. Maximus, Barco, Belgium
Co-Chair: T. Yagi, Mitsubishi Elec., Japan

PRJ4 - 1 **Speckle Contrast Measurement in Arbitrary
10:40** **Observation Distance**

T. Fukui, K. Suzuki, S. Kubota
Oxide, Japan

Speckle contrasts of laser projectors were measured at various observation distances using a quantitative measurement technique. Measured speckle contrast functions were found to be different by projection architectures. The result was analyzed theoretically and applied to the new instrument for practical qualifications in arbitrary observers' position.

**PRJ4 - 2 Study of Microcapsule Diffuser for Speckle
11:00 Reduction in Laser Display**

*S. Okagaki, J. Kondo, K. Kojima, Y. Nakano, A. Miyata,
K. Kubo, Y. Yoshida*

Mitsubishi Elec., Japan

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.

**PRJ4 - 3 Speckle-Reduced Zoomable Holographic Projection
11:20**

*H. Yamanashi, T. Shimobaba, T. Kakue, M. Oikawa,
N. Okada, Y. Endo, R. Hirayama, N. Takada*, T. Ito*

Chiba Univ., Japan

**Kochi Univ., Japan*

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.

**PRJ4 - 4 Speckle Reduction for Illumination with Lasers and
11:40 Stationary, Heat Sunked, Phosphors**

F. P. Shevlin

DYOPTYKA, Ireland

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-sunked, phosphor.

**PRJ4 - 5 Reliability Study on High Power 638 nm Broad
12:00 Stripe LD with a Window-Mirror Structure**

T. Yagi, H. Mitsuyama, T. Nishida, K. Kadoiwa

Mitsubishi Elec., Japan

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.

12:20 - 12:35

Small Hall

Short Presentation PRJp: Projection

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

----- Lunch -----

14:50 - 17:50

Main Hall C

Poster PRJp: Projection**PRJp - 1 Development of a Laser Head-Up Display with Multi-Event Information**

C.-Y. Chen, Q.-L. Deng^{}, Y.-C. Chen^{**}, M.-C. Chou^{**},
K.-Y. Chiu, C.-C. Su, P.-J. Wu^{*}*

Nat. Yunlin Univ. of S&T, Taiwan

^{}Nat. Chiao Tung Univ., Taiwan*

*^{**}ITRI, Taiwan*

The wide laser head-up display is proposed in this study. A set of mirrors is first equipped in front of a laser projector, dividing the image into three images with the angle 122°. A projection lens is then designed to project the images onto the windshield with the distances 160 cm.

PRJp - 2 A Collimated Illumination Beam Design for Compact Projection System

C.-H. Lin, C.-Y. Hung, Y.-H. Chang, W.-C. Su^{}*

Nat. Yunlin Univ. of S&T, Taiwan

^{}Nat. Changhua Univ. of Education, Taiwan*

A system including diffusers, concave lenses, condenser lenses and a pair of microlens arrays is designed to expand the light source of 4 × 4 green lasers ($\lambda = 532$ nm) to a approximately collimated illumination beam which area is 122 mm x 116 mm and suitable for pico-projector applications.

PRJp - 3 A Study of Optical Design of Local Dimming Projector with Liquid Crystal Elements

W.-T. Li, Y.-C. Chen, Y.-C. Fang

Nat. Kaohsiung First Univ. of S&T, Taiwan

This study is to improve the contrast of the projector lighting design. The structural design of the projector is using telecentric of optical design. Liquid crystal lens array as a light source with a local dimming system. The projector of Contrast achieve substantial improvement in the imaging chip components.

PRJp - 4 Withdrawn

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 angle 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

14:00 - 15:25

Meeting Room 204

EP1: New Displays

Chair: T. Fujisawa, DIC, Japan
Co-Chair: M. Higuchi, NIMS, Japan

EP1 - 1: **Invited Trend of Ch-LCD e-Paper Technologies**

14:00

*J. Chen, J.-W. Shiu, C.-C. Tsai, W.-W. Chiu, C.-Y. Huang
ITRI, Taiwan*

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.

EP1 - 2 **Reverse-Type TN-LCD with Reflective Mode Showing Permanent Memory Display and Excellent Moving Picture Quality**

14:25

Y. Toko, K. Kato, R. Takahashi, T. Takahashi*
Stanley Elec., Japan
Kogakuin Univ., Japan

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.

EP1 - 3 **Novel Thermal Recording Medium Enabling Both Emissive and Reflective Multicolor Representations Consisting of Leuco Dyes and Luminescent Molecules**

14:45

*K. Nakamura, Y. Kobayashi, K. Kanazawa, N. Kobayashi
Chiba Univ., Japan*

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.

EP1 - 4 **Alternating-Current-Driven
15:05** **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 -----

15:40 - 17:10

Meeting Room 204

EP2: Electrochromic Displays

Chair: N. Kobayashi, Chiba Univ., Japan

Co-Chair: Y. Toko, Stanley Elec., Japan

EP2 - 1: *Invited* Flexible Electrochromic Display

15:40

*T. Yashiro, Y. Okada, Y. Najjoh, S. Hirano, T. Sagisaka,
D. Gotoh, M. Inoue, S. C. Kim, K. Tsuji, H. Takahashi,
K. Fujimura*

Ricoh, Japan

We have developed Electrochromic materials that show various colors based on bi-pyridine compounds. These are adsorbed on the surface of nanostructured Titanium dioxide layer as a Grätzel cell structure by low-temperature solution-process. By utilizing flexible TFT, we have demonstrated full-color flexible electronic papers.

**EP2 - 2: *Invited* Silver Deposition Based Electrochromism as
16:05** **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.

EP2 - 3 Stretchable Electrochromic Devices Using Metallo-Supramolecular Polymers**16:30***J. Zhang^{*}, T. Sato^{*}, C.-W. Hu^{*}, M. Higuchi^{*,**}**^{*}NIMS, Japan**^{**}JST-CREST, Japan*

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.

EP2 - 4 Electrochromic Lens for Smart Glasses**16:50***K. Yutani, S. C. Kim, S. Yamamoto, Y. Okada, Y. Najoh, S. Hirano, D. Gotoh, M. Inoue, T. Sagisaka, T. Yashiro**Ricoh, Japan*

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.

EP

Author Interviews and Demonstrations

17:20 – 18:00

Thursday, December 5**9:00 - 10:10****Meeting Room 204****EP3: Electrophoretic Displays**

Chair: G. Zhou, Philips Res., the Netherlands

Co-Chair: T. Kitamura, Chiba Univ., Japan

EP3 - 1: Withdrawn**EP3 - 4L: Invited Optimum Approach for Product Development Which is Using Electrophoretic Paper-Like Display System****9:00***K. Hashimoto**Sony, Japan*

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.

EP3 - 2: Invited Novel Concept for Smart Windows

9:25

*K.-M. H. Lenssen, M. L. Trouwborst,
M. H. W. M. van Delden
Philips Res., the Netherlands*

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.

EP3 - 3 Diagnostic of Electrophoretic Particles by Dielectric Dispersion Spectra

9:50

A. Ando, R. Kiyoe, Y. Nishio, H. Inoue, O. Sakai*
Sakura Color Prods., Japan
Kyoto Univ., Japan

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 $10^{-17} \sim 10^{-16}$ C.

----- Break -----

10:40 - 11:55

Meeting Room 204

EP4: Evaluations

Chair: N.-S. Roh, Samsung Display, Korea

Co-Chair: Y. Hotta, Ricoh, Japan

EP4 - 1: Invited Comparison of e-Paper Displays, Transflective and Transmissive LCDs under Bright Ambient Light and Image Enhancement Algorithms for Optimized Grey Level and Color Perception

10:40

K. Blankenbach, A. Sycev, S. Kurbatinski, M. Zobl**
Pforzheim Univ., Germany
*STZ Display Syss., Germany
**BMW Group, Germany*

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.

EP4 - 2: Invited The First Half of Process on the Way Toward International Standard for Electronic Paper Displays
11:05

T. Takahashi^{,***}, K. Hyodo^{**,***}*

^{}Dai Nippon Printing, Japan*

*^{**}Konica Minolta, Japan*

*^{***}Elect. Paper Consortium, Japan*

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.

EP4 - 3: Invited Why Paper is Superior to Computer Displays in Cross-Reference Reading for Multiple Documents?
11:30

H. Shibata^{}, K. Takano^{**,*}, K. Omura^{*}*

^{}Fuji Xerox, Japan*

*^{**}Univ. of Electro-Commun., Japan*

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.

EP

11:55 - 12:20

Meeting Room 204

Short Presentation EPp: Electronic Paper

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

----- Lunch -----

14:50 - 17:50

Main Hall C

Poster EPp: Electronic Paper

EPp - 1 Preparation of Functional Paper Sheets Utilizing Twisting Ball Technology

H. Aoki, M. Yukawa, S. Maeda

Tokai Univ., Japan

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.

EPP - 2 Writable Electronic Paper Based on Twisting Ball Type Electronic Paper

Y. Komazaki, T. Torii

Univ. of Tokyo, Japan

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.

EPP - 3 Increasing Rewriting Speed of Optical Rewritable e-Paper by Process Optimization

J. Sun

Hong Kong Univ. of S&T, Hong Kong

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.

EPP - 4L Effect of External Additive on Display Characteristics in Toner Display

*K. K. C. Kumara, S. Nakamura, N. Miyagawa,
T. Kitamura*

Chiba Univ., Japan

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.

EPP - 5L Organic Conducting Polypyrrole-Silica Nanocomposite Particles as the Display Elements for Electronic Papers

T. Sugiura, H. Aoki, J. Shindo, R. Tanizaki, S. Maeda

Tokai Univ., Japan

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.

EPp - 6L Transparent-Mirror-Black Three-Way Electrochromic Smart Window Composed of a Pair of ITO-Coated Flexible Plastic Films

M. Oikawa, R. Onodera, S. Seki, K. Yamada, E. Harada*, Y. Sawada*, T. Mizuno**, T. Uchida**

Sendai Nat. College of Tech., Japan

**Tokyo Polytechnic Univ., Japan*

***Univ. of Electro-Commun., Japan*

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 some mechanical flexibility with a three-way state.

EPp - 7L The Effect of Angle on Visibility during Reading E-Books by Age Groups

Y. Ishii, R. Cui, T. Kojima, M. Miyao

Nagoya Univ., Japan

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.

EP

EPp - 8L The Effects of Environmental Illuminance on Visibility during Reading E-Books

R. Cui, Y. Ishii, T. Kojima, M. Miyao

Nagoya Univ., Japan

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

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

*W. Milne^{***}, T. Hallam^{****}, G. S. Duesberg^{****}, C. Li^{**},
W. Lei^{**}, B. Wang^{**}, M. T. Cole^{*}*

^{}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.

**MEET1 - 3: *Invited* Development of Smart Digital X-ray Tubes by
9:45 Optimizing Carbon Nanotube Field Emitters and
Their Driving**

Y.-H. Song^{,**}, J.-W. Kim^{*,**}, J.-W. Jeong^{*}, J.-T. Kang^{*},
S. Choi^{*}, J. Choi^{*}, S. Ahn^{*,***}*

^{}ETRI, Korea*

*^{**}Univ. of S&T, Korea*

*^{***}Sun Moon Univ., Korea*

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.

**MEET1 - 4 Cathodoluminescence from Electron Beam
10:05 Crystallized Silicon Thin Films**

*S. Y. Park, J. S. Kang, H. R. Lee, S. W. Lee, K. C. Park
Kyung Hee Univ., Korea*

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.

----- Break -----

MEET

10:40 - 12:00

Meeting Room 206

MEET2: EL Quantum Dots Technologies

Chair: J. Jang, Kyung Hee Univ., Korea

Co-Chair: T. Yatsui, Univ. of Tokyo, Japan

**MEET2 - 1: *Invited* Electroluminescent Quantum Dots for
10:40 Lighting and Displays**

*B. S. Mashford, M. Stevenson, C. Hamilton, Z. Zhou,
C. Breen, J. S. Steckel, S. Coe-Sullivan, P. T. Kazlas*

QD Vision, USA

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

C. Lee, M. Park, J. Lim, J. Kwak^{}, K. Char, S. Lee, J. Kim^{**}, C. J. Han^{**}, B. Yoo^{**}, M. S. Oh^{**}, J. Lee^{**}*

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

B. L. Choi, T.-H. Kim, K.-S. Cho, E. K. Lee, D.-Y. Chung, J. Y. Ku, J. M. Kim^{}, S. Hwang*

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 -----

The 20th Anniversary Address

Shunsuke Kobayashi

Tokyo Univ. of Sci. Yamaguchi

Wednesday, December 4, 2013

12:00 – 12:30

Conference Hall, 1F



13:30 - 14:30

Meeting Room 206

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
13:30 Improvements of Brightness and Efficiency***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
13:50 Products***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
14:10 Operated by a Dressed Photon***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 -----

15:10 - 16:25

Meeting Room 206

MEET4: Novel Materials and Components

Chair: W. Milne, Univ. of Cambridge, UK

Co-Chair: Y.-H. Song, ETRI, Korea

MEET4 - 1: *Invited* Graphene Synthesis on Thin Metal Films

15:10

*Y. W. Kim, E. Moyer, 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 -----

16:50 - 17:50**Meeting Room 206****MEET5: MEMS Imaging and Sensing**

Chair: Y. Bonnassieux, École Polytechnique, France

Co-Chair: T. Maindron, CEA-LETI, France

MEET5 - 1: Invited Hands On Access Fabrication Facility for MEMS Development and Production**16:50***K. Totsu, M. Moriyama, Y. Suzuki, T. Ono, S. Yoshida, M. Esashi**Tohoku Univ., Japan*

We offer an open access fab for MEMS developments. Users can utilize the fab and operate the equipment by themselves. Over 120 companies have utilized the fab since 2010. To accelerate University's R&D and education, product fabrication by a company user is started in July 2013.

MEET5 - 2 Localized Microplasma Generation in MEMS Gas Channel**17:10***R. Sato, D. Yasumatsu, S. Kumagai, M. Hori*, M. Sasaki**Toyota Tech. Inst., Japan***Nagoya Univ., Japan*

A device for generating the localized high density atmospheric pressure microplasma is realized based on the inductive coupling. The problem of the difficult ignition is solved by setting Al floating electrode. This method is suited for miniaturization and the localized microplasma generation in the MEMS gas channel.

MEET5 - 3 Commercial Sub-THz Video Camera

17:30

*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

–*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



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



Workshop on Display Electronic Systems

Wednesday, December 4

14:00 - 14:05

Main Hall B

Opening

Opening Remarks

14:00

H. Okumura, Toshiba, Japan

14:05 - 15:15

Main Hall B

DES1: Vehicle Applications

Chair: K. Morita, NTSEL, Japan

Co-Chair: H. Okumura, Toshiba, Japan

DES1 - 1: *Invited* Recovery of Sustained Attention by Brief 14:05 Stimulus Exposure in the Peripheral Visual Field

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 14:30 Vision for Driver Assistance

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 14:55 Automobile HUD User Interface

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 -----

15:40 - 17:20

Mid-sized Hall B

INP2/DES2: AR/VR Interactive Systems***Special Topics of Interest on Augmented Reality and Virtual Reality***

Chair: N. Sakata, Osaka Univ., Japan

Co-Chair: N. Hashimoto, Citizen Holdings, Japan

INP2/ Invited Reality Beyond Its Physicality**DES2 - 1:** *M. Inami***15:40** *Keio Univ., Japan*

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.

INP2/ Invited A Tablet Interface for Laying Out AR Objects**DES2 - 2:** **-Outlook of Relationship with Smartphone and AR-****16:10** *N. Sakata, R. Nagashima, S. Nishida**Osaka Univ., Japan*

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.

INP2/ Invited The Possibility of the Eyeglass-Type Mobile**DES2 - 3:** **Phone****16:35** *T. Horikoshi**NTT DoCoMo, Japan*

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.

INP2/ A Cartoon-Character Costume with Active Facial**DES2 - 4** **Expression****17:00** *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

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

T. Kuroda, Y. Kuroda^{}, K. Hori^{**}, N. Ohboshi^{***}*

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
11:05 Perception-Based Displays Utilizing Illusions

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
11:30 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.

DES3 - 4L Effectiveness of Freehand Modeling by BlueGrotto for CSCW in VR Space

11:55

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.

12:10 - 12:25

Mid-sized Hall B

Short Presentation DESp: Display Electronics and Systems

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

----- Lunch -----

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.

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/>

**DES4/
VHF1 - 2
13:55** **Useful Field of View in Augmented Reality:
Comparison Between Distribution of Attention
under Binocular and Monocular Observation**

A. Kitamura, H. Naito, T. Kimura, K. Shinohara,
T. Sasaki**, H. Okumura***

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:
14:15** **Invited e-Heritage, Cyber Archaeology, and Cloud
Museum**

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 -----

14:50 - 17:50

Main Hall C

Poster DESp: Display Electronics and Systems

**DESp - 1 Dynamic Dimming Algorithm for Low Power and
High Image Quality Using Edge-Type LED Backlight**

L. Yang, C. Li, Y. Chen*, H. Li*, J. He*, L. Chu*, Z. Tu,
X. Zhang*

Xi'an Jiaotong Univ., China

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

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.

DESp - 2 LED Module Integrated with Microcontroller, Sensors, and Wireless Communication*K. Sato, A. Tsuji, S. Suyama, H. Yamamoto***Univ. of Tokushima, Japan***CREST, Japan*

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.

DESp - 3 Image Upscaling Ringing Suppression Using Adaptive Edge Detection Method*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 a practical method to suppress image upscaling 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.

DESp - 4 Eyeglass-Based Hands-Free Videophone Using Fish-Eye Cameras and HMD*S. Kimura, T. Horikoshi**NTT DoCoMo, Japan*

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.

DESp - 5L Weighted Roll-Off Scheme for Low Power Local Dimming Liquid Crystal Displays*S.-K. Kim, E. Song, H. Nam**Kyung Hee Univ., Korea*

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 Grayscale
 9:00 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 grayscale as compared to pulse width modulation and low power in fast responding displays.

**DES5 - 2 A New Smart Charge Sharing Method for Liquid
 9:25 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-
 9:45 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
 10:05**

*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 -----

10:40 - 12:00

Small Hall

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***J.-Y. Kim, S.-J. Ahn, C.-H. Lee, S.-K. Hong, O.-K. Kwon**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 V_{th} 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 -----

13:30 - 14:50

Small Hall

DES7: Low Power Systems

Chair: H. Okumura, Toshiba, Japan
 Co-Chair: A. Nagase, Mitsubishi Elec., Japan

DES7 - 1: Invited A Novel Color Reflective LCD Using Memory-in-Pixel Technologies with Newly-Designed System and Pixel Structure
 13:30

*M. Tamaki, Y. Fukunaga, M. Mitsui, K. Maeda, M. Kabe,
 Y. Teranishi, T. Nakanishi, H. Omori, S. Hayashi,
 N. Takasaki, F. Goto, T. Harada, S. Kimura*
Japan Display, Japan

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.

DES7 - 2: Invited Image Compression IF Technologies for Low Power FPDs
 13:50

H. Okumura
Toshiba, Japan

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 %.

DES7 - 3: Invited Low Power Image Sensor Technologies
 14:10

J. Deguchi
Toshiba, Japan

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.

DES7 - 4 Efficient Local Dimming Algorithm for LCDs with Single-Edge LED Backlight
 14:30

D. Schäfer, T. Jung, M. Krause, C. Xu
Saarland Univ., Germany

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 -----

15:10 - 16:15

Small Hall

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^{**,****}

^{*}JSR, Japan

^{**}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., $6.9 \times 10^{-5} \Omega\text{cm}$ at 300°C for Ru⁰). 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

S.-G. Kang^{*,**}, H. T. Jang^{*}, Y.-J. Lee^{*}, J.-H. Kim^{*}

^{*}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 - 5 **Withdrawn**

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_2O_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 $8.5\Omega/\square$ and 74%.

FLXp - 8 **Colorful Thermoformable LCD and Its Sequential Segment Driving**

W.-T. Chen, M.-H. Yang, C.-C. Tsai, R.-L. Chang,
C.-L. Chin, Y.-Z. Lee, J.-L. Chen
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**

H. Xu^{}, M. Xu^{*}, J. Pang^{**}, J. Zou^{*}, H. Tao^{*}, M. Li^{*}, D. Luo^{*},*
L. Wang^{}, J. Peng^{**}*
^{}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_2O_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 .

FLXp - 10L The Effect of Isopropyl Alcohol and Silicon Dioxide Nanoparticle on the Reflection Loss for Single Crystalline Silicon

C. Wei, C.-M. Hu

Tatung Univ., Taiwan

The effect of amount of SiO₂ 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 -----

13:30 - 14:30

Main Hall A

FMC5/FLX1: Flexible Materials

Chair: Y. Mizushima, Corning, Japan

Co-Chair: M. Kimura, Nagaoka Univ. of Tech., Japan

**FMC5/
FLX1 - 1: Invited Highly Transparent and Conductive Carbon Nanotube Film on Plastic: Cellulose-Assisted Film Deposition Followed by Solution and Photonic Processing**

13:30

*Y. Kim, Y. Yokota, S. Shimada, R. Azumi, T. Saito,
N. Minami*

AIST, Japan

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 Ω/sq at transmittance of 89-98%.

FMC5/ FLX1 - 2: Invited Challenges toward Reliable Evaluation of High Water Barrier Property

13:50

S. Hara^{,**}, A. Suzuki^{**}, H. Takahagi^{**}*

**AIST, Japan*

***CEREBA, Japan*

Reference films with 10^{-2} - 10^{-4} g/m²/day in water vapor transmission rate (WVTR) were developed. Using them, consistency between two WVTR measurement systems was successfully achieved to 10^{-4} g/m²/day level. Furthermore, CEREBA's strategy to achieve a reliable WVTR evaluation technology to 10^{-6} g/m²/day is presented.

FMC5/ Invited Novel Materials for Printable Electronics

FLX1 - 3:

14:10

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, SiO₂ dielectric layer and photoluminescence treated Si nanoparticles with application in FPDs and LEDs are introduced.

----- Break -----

15:10 - 15:15

Main Hall A

Opening

Opening Remarks

15:10

M. Ito, Toppan Printing, Japan

15:15 - 16:20

Main Hall A

FLX2: Advanced Processes for Flexible Displays

Chair: T. Kamata, AIST, Japan

Co-Chair: Y. Mishima, FUJIFILM, Japan

FLX2 - 1: Invited The Potential of Carrier Laminated Ultra-Thin Glass Technology Corresponding to Sheet-to-Sheet Process for Thinner and Flexible Displays

15:15

Y. Matsuyama, K. Ebata, D. Uchida, T. Higuchi, S. Kondo^{}*

Asahi Glass, Japan

**AGC America, USA*

We propose a carrier laminated ultra-thin glass technology. This laminated substrate has good thermal and chemical durability for LCDs or OLEDs processes, and can be easily separated carriers after assembling display-cell. Using this technology, thin and flexible display can be manufactured without chemical thinning.

FLX2 - 2 **Investigation of Roll to Sheet Imprinting for a Process to Fabricate TFTs**

15:40

H. Koyama^{,**}, K. Fukada^{**}, Y. Murakami^{*,***}, S. Inoue^{**},
T. Shimoda^{**,****}*

**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 × 150 × 0.7 mm³). The resistivity of the electrodes on a glass substrate was 3.5 × 10⁻⁵ Ω cm, making this technique useful for electrodes of TFTs.

FLX2 - 3 **Development of a Wet-On-Wet Process for a Fully-Printed TFT Fabrication**

16:00

Y. Kusaka, K. Sugihara^{}, M. Koutake^{**}, H. Ushijima*

AIIST, 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.

----- Break -----

16:50 - 18:05

Main Hall A

FLX3: Carbon Related Materials

Chair: H. Fujikake, Tohoku Univ., Japan

Co-Chair: T. Furukawa, Yamagata Univ., Japan

FLX3 - 1: Invited Fabrication of Carbon Nanotube TFT for Sheet Electronic Device by Printing Method

16:50

H. Endoh^{}, S. Yorozu^{*}, F. Nihey^{*,**}, H. Numata^{*,**},
T. Sekitani^{***}, T. Someya^{***}*

**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.

FLX3 - 2: Invited Carbon Nanotube Transparent Conductive Films for Flexible Display Applications

17:15

*D. J. Arthur, R. P. Silvy, Y. Tan, P. Wallis**SouthWest NanoTechs., USA*

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.

FLX3 - 3: Invited Double-Walled Carbon Nanotube Transparent Conductive Film for Next Generation Flexible Device

17:40

*T. Oi, H. Nishino, K. Sato, O. Watanabe, S. Honda,**M. Suzuki**Toray Inds., Japan*

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.

Author Interviews and Demonstrations

18:30 – 19:10

Friday, December 6

9:00 - 10:30

Conference Hall

FLX4: Substrates and Materials for Flexible Displays

Chair: T. Shiro, Teijin, Japan

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

FLX4 - 1: Invited Low Coefficient of Linear Thermal Expansion Polyimide Film for TFT Device Substrate

9:00

*T. Okuyama, I. Kobayashi, N. Watanabe, T. Tsuchiya,**M. Nakamura**Toyobo, Japan*

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.

FLX4 - 2: Invited Development of High Barrier Film for OLED Devices

9:25

K. Hirabayashi, H. Ito, T. Mori
Konica Minolta, Japan

We are developing a high barrier film for flexible OLED devices. It has achieved a water vapor transmission rate (WVTR) of 10^{-6} g/m²/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.

FLX4 - 3 Gas Barrier Film Formation with Silazane Coating Material

9:50

N. Satake, S. Kawato, Y. Ozaki, M. Kobayashi
AZ Elect. Materials Manufacturing Japan, Japan

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.

FLX4 - 4 Application of Laser Fusing Cutting for Ultra-Thin Glass

10:10

N. Inayama, T. Fujii
Nippon Elec. Glass, Japan

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.

----- Break -----

10:40 - 11:55

Conference Hall

FLX5: Advanced Devices and Materials

Chair: H. Maeda, DNP, Japan
 Co-Chair: K. Akamatsu, Sony, Japan

FLX5 - 1: Invited Flexible Pressure Sensor Array Fabricated by Printing Method

10:40

S. Uemura, Y. Watanabe, S. Hoshino, H. Sakai,
K. Tokoro, H. Tokuhisa, T. Kodzasa, M. Yoshida
AIST, Japan

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 be presented, that have shown mobilities of above $1\text{cm}^2/\text{Vs}$ when deposited by vacuum evaporation. A new deposition process has been found which combines advantages of vacuum deposition and solution processing.

----- Lunch -----

13:30 - 14:15

Conference Hall

FLX6: Flexible Oxide TFT
Special Topics of Interest on Oxide TFT

Chair: M. Ito, Toppan Printing, Japan

Co-Chair: K. Uemura, Nippon Steel Sumitomo Metal, Japan

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

*H. S. Shin, S. M. Lee, S. Oh, J.-U. Bae, W. Shin,
 I. B. Kang*

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

*C.-C. Chen, H.-C. Zang, S.-T. Huo, Z.-H. Ling, J. Ma,
X.-F. Li*, L.-L. Chen*, J.-H. Zhang**

Tianma Micro-Elect. Group, China

**Shanghai Univ., China*

IGZO TFT array was fabricated on a Polyimide (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 **Low-Temperature IGZO TFT Backplane and Its
14:00** **Application in Flexible AMOLED Displays on
Ultrathin Polymer Films**

*J.-L. P.J. van der Steen, A. K. Tripathi, J. Maas,
K. van Diesen-Tempelaars, L. van Leuken, G. de Haas,
B. van der Putten, I. Yakimets, F. Li, T. Ellis, T. van Mol,
G. Gelinck, K. Myny*, P. Vicca*, S. Smout*, M. Ameys*,
T. H. Ke*, S. Steudel*, M. Nag*, S. Schols*, J. Genoe*,
P. Heremans*, Y. Fukui**, S. Green****

Holst Ctr., the Netherlands

**imec, Belgium*

***Panasonic, Japan*

****Vitrex 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.

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 Touch Panels and Input Technologies

Wednesday, December 4

14:00 - 15:25

Small Hall

INP1: Touch Panel (1) & Haptics

Chair: H. Noma, Ritsumeikan Univ., Japan

Co-Chair: H.-S. Koo, Minghsin Univ. of S&T, Taiwan

INP1 - 1: *Invited* Risk Management for Pressure Ulcers Using MEMS Tactile Sensor

14:00

*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.

INP1 - 2: *Invited* A Deformation Detection Touch Panel using a Piezoelectric Poly(L-lactic acid) Film

14:25

M. Ando^{,***}, H. Kawamura^{*}, H. Kitada^{*}, Y. Sekimoto^{*},
T. Inoue^{*}, S. Nishikawa^{**}, M. Yoshida^{**}, K. Tanimoto^{**},
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.

INP1 - 3 Driving Schema of High Integrated Panel with TSP and 3D

14:50

*D.-W. Kuo, J.-S. Liao, H.-H. Chen, H.-M. Su, W.-T. Tseng
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.

INP1 - 4L AdDetect: Recognition above the Surface in Multi-Touch Tabletop Environments
15:10

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 -----

INP

15:40 - 17:20	Mid-sized Hall B
INP2/DES2: AR/VR Interactive Systems	
<i>Special Topics of Interest on Augmented Reality and Virtual Reality</i>	

Chair: N. Sakata, Osaka Univ., Japan
 Co-Chair: N. Hashimoto, Citizen Holdings, Japan

INP2/ Invited Reality Beyond Its Physicality

DES2 - 1: *M. Inami*
15:40 *Keio Univ., Japan*

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.

INP2/ Invited A Tablet Interface for Laying Out AR Objects
DES2 - 2: **-Outlook of Relationship with Smartphone and AR-**

16:10 *N. Sakata, R. Nagashima, S. Nishida*
 Osaka Univ., Japan

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.

INP2/ Invited The Possibility of the Eyeglass-Type Mobile
DES2 - 3: **Phone**

16:35 *T. Horikoshi*
 NTT DoCoMo, Japan

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.

**INP2/
DES2 - 4** **A Cartoon-Character Costume with Active Facial
Expression**
17:00 *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.

INPp - 3 A Novel Stylus for LCD Base on Capacitive Touch

*Y.-L. Ho, M.-C. Weng, Y.-C. Chen, H.-H. Chen, H.-M. Su,
W.-Z. Zeng*

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.

INPp - 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 -----

13:30 - 15:00

Small Hall

INP3: Touch Panel (2)

Chair: R. Hattori, Kyushu Univ., Japan

Co-Chair: M. Miyamoto, Sharp, Japan

**INP3 - 1: *Invited* Single ITO Layer Multi-Touch Sensor Panel
13:30**

R. Hattori, K. Kyoung, R. Yoneda

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.

**INP3 - 2: *Invited* How to Realize High SNR Projected
13:55 Capacitive Touch Systems with Very Large Format**

M. Miyamoto

Sharp, Japan

SNR enhancement techniques for projected capacitive touch systems are introduced. They achieve: (i) unified touch user interface for wide range of applications from smart phone size up to over 100-in., and (ii) passive stylus input with tip diameter less than 2 mm.

INP3 - 3 Noise Immunity Enhancement for Capacitive Touch-Screens**14:20**

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.

INP3 - 4 High Efficient Anti-Noise Touch in Cell Display**14:40**

C.-Y. Hsu, S.-Z. Peng, S.-H. Huang, H.-H. Chen, H.-M. Su
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 -----

15:10 - 16:30**Small Hall****INP4: 3D/2D Imaging Systems**

Chair: C. Niclass, Toyota Central R&D Labs., Japan
 Co-Chair: K. Kagawa, Shizuoka Univ., Japan

INP4 - 1: *Invited* Long-Range 3D Imaging in CMOS for Road Environment Recognition**15:10**

C. Niclass, M. Soga, H. Matsubara, M. Ogawa,
M. Kagami, T. Yamashita, T. Naito
Toyota Central R&D Labs., Japan

With the increasing interest in long-range 3D imaging for advanced driver assistance systems, we introduce a time-of-flight sensor in CMOS technology that achieves ranges of up to 100 m with a resolution of 202x96 pixels at 10 frames/s. The proposed sensor concept acquires real-time 3D images in challenging daylight conditions.

SID Display Week 2014

June 1 – 6, 2014

San Diego Convention Center

San Diego, California, U.S.A.

INP4 - 2 **Time-Multiplexed 3D Camera System with an
15:35** **Electro-Optical Filter Alternately Transmitting Visible
and Near Infrared Radiation**

J. Shin, J. Osterman^{}, B. Kang, K. Lee, J. D.K. Kim
Samsung Advanced Inst. of Tech., Korea
^{*}LC-Tec Displays AB, Sweden*

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.

INP4 - 3 **Optical Pixel-Sensor Array Using TFT Technology as
15:55** **Image-Scan/Fingerprint Panel**

*A.-T. Cho, C. Chang, Z.-S. Zheng, J.-F. Cho, H.-L. Hsieh,
J.-H. Jan, J.-W. Chen, A. Liu, R.-C. Cheng, J.-P. Tseng,
J.-J. Chang, M.-F. Chiang, Y.-C. Lin
AU Optronics, Taiwan*

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.

INP4 - 4L **Multi-Mode Simultaneous Image Acquisition with
16:15** **Integrated Compound-Eye Camera for Human
Interface: Wide-Angle Video, 3D Gesture
Recognition, and Eye Tracking**

K. Kagawa, K. Shimonomura^{}, S. Kawahito
Shizuoka Univ., Japan
^{*}Ritsumeikan Univ., Japan*

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.

Author Interviews and Demonstrations

18:30 – 19:10

Supporting Organizations:

Human Interface Society
Information Sensing Research Committee, ITE

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Special Topics of Interest on Oxide TFT

Facilitator:	M. Kimura	Ryukoku Univ.
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OLED:	T. Uchida	Tokyo Polytechnic Univ.
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Special Topics of Interest on Augmented Reality and Virtual Reality

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Demonstration Session

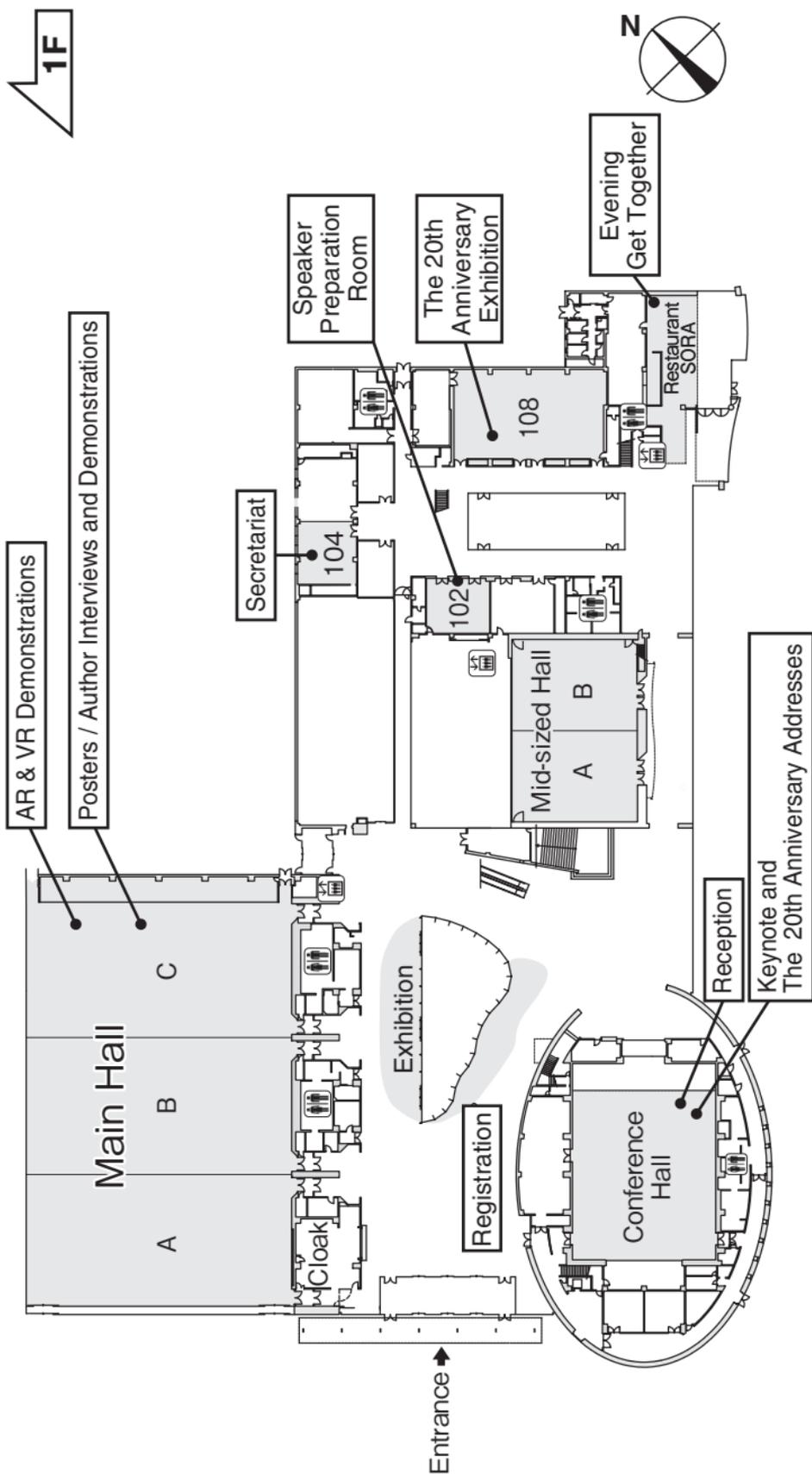
Augmented Reality and Virtual Reality (AR & VR)

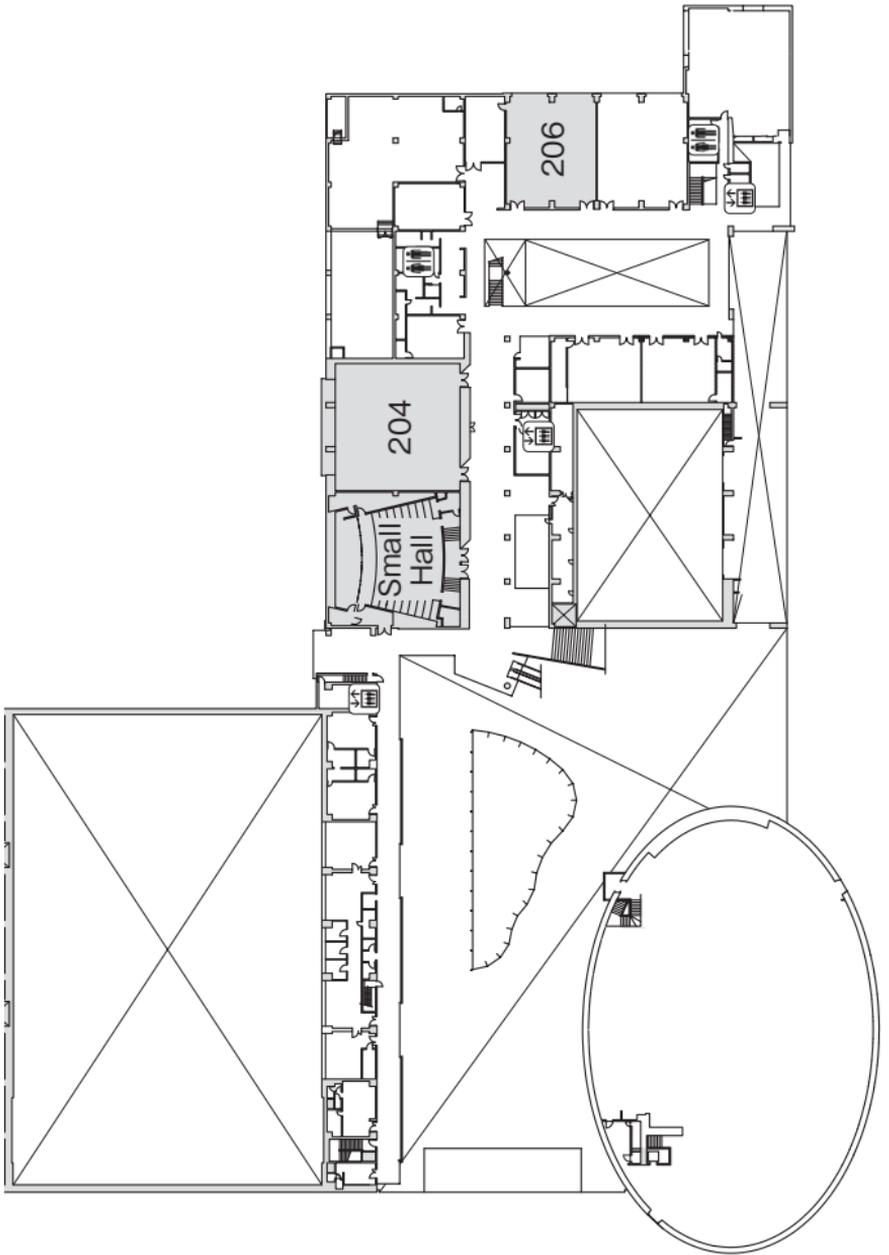
by 3D, VHF, PRJ, DES and INP Workshops
Thursday, December 5, 2013
14:50 – 17:50
Main Hall C, 1F

IDW '14

The 21st International Display Workshops
December 3 – 5, 2014
Toki Messe Niigata Convention Center
Niigata, Japan
<http://www.idw.ne.jp>

FLOOR MAP





IDW '13 Timetable

Date	1F Lobby	Conference Hall	Main Hall A	Main Hall B	Mid-sized Hall A	Mid-sized Hall B	Small Hall	204	206	Main Hall C	1F Lobby		
Wednesday, December 4	Title: Dec. 3 Registration 17:00-20:00 Evening Get-Together at Sora (1F) 18:00-20:00												
	Registration 8:00-18:00	Opening, Keynote & the 20th Anniversary Addresses 9:30-12:30		Lunch								AMDp, OLEDp, 3Dp, VHFp, AMDp/OLEDp 13:40 - 16:40	Exhibition 12:40-18:00
FMC1 14:00-15:20		DES1 14:00-15:15	LCT1 14:00-15:00	PRJ1 14:00-15:00	INP1 14:00-15:25	EP1 14:00-15:25	PDP1 14:00-15:15						
Break													
FMC2 15:40-17:00				LCT2 15:40-16:55	INP2/DES2 15:40-17:20	PRJ2 15:40-17:20	EP2 15:40-17:10	PDP2 15:50-17:00					
										Author Interviews & Demonstrations 17:20-18:00			
Reception at Conference Hall (1F) 18:30-20:30													
Thursday, December 5	Registration 8:00-18:00	OLED1 9:00-10:30	FMC3 9:00-10:20	AMD1 9:00-10:25	LCT3 9:00-10:25	3D1 9:00-10:15	PRJ3 9:00-10:20	EP3 9:00-10:10	MEET1 9:00-10:25	PHp, FLXp, INPp 9:00-12:00			
		Break											
		OLED2 10:40-12:00	FMC4 10:40-12:00	AMD2 10:40-12:25	LCT4 10:40-12:00	DES3 [†] 10:40-12:25	PRJ4 [†] 10:40-12:35	EP4 [†] 10:40-12:20	MEET2 10:40-12:00				
		Lunch											
		OLED3 13:30-14:55	FMC5/FLX1 13:30-14:30	AMD3 13:30-14:55			DES4/VHF1 13:30-14:45	INP3 13:30-15:00	MEET3 13:30-14:30				
		Break											
OLED4 15:10-16:30	FLX2 15:10-16:20	AMD4 15:10-16:40	FMC6 15:10-16:30	3D2/VHF2 15:10-16:30	INP4 15:10-16:30	PH1 15:10-16:25	MEET4 15:10-16:25	LCTp, PRJp, Epp, DESp					
Break													
OLED5 16:50-18:15	FLX3 16:50-18:05	AMD5 16:50-18:10	FMC7 16:50-18:10	3D3 16:50-18:10			PH2 16:50-18:20	MEET5 16:50-17:50	AR & VR Demonstrations 14:50-17:50				
										Author Interviews & Demonstrations 18:30-19:10			
Friday, December 6	Registration 8:00-13:00	FLX4 9:00-10:30	PH3 9:00-9:55	AMD6 9:00-10:20	LCT5 9:00-10:20	3D4 9:00-10:20	DES5 9:00-10:20	VHF3 9:00-10:15	FED1 9:00-10:30	FMCp 9:00-12:00			
		Break											
		FLX5 10:40-11:55			AMD7 10:40-12:20	LCT6 10:40-12:15	3D5 10:40-11:55	DES6 10:40-12:00	VHF4 10:40-12:10	FED2/PH4 10:40-12:10			
	Lunch												
	FLX6 13:30-14:15	FMC8 13:30-15:05			LCT7 13:30-14:30			DES7 13:30-14:50	VHF5 13:30-15:00	FED3 13:30-15:00			
Break													
							DES8 15:10-16:15	VHF6 15:10-16:10	FED4 15:10-16:30				
										Author Interviews & Demonstrations 16:40-17:20			

[†]Including Short Presentations

IDW '13 Special Topics of Interest Navigator

	Oxide TFT				Augmented Reality and Virtual Reality		Lighting Technologies		
Date	Conference Hall	Main Hall A	Main Hall B	Main Hall C	Mid-sized Hall B	Main Hall C	Conference Hall	Main Hall A	Main Hall C
Wednesday, December 4				AMDp1, AMDp2, AMDp3/ OLEDp2: Poster 13:40-16:40	PRJ1: Projection AR 14:00-15:00	VHFp1: Poster 13:40-16:40			OLEDp1: Poster 13:40-16:40
					INP2/DES2: AR/VR Interactive Systems 15:40-17:20				
Thursday, December 5		FMC3: Oxide TFT: Process Technologies 9:00-10:20		FLXp: Poster 9:00-12:00	3D1: Practical 3D Systems 9:00-10:15				PHp: Poster 9:00-12:00
			AMD2: Oxide TFT: Applications 10:40-12:25		DES3 [†] : Human Perceptions in Augmented Reality 10:40-12:25				
			AMD3: Oxide TFT: Reliability (1) 13:30-14:55		DES4/VHF1: Sensing Technologies for Virtual/ Augmented Reality 13:30-14:45				
			AMD4: Oxide TFT: Reliability (2) 15:10-16:40			DESp: Poster			
			AMD5: Oxide TFT: Modeling & Devices 16:50-18:10			AR & VR Demonstrations 14:50-17:50	OLED5: OLED for Lighting Applications 16:50-18:15		
Friday, December 6				FMCp: Poster 9:00-12:00				PH3: Phosphors for Lighting 9:00-9:55	FMCp: Poster 9:00-12:00
	FLX6: Flexible Oxide TFT 13:30-14:15							FMC8: Lighting Technologies 13:30-15:05	

IDW '13 Session Navigator

	Wednesday, Dec. 4				Thursday, Dec. 5					Friday, Dec. 6					
	9:30-12:30	PM		17:20-18:00	AM		PM			18:30-19:10	AM		PM	16:40-17:20	
	Conference Hall														
Plenary	Opening, Keynote & the 20th Anniversary Addresses														
LCT	Mid-sized Hall A		Main Hall C	Mid-sized Hall A		Main Hall C			Mid-sized Hall A			Main Hall C			
	Keynote & Special Session (1)	Special Session (2)	A.I.	Display Mode (1)	LC Materials	Posters			A.I.	Display Mode (2)	Evaluation	Photo Alignment	A.I.		
AMD	Main Hall C			Main Hall B					Main Hall C	Main Hall B		Main Hall C			
	Posters*			Advanced Si TFT	Oxide TFT: Applications	Oxide TFT: Reliability (1)	Oxide TFT: Reliability (2)	Oxide TFT: Modeling & Devices	A.I.	Novel Applications	Printed TFT		A.I.		
FMC	Main Hall A		Main Hall C	Main Hall A			Mid-sized Hall A		Main Hall C	Main Hall C		Main Hall A	Main Hall C		
	20th Anniversary: Past, Present, and Future (1)	20th Anniversary: Past, Present, and Future (2)	A.I.	Oxide TFT: Process Technologies	Materials	Flexible Materials*	Optical Films	Manufacturing	A.I.	Posters		Lighting Technologies	A.I.		
PDP	206		Main Hall C												
	Advanced Materials & Discharge	Large Screen & Discharge Applications	A.I.												
PH				Main Hall C			204		Main Hall C	Main Hall A	206		Main Hall C		
				Posters			Phosphors & Their Applications (1)	Phosphors & Their Applications (2)	A.I.	Phosphors for Lighting	Applications & New Materials*		A.I.		
FED										206			Main Hall C		
										Novel Devices & Applications	Applications & New Materials*	Fabrication Process & CNT Emitters	FE Materials & Mechanisms	A.I.	
OLED	Main Hall C			Conference Hall					Main Hall C						
	Posters*			Materials & Devices	Display Technologies	Flexible & Backplane Technologies	Process Technologies	OLED for Lighting Applications	A.I.						
3D	Main Hall C			Mid-sized Hall B		Mid-sized Hall B			Main Hall C	Mid-sized Hall B			Main Hall C		
	Posters			Practical 3D Systems		Visual Comfort for 3D Display*	Holography	A.I.	3D Display (1)	3D Display (2)			A.I.		
VHF	Main Hall C				Mid-sized Hall B			Main Hall C	204				Main Hall C		
	Posters				Sensing Technologies for Virtual/Augmented Reality*	Visual Comfort for 3D Display*		A.I.	Improving Visual Experience	Visual Perception	Color	Display Parameters & Human Performance	A.I.		
PRJ	Mid-sized Hall B	Small Hall	Main Hall C	Small Hall		Main Hall C									
	Projection AR	Projection Components	A.I.	Projection Technologies	Laser & Speckle Reduction + Short Presentations	Posters			A.I.						
EP	204		Main Hall C	204			Main Hall C								
	New Displays	Electrochromic Displays	A.I.	Electrophoretic Displays	Evaluations + Short Presentations	Posters			A.I.						
MEET				206					Main Hall C						
				Fundamental Components & Process Technologies	EL Quantum Dots Technologies	Emerging Quantum Dots Technologies	Novel Materials & Components	MEMS Imaging & Sensing	A.I.						
DES	Main Hall B	Mid-sized Hall B	Main Hall C	Mid-sized Hall B			Main Hall C			Small Hall			Main Hall C		
	Vehicle Applications	AR/VR Interactive Systems*	A.I.		Human Perceptions in Augmented Reality + Short Presentations	Sensing Technologies for Virtual/Augmented Reality*	Posters			A.I.	Display Driving (1)	Display Driving (2)	Low Power Systems	Display Electronic Systems	A.I.
FLX				Main Hall C		Main Hall A			Main Hall C	Conference Hall			Main Hall C		
				Posters		Flexible Materials*	Advanced Processes for Flexible Displays	Carbon Related Materials	A.I.	Substrates & Materials for Flexible Displays	Advanced Devices & Materials	Flexible Oxide TFT	A.I.		
INP	Small Hall	Mid-sized Hall B	Main Hall C	Main Hall C			Small Hall		Main Hall C						
	Touch Panel (1) & Haptics	AR/VR Interactive Systems*	A.I.	Posters		Touch Panel (2)	3D/2D Imaging Systems		A.I.						

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

VHF: Workshop on Applied Vision & Human Factors
 PRJ: Workshop on Projection & Large-Area Displays & Their Components
 EP: Workshop on Electronic Paper
 MEET: Workshop on MEMS & Emerging Technologies for Future Displays & Devices
 DES: Workshop on Display Electronic Systems
 FLX: Workshop on Flexible Displays
 INP: Workshop on Touch Panels & Input Technologies

A.I.: Author Interviews & Demonstrations
 *: Joint Session

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



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<http://www.idw.ne.jp/>