DAILY PROGRAM

Friday
September 22

2017

IDMC'17

International Display Manufacturing Conference

Taipei World Trade Center Nangang Exhibition Hall, Taiwan, September 20-22, 2017

國際顯示製程前瞻技術研討會

DAILY PROGRAM

Friday, September 22

09:00-10:30 **Room 504a**

Session 10: Automotive, IoT, Medical, and Novel Applications

Chairs: Chiu-Lien Yang, Innolux Corporation, Taiwan
Fang-Cheng Lin, National Chiao Tung University, Taiwan

Fri-S10-01 (Invited)
Vision Technology for Automotive
Chen Jung Tsai, Xiuling Zhu, William Wang, Wendy Zhang and Kenny Chan, Hong Kong Applied Science and Technology Research Institute Company Limited *(Hong Kong)*

An automotive head-up-display (HUD) can lengthen the time of the drivers spending on viewing the road situation for safer driving and reduce the eye strain for more comfortable driving. Holographic HUDs has number of significant advantages when compared to traditional HUD technologies, such as lower power consumption and compact packaging size. In this paper, we will introduce our latest development in holographic HUD, including fast response time liquid-crystal-on-silicon spatial light modulator (LCoS SLM), 2D laser holographic projection and augmented reality (AR) HUD system.

Fri-S10-02 (Invited)
Display-Based Visual Stimulus Design for Eliciting Steady-State Visual Evoked Potentials and Its Applications
Masaki Nakanishi[1], Yijun Wang[1,2], Yu-Te Wang[1] and Tzyy-Ping Jung[1]
1) University of California, San Diego *(USA)*
2) Chinese Academy of Science *(China)*

Steady-state visual evoked potentials (SSVEPs) are brain's electrical responses to repetitive visual stimulation. An efficient display-based visual stimulus design plays an important role to encode flexible information in brain, leading to various applications based on SSVEPs. This paper shows recent advances in stimulus design for eliciting SSVEPs and its applications.

Fri-S10-03 (Invited)
RDL Process Development for Panel Level Fan-Out Package
Wei Yuan Cheng, Jie-Mo Lin and Yuh-Zheng Lee, Industrial Technology Research Institute *(Taiwan)*

Fan-out package allows the layout of metal trace being extended to the region larger than chip, which increases the accommodated pin count within package and reduce the overall package thickness. And fan-out panel level package (FOPLP) had drawn much attention in recent years because of its processing size. This research focused on the redistribution layer (RDL) process development for panel level fan-out package by combining LCD facilities and panel-form plating equipment.

09:00-10:30		Room 504b
Session 11:	**Flexible & Foldable AMOLEDs**	
Chairs:	Glory Chen, Industrial Technology Research Institute, Taiwan MT Lee, AU Optronics Corporation, Taiwan	

Fri-S11-01 (Invited)
Manufacturing Technology for Flexible OLED Mass Production
Jerry Jrjyan Chen, Thin Film Products Group, AKT/Applied Materials *(USA)*

The flexible OLED has been emerging, strongly driven by consumer demand for superior display quality and flexible form factor. As a leading equipment supplier, Applied Materials has provided mass production solutions to enabling display manufacturers to produce high quality OLED panels with high reliability and throughput.

Fri-S11-02 (Invited)
Foldable Touch AMOLED Integrated with Multifunction Front Plate
Kuan-Ting Chen, Yung-Hui Yeh, Glory Chen, Jia-Chong Ho, Cheng-Chung Lee and Janglin Chen, Industrial Technology Research Institute *(Taiwan)*

Plastic AMOLED with glass window were commonly used for smartphone application. However, the flexibility of device was limited by rigid glass window. In order to improve the mechanical of foldable AMOLED display, we integrated an ultra-thin plastic window on foldable touch AMOLED. A 3mm bending radius foldable on-cell touch AMOLED prototype with plastic window was demonstrated.

Fri-S11-03 (Invited)
Flexible AMOLED Displays with Novel Bendable Interactive Interface
Keh-Long Hwu, Chia-Chun Chang, Ji-Feng Chen, Ming-Chang Hsu, Wei-Jung Hsieh, Wen-Ting Wang, Cheng-Hao Chang, Yen-Huei Lai, Wan-Tsang Wang, Che-Ming Hsu, Hong-Shen Lin and Yu-Hsin Lin, AU Optronics Corporation *(Taiwan)*

Flexible display surpasses the conventional flat display by its ability to change the display geometric appearance, and can provide users with alternative user-display interactions. In this paper, a bendable phone technology with flexible AMOLED display is disclosed where a novel bending human-device interface renders more intuitive operation and control of the device on the users' end, and feedback from the device.

Fri-S11-04
Realizing 2-in-1 Tablet/Phone Foldable AMOLED with Symmetric Panel Stacking Structure
Chi-Shun Chan, Meng-Ting Lee, Cheng-Liang Wang, Ching-Chieh Fu, Ching-Yao Shih, Kuan-Heng Lin, Yi-Hong Chen, Jia-Hua Lin, Yuan-Chen Chin, Annie Tzu-Yu Huang, Hsueh-Hsing Lu and Yu-Hsin Lin, AU Optronics Corporation *(Taiwan)*

A foldable AMOLED display using symmetric panel stacking with an innovative design of color filter structure was demonstrated to surpass 1 million folding cycles at 2mm folding radius.

Moreover, no additional defect was found after we placed the foldable display in 60oC/90%RH for further environmental test.

09:00-10:30	Room 504c
Session 12:	**LC Technology (II)**
Chairs:	Liang Ying Huang, AU Optronics Corporation, Taiwan Shih-Hsien Liu, Industrial Technology Research Institute, Taiwan

Fri-S12-01 (Invited)
LCOS Technologies for Augmented Reality Applications
(Simon)Kuan-Hsu Fan-Chiang, Himax Display, Inc. *(Taiwan)*

Liquid crystal on silicon (LCOS) microdisplay takes the advantage of mature CMOS processes and reflective liquid crystal light valves to produce high quality, high information content displays. In this talk, I will introduce the recent technology developments of LCOS devices for augmented reality (AR) applications and how we forecast the market growth in the near future

Fri-S12-02 (Invited)
Application of Digitally Driven LCoS-SLM to Holographic and Deep Blue Lithography
Sudarshan Kundu[1], Cynthia Hsu[1], Lily Ting[1], Ron Hsu[1], and Jhou-Pu Yang[2], Huang-Ming Philip Chen[2]
1) Jasper Display Corporation (Taiwan)
2) National Chiao Tung University (Taiwan)

Pulse width modulation is a modulation technique to encode a message by using pulsed signal. By controlling the pulse width, it can attain the required RMS voltage at a pixel to control its grey level accurately. Such technique has been used to LCoS SLM for holographic display in visible spectral region and for mask-less lithography in deep blue wavelengths.

Fri-S12-03
One-Step Azo Dye Photoalignment Stabilization for Mass Production
Cuiling Meng[1], Man Chun Tseng[2], Abhishek K. Srivastava[3], Vladimir G. Chigrinov[4] and Hoi-Sing Kwok[2]
1) The Hong Kong University of Science and Technology *(China)*
2) The Hong Kong University of Science and Technology *(Hong Kong)*
3) The Hong Kong University of Science and Technology *(India)*
4) The Hong Kong University of Science and Technology *(Russia)*

Presented is a novel azo dye stabilization method that only requires single-shot UV light exposure. The proposed photoalignment layer offers highly acceptable thermal and photo-stability, as well as low pre-tilt angle (0.2°) and image sticking (1.01). Also, both VHR (99.0%) and RDC.

Fri-S12-04

Improvement of Color Shift and Viewing Angle of Two Domain Electrically Suppressed Helix Ferroelectric Liquid Crystal Display via Azo-dye Photo-alignment Technology

Liangyu Shi[1], Abhishek K. Srivastava[2], Vladimir G. Chigrinov[3] and Hoi-Sing Kwok[4]

1) The Hong Kong University of Science and Technology *(China)*
2) The Hong Kong University of Science and Technology *(India)*
3) The Hong Kong University of Science and Technology *(Russia)*
4) The Hong Kong University of Science and Technology *(Hong Kong)*

Photo-alignment technology by the mechanism of azo-dye reorientation has been applied to a two domain electrically suppressed helix ferroelectric liquid crystal display to improve the viewing angle and color shift due to the birefringence. The simulation results show ESHFLC display is better than IPS and MVA at 255 gray level.

11:00-12:30 **Room 504a**

Session 13: Oxide TFT (I)

Chairs: Yung-Hui Yeh, Industrial Technology Research Institute, Taiwan
Chien-Hung Chen, AU Optronics Corporation, Taiwan

Fri-S13-01 (Invited)

Highly Robust Oxide TFTs for Flexible and Stretchable Electronics

Jin Jang and Suihi Lee, Advanced Display Research Center / Kyung Hee University *(South Korea)*

Plastic AMOLED displays are of increasing attention recently for mobile applications. The TFT backplane on polyimide (PI) substrates are widely used for smartphone displays. We developed a nonlaser detach process of PI substrate from carrier glass by using a GO/CNT buffer which is being used for highly robust oxide TFTs and TFT circuits in our lab [1]. The bulk accumulation oxide TFTs exhibiting both high on-currents and uniform threshold voltage can be applied to high resolution displays and high speed TFT circuits [2]. In this talk I will discuss our recent research results on TFTs and TFT circuits on PI substrates. We have also developed highly robust TFTs using TFTs in neutral plane [3] and high mobility a-IGZO TFTs on PI substrate by introducing top interface engineering [4,5]. The performance, electrical stability and mechanical stability will be introduced.

Fri-S13-02 (Invited)

High Density Plasma Sputtering for Oxide TFT Applicable to the High Resolution Display

(Sang-Hee Ko) Park[1], JaeHan Ahn[1], Sung Haeng Cho[2], Jeong-Rak Lee[3], Wan-Woo Park[3] and Jin Young Do[3]

1) Korea Advanced Institute of Science and Technology *(South Korea)*
2) Electronics and Telecommunications Research Institute *(South Korea)*
3) Advanced Vacuum and Clean Equipment Optimizer *(South Korea)*

We report the effects of electron cyclotron resonance (ECR) sputtering method on the oxide thin-film transistor (TFT) performance. DC and high density plasma sputtering methods were applied for the deposition of ITZO thin films in the top gate (TG) TFT and back channel etch

(BCE) typed bottom gate TFT for the application to the large size high resolution AMOLED and small sized high resolution flexible display, respectively. ITZO films deposited at low operating pressure of 0.3 mTorr with highly dense plasma (1.97x1011 cm-3) using ECR sputtering system resulted in dense ITZO films with high mobility. Top gate ITZO TFT results in superb performance of TFT with the saturation mobility of 31.1 cm2/V.s and almost negligible Von shift after 2 hours bias stress at the condition of Vgs = 20V and Vds= 0.1V at 60oC.
The BCE TFT with shorter channel length and smaller parasitic capacitance is suitable for the materialization of ultra-high resolution flexible display due to the small TFT footprint. ECR sputtering processed BCE TFT shows no channel dependency within the channel length of 6-40 um with good uniformity. In addition, low target voltage and operating pressure of ECR sputtering induces less surface damage of gate insulator (GI) during the active film deposition, resulting in enhanced device performance including transfer characteristics and device stability under various bias stresses. BCE TFT on polyimide substrate shows mobility of 25 cm2/V.

Fri-S13-03
Vertically-Stacked Complementary Inverter Composed of P-Type SnO and N-Type ZnO Thin-Flim Transistors
Hao-Lin Yang, Wei-Chen Lin, Yun-Shiuan Li, I-Chun Cheng , Dung-Yue Su and Feng-Yu Tsai, National Taiwan University *(Taiwan)*

High-performance vertically-stacked complementary inverters based on oxide-TFTs were demonstrated. The inverter is composed of a p-type SnO TFT and a n-type ZnO TFT. The static voltage grain of the inverter with a geometric aspect ratio of 5 reaches 34.2 V/V at a supplied voltage of 10 V.

Fri-S13-04
Exploring Ionized Oxygen Vacancy Distribution in Amorphous Oxide Thin-Film Transistors under Negative Bias Illumination Stress by TCAD
Wan-Ta Fan[1], Po-Tsun Liu[2], Chien-Min Chang[2] and Po-Yi Kuo[2]
1) Silvaco *(Taiwan)*
2) National Chiao Tung University (Taiwan)

One of promising Amorphous metal oxide semiconductors (AOS) thin film transistors (TFTs), a-InWO TFT has been fabricated. Based on this established TCAD model which is in agreement with measurement, we analyzed ionized oxygen vacancy (Vo) distribution under negative bias illumination stress (NBIS). This paper proposes an approach that visualizing ionized

11:00-12:30	**Room 504b**
Session 14:	**Display Electronics and Systems**
Chairs:	Chih-Lung Lin, National Cheng Kung University, Taiwan Chun-Ho Chen, National Chiao Tung University, Taiwan

Fri-S14-01 (Invited)
TFT Technologies and Driving Approaches For Low Power AMOLED Displays

Xiao-Jun Guo, Shanghai Jiao Tong University *(China)*

Active-matrix organic light emitting diode (AMOLED) displays are rapidly expanding their market share for small-sized mobile applications. For battery powered mobile applications, low power consumption is important to increase operating lifetime, and decrease the system weight and volume for the less required capacity of the battery. The power consumption in AMOLED displays will be analyzed. Then approaches at different levels to decrease the power consumption will be discussed.

Fri-S14-02 (Invited)
Influence of Human Body on Electrostatic Capacitive Touch Sensor
Reiji Hattori, Kyushu University *(Japan)*

We examined the influence of human body on three types of electrostatic capacitive touch sensors, which are a mutual capacitive, a self-capacitive and a swept-frequency capacitive sensors. The human body is not always grounded and causes the noise. We present the system which can obtain a biological information.

Fri-S14-03 (Invited)
Psychophysical Studies for Interactive Displays
Seung-Woo Lee, Kyung Hee University *(Korea)*

Psychophysics is the scientific study of relation between physical stimuli and the sensations and perceptions they produce. These days, interaction between human and machine (or system) is done through a display, which is called as an interactive display. In this talk, some psychophysical studies are introduced for better interactive displays.

Fri-S14-04
5" FHD Ultra-Narrow Border of In-Cell Touch LCD by Using TGP and OTSD Technology
Cheng-Chieh Lee, AU Optronics Corporation *(Taiwan)*

A 5 inch FHD ultra-narrow border (0.35mm) with in-cell touch function display was demonstrated. We manufacture an ultra-narrow border of TFT-LCD with in-cell touch function. For the narrow border panel, we integrate the One Third Source line Driving (OTSD) and Tracking Gate line in Pixel (TGP) technology.

11:00-12:30	**Room 504c**
Session 15:	**LC Technology (III)**
Chairs:	Wing-Kit Choi, National Taiwan University, Taiwan Hung-Ming Chen, National Chiao Tung University, Taiwan

Fri-S15-01 (Invited)
Liquid Crystal Materials for Lens Application
Shih-Hsien Liu, Industrial Technology Research Institute *(Taiwan)*

Liquid crystal (LC) lens have several advantages which include thin, electrically tunable focusing, high-speed switching, and low power consumption. We demonstrated new liquid crystal materials that not only have high birefringence ($\triangle n \geqq 0.30$), high dielectric anisotropy ($\triangle \varepsilon \geqq 10$), but also have low viscosity ($\eta \leqq 16$mPa.s).

Fri-S15-02

Optically Rewritable Liquid Crystal Display with LED Light Printer

Man-Chun Tseng[1], Wan-Long Zhang[1], Cui-Ling Meng[2], Shu-Tuen Tang[1], Chung-Yung Lee[1], Abhishek K. Srivastava[3], Vladimir G. Chigrinov[4] and Hoi-Sing Kwok[1]

1) The Hong Kong University of Science and Technology *(Hong Kong)*
2) The Hong Kong University of Science and Technology *(China)*
3) The Hong Kong University of Science and Technology *(India)*
4) The Hong Kong University of Science and Technology *(Russia)*

Optically rewritable liquid crystal display (ORW-LCD) is an electronic paper display invented at the HKUST SKL. A TFT based polarization-controllable light-printer with 420nm LED light source for ORW-LCD is proposed. Experimental results with gray scale images are presented.It can be made on flexible e-paper device based on the photo-rotation mechanism.

Fri-S15-03

The Influence of Flexoelectric Effect on the Vcom Shift in Fringe-Field Switching Liquid Crystal Display

Jhong-Ciao Ke, Te-Chen Chung, Chia-Te Liao, Chia-Min Yu and Yan-Bing Qiao, InfoVision Optoelectronics (Kunshan) Co., Ltd. *(China)*

The Origin of Vcom Shift in Fringe-Field Switching-Liquid Crystal Display (FFS-LCD) Is Investigated. The Direction of Vcom Shift in FFS-LCD by Using Positive And Negative Dielectric Anisotropy Is Opposite. It Can Be Explained Well by the Flexoelectric Effect (FEE), Indicating That the Vcom Shift Is Mainly Attributed to the FEE.

14:00-15:30 **Room 504a**

Session 16: Oxide TFT (II)

Chairs: Hsing-Hung Hsieh, Ph, Taiwan
Chien-Hung Chen, AU Optronics Corporation, Taiwan

Fri-S16-01 (Invited)

Recent Progress on New Amorphous Oxide Semiconductor

Toshio Kamiya, Tokyo Institute of Technology *(Japan)*

This paper will first review the present status of amorphous oxide semiconductor (AOS) technology.
Then, the defects found to date for AOSs are reviewed.
We will also show some new AOS materials that are realized by understanding and controlling these AOS-specific defects.

Fri-S16-02 (Invited)
Vacuum to Printing: Revolutionary Functional Soluble Semiconductor Material in Display Application
Kuo-Hui (Kent) Su, Evonik *(Taiwan)*

In this talk, we will present the evolution of soluble functional material development in thin film transistor application, and introduce the state-of-the-art for iXsenic technology including the MP-ready product, photo-patternable and printable semiconductor.

Fri-S16-03
Elevated-Metal Metal-Oxide Thin-Film Transistors Based on Indium-Tin-Zinc Oxide
Zhihe Xia, Lei Lu, Jia-Peng Li, Zhuo-Qun Feng, Sun-Bin Deng, Sisi Wang, Man Wong and Hoi-Sing Kwok, The Hong Kong University of Science and Technology *(Hong Kong)*

The elevated-metal metal-oxide thin-film transistor based on indium-tin-zinc oxide as channel material was proposed and demonstrated in report. The resulting TFT exhibited good performance metrics: a relatively higher field-effect mobility of 23.2±0.8 cm2/Vs, a width-normalized off-state current of at most 8.1×10-19 A/μm, and robust stability against gate-bias stress.

Fri-S16-04
Short-Channel Elevated-Metal Metal-Oxide (EMMO) Thin-Film Transistor with Dehydrogenated Passivation Etch-Stop Layer
Lei Lu[1], Jia-Peng Li[2], Nanan Lv[3], Zhuo-Qun Feng[1], Zhi-He Xia[1], Sisi Wang[1], Sarah Bebiche[1], Man Wong[1] and Hoi-Sing Kwok[1]
1) The Hong Kong University of Science and Technology *(Hong Kong)*
2) Soochow University *(Hong Kong)*
3) Soochow University *(China)*

Due to inherent hydrogen in passivation etch-stop (PES) layer, the scalability of Elevated-metal metal-oxide (EMMO) TFT was limited by a negative shift of turn-on voltage with decreasing channel length (L). Scalability was found to improve with dehydrogenation of PES, thus enabling the realization of displays with even higher pixel resolution.

14:00-15:30	**Room 504b**
Session 17:	**Printed Display and Electronics (II)**
Chairs:	Yongtaek Hong, Seoul National University, South Korea Yuh-Zheng Lee, Industrial Technology Research Institute, Taiwan

Fri-S17-01 (Invited)
Novel Cross-linkable Transport Materials for Inkjet Printed OLEDS and QLEDS
Zheng Cui, Jinyong Zhuang, Liming Xie, Pengyu Tang, Changting Wei, Zhenhua Xing and Wenming Su, Suzhou Institute of Nanotech *(China)*

Inkjet printed organic light emitting diodes (OLEDs) and quantum dot light emitting diodes (QLEDs) have been fabricated based on the novel cross-linkable electron transport and hole transport material, respectively. The performance of the inkjet printed device was comparable to the spin-coated ones. These results indicate that the cross-linkable materials are very promising for inkjet printed OLEDs and QLEDs.

Fri-S17-02 (Invited)
Development Opportunities and Challenges of Printed Display Technology
Dong Fu, Guangdong Juhua Printed Display Technology Co. Ltd. *(China)*

Recently, printing display technology has been widely investigated by many Key players in the display industrial field. By dissolving functional materials (e.g. OLED/QLED materials) into the solvents, and using ink jet printing, bar-coating, slot-die coating, and post drying process to fabricate displays(OLED/QLED).
Contrary to traditional evaporation method, printed display does not require vacuum environment, therefore, it can save the equipment cost and operation cost.
Furthermore it is a drop on demand technology, which means the materials only deposited on where it needs to be. Compare to evaporation technology, which the materials wasted on the wall of the vacuum chamber as well as on the masks, so the material usage is much higher for printed displays, with all this advantages, printed display is the main stream for future display fabrication.
Despite all advantages of this new technology, it also faces many difficulties. For example, the pattern of substrates, stable printing process (e.g. stable and accurate ink jet printing process), post drying process, uniform film formation, and last but not least, Mura free printing technology.
By embrace the opportunity to develop advanced display technology and overcome difficulties, we can make a huge break through in the display world, and to be the leader of future display market.
Guangdong Juhua printed display technology Ltd., Co. is fully focused on the printed display technology development and printed display eco-system construction, and drive the printed display technology to be matured and ready for the market.

Fri-S17-03 (Invited)
Cambrios ClearOhm® Silver Nanowire Materials: Enabling the Future of Flexible Electronics
Haixia Dai and Michael Spaid, Cambrios Advanced Materials Corporation *(USA)*

Cambrios Advanced Materials has developed and commercialized a superior transparent conductive ITO-alternative material, ClearOhm® ink, consisting of a dispersion of silver nanowires. It can achieve a wide range of film sheet resistances ranging from 5 to 300 ohms/square by simple wet coating and printing methods. Besides excellent optical and electrical performance, ClearOhm® films have shown extreme flexibility and bendability, and are the best solution for flexible/foldable products.

Fri-S17-04
Exploration of Paper-Based Silver Nanowire Electrode for Piezoelectric PVDF Sensing Application
Yadi Zhang[1], Duo-Hua Xu[1], Yu-Wang Xu[1], Wei Zhang[1] and Bo-Ru Yang[2]
1) Sun Yat-sen University *(China)*
2) Sun Yat-sen University *(Taiwan)*

Paper substrates is cost-effective and disposable, which is perfectly match for printed devices. However, it's difficult to fabricate electronic devices onto the paper substrate owing to its roughness. Here, a chitosan buffer layer was proposed to fabricate a uniform, good adhesion, patterned paper-based AgNW electrode for PVDF pressure sensor application.

14:00-15:30	**Room 504c**
Session 18:	**OLED, Lighting, and u-LED (I)**
Chairs:	Chien-Chung Lin, National Chiao Tung University, Taiwan Horng-Show (Frank) Koo, Minghsin University of Science and Technology, Taiwan

Fri-S18-01 (Invited)
Opportunities of PMOLED Display
Yung-Cheng Tsai, WiseChip *(Taiwan)*

Base on the mature manufacture, PMOLED panel has more advantages to achieve the feature of flexible and transparent electronics. The simplified architecture of PMOLED brings features of the combination with touch sensor, sensing detects, optical transform application. Even more than possible, the VR and near-field optics are feasible quantity products.

Fri-S18-02 (Invited)
Emerging Quantum Dot and Quantum Rod Displays
Xia-wei Sun, Southern University of Science and Technology *(China)*

We present highly efficient colloidal core-shell quantum dots, quantum rods and perovskite nanocrystals for energy-saving quality display and lighting applications. We applied these luminescent materials to make various devices including luminescent microspheres for on-chip InGaN LED packaging (photoluminescent applications), and assembling aligned quantum rod to make polarized emission films.

Fri-S18-03
Analysis of Using Scattering Film to Eliminate Reflective Diffraction and Keep Image Sharpness for OLED Displays
Po-Han Tsai, Han-Ping Shieh, Yi-Pai Huang, Zong Qin and Chi-Chieh Wu, National Chiao Tung University *(Taiwan)*

To eliminate diffraction in reflected ambient images of OLED display, a scattering film is applied, whose threshold haze and transmittance is calculated based on contrast sensitivity function. The maximum distance between the scattering film and OLED that can make image quality beyond certain MTF criterion is determined for different resolutions.

Fri-S18-04
Metal-Doped Zinc Oxide Electron Transporting Layer for Quantum-Dot Light Emitting Diodes
Sinyoung Cho, Hyo-Min Kim, Jeonggi Kim and Hyunjeong Shin, Kyung Hee University *(South Korea)*

Metal-doped zinc oxide (ZnO) was synthesized by sol-gel method and it was used as electron transport layer (ETL) for inverted quantum-dot light emitting diodes (QLEDs). The QLEDs exhibited the current and power efficiencies of 39.8 cd/A and 18.7 lm/W, respectively.

Fri-S18-05
Solution Processable MoO_3 Hole-Injection Layer for All Solution Processed Inverted Quantum-Dot Light Emitting Diodes
Hyeonjeong Shin, Hyo-Min Kim and Sinyoung Cho, Kyung Hee University *(South Korea)*

This paper reports a solution processable molybdenum trioxide (MoO3) hole injection layer (HIL) for all solution processed inverted green QLEDs (G-QLEDs) exhibiting high current efficiency (CE) and low CE roll-off.

16:00-17:30	**Room 504a**
Session 19:	**High Resolution Applications**
Chairs:	I-Chun Chen, National Taiwan University, Taiwan Po-Tsun Liu, National Chiao Tung University, Taiwan

Fri-S19-01 (Invited)
Thin-Film Electronics for Next Generation Display and IOT Applications
TungHuei Ke, Imec *(Belgium)*

Thin film electronic technologies are very important in the field of flat panel display and X-ray imagers. The industry is driven by the market to produce display with higher resolution and lower power consumption. Interactive functions are integrated in the novel display with flexible form factors. More and more innovations are happening in the development in thin film electronics to achieves those requests. In this presentation, we will show the idea of imec-Holst center for the next generation display and IOT applications. We will discuss the technologies for high resolution display for AR/VR application and our innovations in haptic feedback interface. We will also present the IOT system we realized by thin film electronic technologies.

Fri-S19-02 (Invited)
UHD LTPS Notebook Display with Low Power and Dlim Border
Wen-Ching Tsai, Hsiao-Wei Cheng, Shu-Hao Huang, Peng-Bo Xi and Sung-Yu Su, AU Optronics Corporation *(Taiwan)*

A 15.6-in. UHD LTPS TFT-LCD with MUX3 was demonstrated in this paper. The total power of 15.6 UHD TFT-LCD is 3.7W and the cell border is 1.5mm. A 13.3-in. UHD LTPS TFT-LCD with 15Hz driving was also demonstrated for saving 40% logical power.

Fri-S19-03
The Application of Crystalline IGZO TFTs for Utilizing a Hybrid Array Backplane LCD
Jia-Hong Ye, Ching-Liang Huang, Ming-Yao Chen, Pei-Ming Chen, Kuo-Yu Huang, Chia-Tien Peng, Wei-Ming Huang and Yang-An Wu, AU Optronics Corporation *(Taiwan)*

Crystalline indium gallium zinc oxide (c-IGZO) on glass substrate was deposited and characterized via HRTEM, d-spacing calculation, and NBED analysis. We demonstrate a prototype of 1.4 inch circular LCD with c-IGZO and LTPS hybrid backplane technology to achieve small border size and low power consumption.

16:00-17:30	**Room 504b**
Session 20:	**Touch and Interactive Technology**
Chairs:	Ya-Hsiang Tai, National Chiao Tung University, Taiwan Paul Chen, General Interface Solution Ltd. (GIS), Taiwan

Fri-S20-01 (Invited)
Novel Applications of Thin-Film Devices - Flatpanel Imager, Proximity Sensor, Artificial Retina, etc. –
Mutsumi Kimura, Ryukoku University *(Japan)*

Thin-film devices have been applied to flat-panel displays. The essential advantage is that semiconductor devices can be fabricated on large substrates using various materials at low cost. From this viewpoint, in this presentation, I will propose novel applications using thin-film devices, such as sensing devices, etc.

Fri-S20-02 (Invited)
Compact and High Resolution Virtual Mouse Using Lens Arrays and Light Sensors
Zong Qin, Yi-Pai Huang and Han-Ping D. Shieh, National Chiao Tung University (*Taiwan*)

A virtual mouse prototype is designed and implemented using an LED source, lens arrays and light sensors. The system volume is 3.1mm by 4.5mm by 2, which is much smaller than that of a camera-based device. A detective error of 0.41mm and a minimum resolution resolution of 26ppi were verified in the experiments.

Fri-S20-03
Single Built-In-Camera 3D Interactive System Using Fingertip Width for Depth Estimation
Yu-Kai Chen, Tai-Yu Lu, Chun-Ho Chen, Yi-Pai Huang and Han-Ping Shieh, National Chiao Tung University *(Taiwan)*

In this research, we proposed a single built-in-camera 3D interactive system. By calculating the fingertip width for estimating finger depth, we implement the algorithms into a commercial product, 12.3-inch tablet, to realize the interactive system. The 3D position of fingertip is successfully presented.

16:00-17:30	**Room 504c**
Session 21:	**OLED, Lighting, and u-LED (II)**
Chairs:	Yung-Cheng Tsai, WiseChip, Taiwan Sally Chen, CINNO Research Institute, China

Fri-S21-01 (Invited)
Organic Vapor Jet Printing: A New Printing Technology for Large Area OLED Displays
Chun Hsin (Pete) Liu[1], William Quinn[2], Greg McGraw[2], Siddharth Mohan[2], Gregg Kottas[2], Matthew King[2], Ben Swedlove[2], James Kantor[2], Tomasz Trojacki[2] and Julie Brown[2]
1) Universal Display Corporation Taiwan, Ltd. *(Taiwan)*
2) Universal Display Corporation *(USA)*

Organic Vapor Jet Printing (OVJP) is a solvent-less, mask-less printing technology for depositing patterned organic materials to manufacture large area OLED displays. This talk describes the technology, presents recent results and describes prospects for large area mass production systems.

Fri-S21-02 (Invited)
Recent Advanced Achievement of Micro-LED in ITRI, and Beyond the Next ?!
Yen-Hsiang Fang, Industrial Technology Research Institute *(Taiwan)*

As LEDs are going to play the role of the pixels, it will be totally different in epitaxy, process, package, inspection, driving and application, compared to the traditional LED industry. The industry integration from downstream to upstream will be the most important concept if you have the intent to break into the micro-LED field.

Fri-S21-03 (Invited)
A High-Performance Full-Color Micro Display Based on Quantum-Dot Aerosol Jet Technology and Digital Driving Technology
Hao-chung Kuo[1], Chen-Hsien Chu[1,3], Huang-Yu Lin[1], Chien-Chung Lin[1], Wing-Cheung Chong[2], Zhaojun Liu[2] and Kei-May Lau[2]
1) National Chiao Tung University *(Taiwan)*
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Currently, the light utilization efficiency (LUE) of LCD display is still lower than 2.8 %. Most passive components such as color filters can absorb a large portion of emitted photons from LED backlight. Thus the display needs to be operated at more than ten times of the required power in order to meet the expected output luminescence.The RGB quantum dots (QDs) can be a great alternative candidate to realize full color display and solve the low light utilization efficiency problem in LCD system. The QDs possess unique properties such as high quantum yield, size-dependent emission wavelength, and narrow emission FWHM. This study reports a full-color LED based display by combining UV micro-LED arrays with 282 pixels per inch (PPI) in full color by RGB QDs via aerosol jet printing technology.

Fri-S21-04
Highly Efficient and Long Lifetime Electron Transporting Materials for OLED Applications
Heh-Lung Huang, Po-Wei Hsu and Chi-Jen Lin, e-Ray Optoelectronics Technology Co., Ltd *(Taiwan)*

We designed and developed new electron transport material (ET1) having a deep HOMO level and high Tg. OLED devices using ET1 under 10 mA/cm2 achieved efficiencies more than 12.68 Cd/A with a low driving voltage lower than 4.02V and achieved an EQE more than 11.2%.

Fri-S21-05
Magnesium Doped NiO_x for Efficient All-Inorganic Quantum-Dot Light Emitting Diodes
Gui-Jun Li, Yi-Bin Jiang and Hoi-Sing Kwok, The Hong Kong University of Science and Technology *(Hong Kong)*

Magnesium doped NiOx is used as the hole injecting layer to make the all-inorganic QLEDs in this paper. The magnesium doping is found to effectively mitigate the exciton quenching and provide a deeper valence band for the hole injection. A brightness of over 40000 cd/m2 at 10 V is demonstrated.