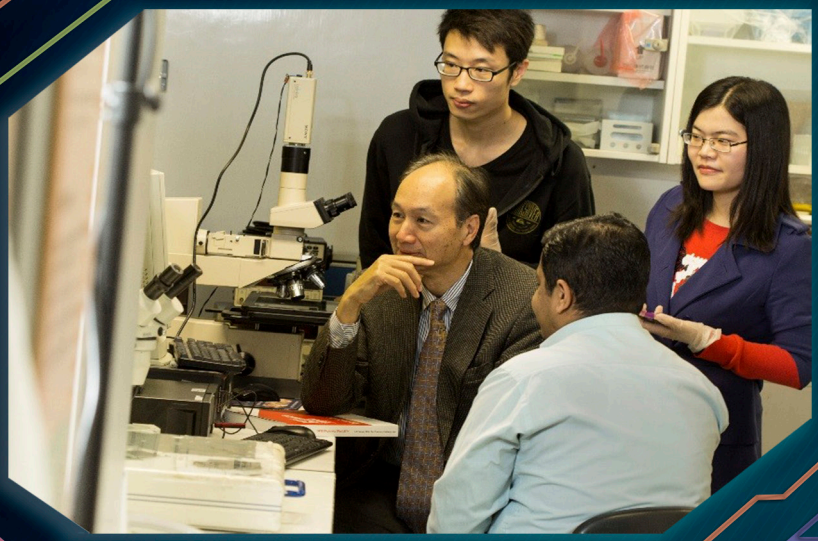
Newsletter Issue No.2



25 INNOVATING TODAY IMAGINING TOMORROW 敢・創・未來 HKUST

SKL 先進顯示與光電子技術 國家重點實驗室 State Key Laboratory on Advanced Displays and Optoelectronics Technologies

State Key Laboratory on Advanced Displays and Optoelectronics Technologies

Welcome

Stepping into the forth year of the State Key Laboratory, it is exciting to review on every footstep of achieving the goal - developing the next generation display technology.

Since its establishment in 2013, the successful operation of the PSKL relies on the tremendous support from various units, including Ministry of Science and Technology of the People's Republic of China (MOST), Hong Kong Innovation and Technology Commission (HKITC), Sun Yat-sen University and Hong Kong University of Science and Technology (HKUST).

In this newsletter, we proudly present to you our newly-accomplished milestones, events, and globally recognized projects.

We hope you, as our precious stakeholders and guests, could share our joy of every breakthrough we attained.

Content

About the State Key Laboratory

Mission of the PSKL

- Become the leading display research center in China;
- Collaborate with the display industry and market to develop innovative technology;
- Generate intellectual properties on display and optoelectronics technology;
- Create a world-class platform for exchanges between Chinese and foreign researchers on display research.

The PSKL was opened on 2013 upon the approval by Ministry of Science and Technology (MOST) of the Central Government.

The PSKL is operated by the collaboration between the Hong Kong University of Science and Technology and Sun Yat-Sen University.

The PSKL focuses on boosting green displays and optoelectronics technologies, therefore, active matrix organic light emitting diodes (AMOLED) displays is one of our major research.

Facilities

Brand New: Organic Electronics Laboratory

Organic Electronics Laboratory has a floor space of 1,030 square meters and resides in the newly-opened Cheng Yu Tung Building.

OEL is a brand new Laboratory managed by Prof. Ching W. TANG, IAS Bank of East Asia Professor and Chair Professor in the Department of Electronic and Computer Engineering, who is also a Research Team Leader of the PSKL.

The construction of the laboratory has been completed in mid-2016. Advanced equipment, including an OLED vacuum evaporation system and a reactive ion etching system, has been installed to enhance the research quality of the PSKL.

Center for Display Research (CDR)

The Centre for Display Research (CDR) at HKUST was established with seed funding from the Hong Kong Government's Trade and Industry Department.

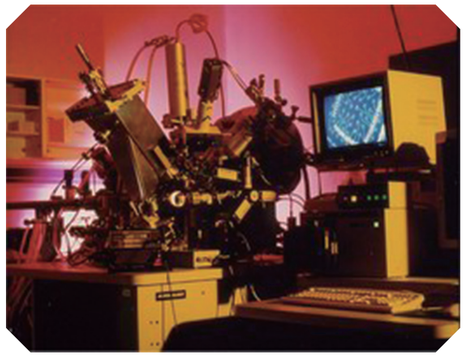
CDR provides technical support services for local LCD manufacturers, conducts research in advanced displays that will be of value to the local industry and trains students with hands-on experience in LCD manufacturing for the local industry.

Nanosystem Fabrication Facility (NFF)

The Nanosystem Fabrication Facility (NFF) of HKUST is the first microfabrication laboratory established at a tertiary institution in Hong Kong.

The mission of the NFF is to provide facilities for the faculty and students of the HKUST to conduct teaching and research, particularly in new discrete semiconductor devices, novel microsensors and microactuators, advanced nanoelectronics process technology and application-specific integrated circuits (ASIC).

Materials Characterisation & Preparation Facility (MCPF)



MCPF is a central facility intensively serving the academic researchers and postgraduate students in schools of science and engineering for the preparation, characterization and analysis of various advanced materials.

In addition to serving HKUST, MCPF also provides services to Hong Kong sister institutions and clients from government laboratories and regional industries. Since the establishment of MCPF in 1991, it has become an indispensable central facility in HKUST.

Miss Su PAN (Right), and other members from the PSKL research team, exchanged remarkable studies with international scholars in IDMC'2015 & 3DSA, held at Taipei.

Events

The PSKL pursues continuous international exchanges on display research.

Therefore, our research team attends conferences and meetings every year in America, Europe and Asia, so as to track the latest trend and market our research.

August 24 -28, 2015

IDMC'2015 & 3DSA, Taiwan

The PSKL research team participated in International Display Manufacturing Conference & 3D Systems and Applications 2015 (IDMC'2015 & 3DSA), organized by National Chiao Tung University from Taiwan.

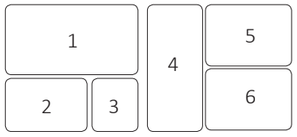
The conference held at Taipei and invited professors and postgraduates from Mainland China, Hong Kong, Korea, Japan and Taiwan. The conference aims at exchanging forefront display research in Asia Pacific, meanwhile studying the development of green display industry. Topics covered in the conference include the application of thin film transistor (TFT) in different forms, highly-proficient OLED, touch technology, E-paper, etc.

August 25, 2015

Visit to the AUO Optronics Corporation

During the IDMC' 2015, the PSKL was invited to visit the development center and factory of AUO Optronics Corporation in Xinzhu, Taiwan.

Representatives from AUO introduced the production of the widely-applied thin film transistor liquid-crystal display panels (TFT-LCD) in sizes ranging from 1.2 inches to over 65 inches, as well as 32 inched transparent display panel to the team. The team also shared research experience with AUO for an inspiring academic exchange.



Figures

1. International scholars gathered in IDMC'2015
2. Scholars shared their research
3. Dr. Rongsheng CHEN presented research poster to other scholars
4. Prof. Kwok delivered speech on the conference
5. The PSKL research team visited AUO
6. AUO's Representative Introduced TFT-LCD Panels to the PSKL research team

May 31 - June 03, 2015

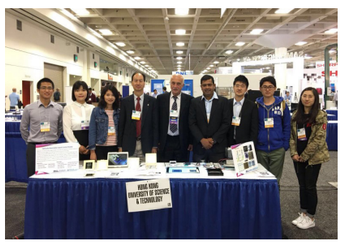
SID's Display Week, San Jose, USA

Prof. Hoi-sing KWOK, the director of the PSKL, led a team of researchers to join the SID Display Week. The event includes symposiums, seminars, business & inventors conferences, etc.

Symposium consists of technical tracks with over 70 technical sessions comprising nearly 400 oral and poster presentations, our researchers and Prof. Kwok also took parts of them. The research team also got inspiration from the display inventions exhibited by multinational enterprises, such as TCL Corporation and LG Display CO.

May 22 - 27, 2016

PSKL research team and Prof. C. W. Tang (Middle), a.k.a "The father of OLED", demonstrated their latest research result at the I-zone

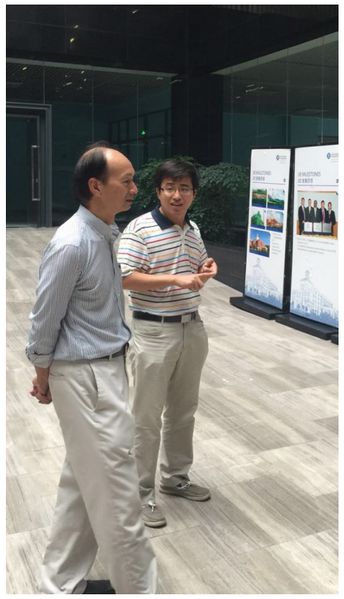


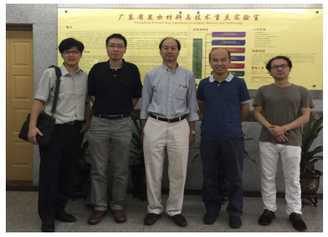
September 03, 2015

Visit to Sun Yat-sen University, Guangzhou

Prof. Kwok visited the School of Microelectronics in SYSU at Guangzhou and met with the Dean, Prof. Siyuan Yu, and their research team. In the meeting, both professors agree to apply for new projects together. Starting from projects about LTPS and ORW E-Paper, both schools will strengthen the academic exchange and resources sharing.

Later, researchers who involve in relevant projects from SYSU visited the PSKL at HKUST on October 2015. They had a thorough discussion with the PSKL research team on technology roadmap for projects' development.





April 30, 2015

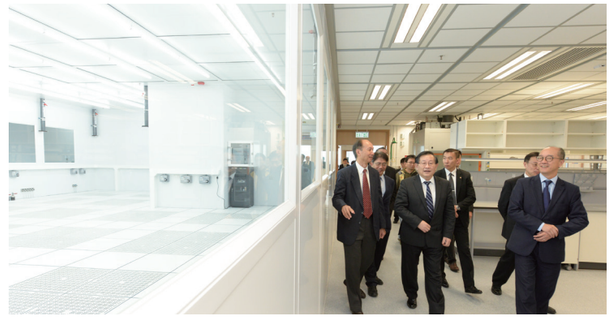
Joint Seminar with Sun Yat-sen University, HKUST

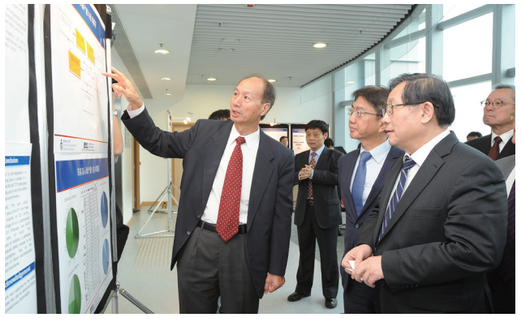
Joint Seminar 2015, held at HKUST, was organized by HKUST Department of Electronics and Computer Engineering (ECE) and the Society for Information Display (SID). The seminar invited Prof. Kai Wang from the Sun Yat-sen University – Carnegie Mellon University Joint Institute of Engineering (SYSU-CMU JIE), as the keynote speaker. Prof. Wang presented on dual-gate photosensitive thin film transistor (TFT), low-dose x-ray imaging and also high-resolution rewritable paper display. The seminar successfully gave insights into solutions for research obstacles faced by the PSKL research team.

CPPCC Vice-Chairman and Minister of Science and Technology (MOST), Prof. Wan Gang (Middle), led a delegation and visited Organic Electronics Laboratory in 2015.

Visitors

The PSKL has welcomed over 300 guests since the opening in 2013. Our research team has introduced our research achivements and exchanged great ideas with the guests.





1 | 2 | 3 | 4 | 5 | 6

Figures

1. The PSKL research team introduced prototypes and research demos to Prof. Wan
2&3. Prof. Kwok gave an overview on the development of the display industry and the PSKL
4. Prof. Wan chatted with students
5. Prof. Wan and the delegation visited the Organic Electronics Laboratory
6. Prof. Hoi Sing Kwok (Left 2), Prof. Ching W Tang (Right 2) and Prof. Chigrinov (Right) led Vice-President Prof. Joseph Lee (Left), President Prof. Tony F Chan and Prof. Wan Gong (Center) to visit the PSKL

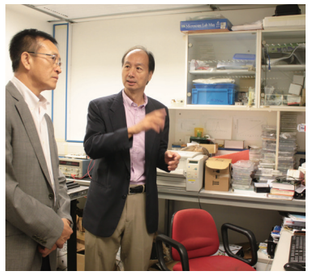
December 12, 2015

CPPCC Vice-Chairman and Minister of Science and Technology Prof Wan Gang Leads a Delegation to Visit SKL

Prof. Wan Gang, Vice-Chairman of the Chinese People's Political Consultative Conference (CPPCC) and Minister of Science and Technology, led a delegation of 17 officials, to visit the PSKL on Advanced Display and Optoelectronics Technologies.

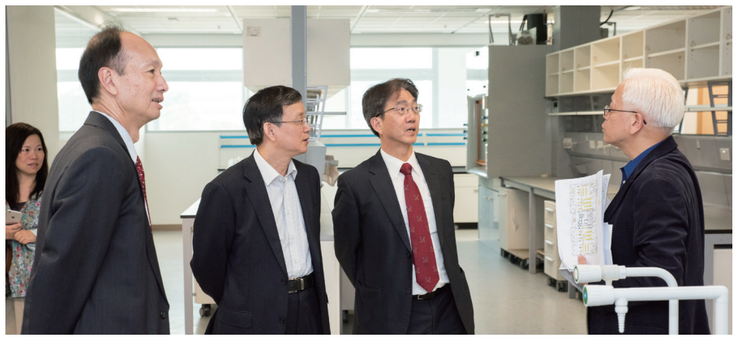
Prof. Wan Gang and the delegation visited the constructing research center and the Organic ELectronics Laboratory which are operated by the PSKL. Prof. Hoi-sing Kwok, Institute for Advanced Study Bank of East Asia Professor Ching W Tang and the research team introduced the laboratory's development and two of their latest products – a more energy-efficient bistable LCD monitor with better output quality and a new electronic shelf labeling system.

Science and Technology Departments in Mainland China



August 31, 2015

Dr. Fan Jianping,
Dean of Shenzhen Institute of Advanced Technology (SIAT) of Chinese Academy of Sciences (CAS)

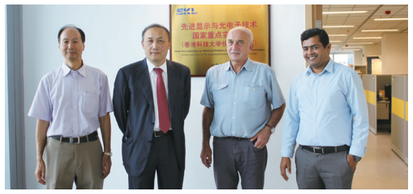


April 13, 2015

Dr. Jianguo Hou,
Ministry of Science and Technology (MOST)

June 20, 2016

President, Prof. Yang Wei,
National Natural Science Foundation of China



March 17, 2016

Deputy Director, Madam Qiu Hong,
Liaison Office of the Central People's Government

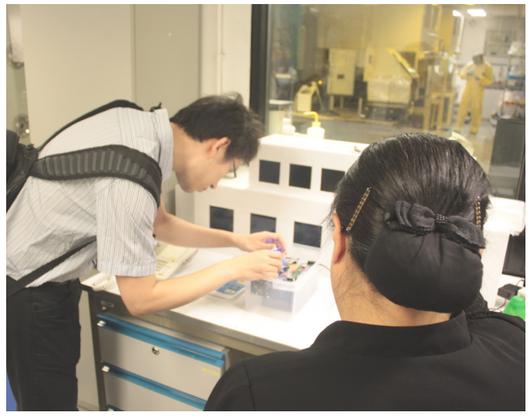
November 04, 2015

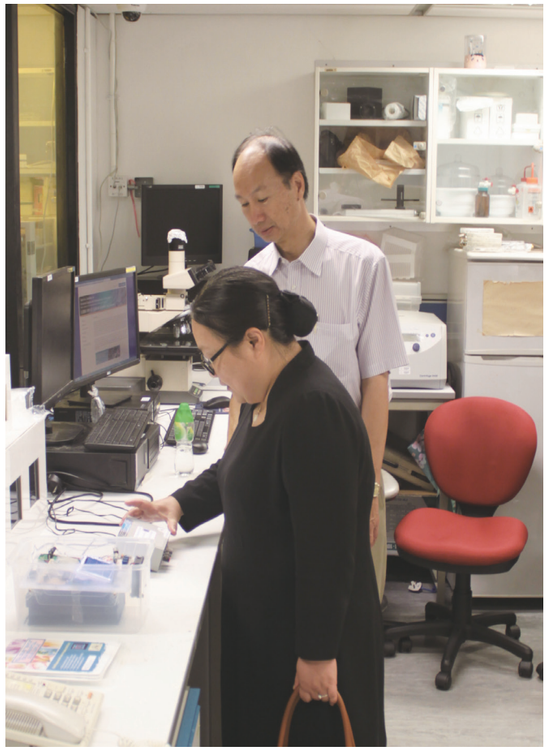
Vice Minister, Dr. Cao Jianlin,
Ministry of Science and Technology (MOST)

June 13, 2015

Ms. Youmei Dong,
Executive Vice President of BOE Technology Group Ltd.

BOE



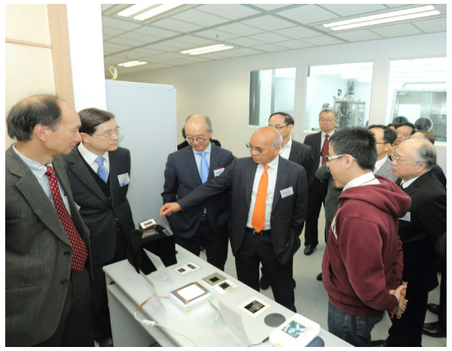


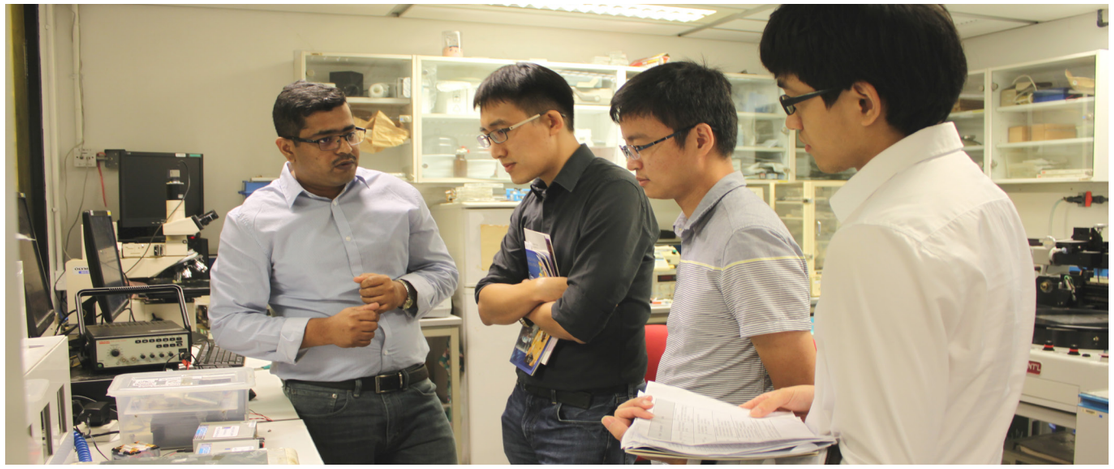
Connection with Enterprises

February 22, 2016

Dr. Henry Kar-Shun Cheng , GBS & Mr. Kar-Shing Cheng

新世界發展有限公司
New World Development Company Limited





September 15, 2015

Huawei Technologies Co. Ltd.

HUAWEI

Achievement

The PSKL accumulates over hundreds of patent applications and papers publication. We also continuously launch innovations on display technology.

Our efforts never waste and moreover, are recognized for academic and industrial excellence.

Prof. Hoi-sing Kwok (Right 1), received plague on "The 10th Anniversary of the Establishment of Partner State Key Laboratories in Hong Kong cum Plaque Awarding Ceremony for Hong Kong Branches of the Chinese National Engineering Research Centres".

December 06, 2015

CPPCC Vice-Chairman and Minister of Science and Technology Prof Wan Gang Award Plague to the PSKL

Prof Wan Gang, Vice-Chairman of the Chinese People's Political Consultative Conference (CPPCC) and Minister of Science and Technology, officiated at the two centers' plaque awarding ceremony today before leading a delegation to visit HKUST.

Prof. Wan Gang awarded plague to Prof. Hoi-sing Kwok, Director of the PSKL in "The 10th Anniversary of the Establishment of Partner State Key Laboratories in Hong Kong cum Plaque Awarding Ceremony for Hong Kong Branches of the Chinese National Engineering Research Centres", for recognizing the research achievements accomplished by the laboratory.

1		
2	3	4

Figures
1&3. Prof. Wan Gang awarded plague to Prof. Hoi-sing Kwok
2. The PSKL research team celebrated with Prof. Kwok on the ceremony
4. (From left) Prof Guanghao Chen, Prof Nancy Ip, President Prof Tony F Chan, Vice-President Prof Joseph Lee, Prof Benzhong Tang and Prof Hoi-sing Kwok attend the ceremony

Winners of Distinguished Paper Award, Mr. Guijun Li (Left 3) & Mr. Ken Tseng (Left 2) and winners of the Poster Paper Award, Mr. Ronald Ching (Right 2) & Ms. Pan Su (Right 3), with their supervisors, Prof. Hoi-sing Kwok (Right 1) and Prof. V.G. Chigrinov (Left 1)

August 24-28, 2015

Ph.D. candidates win Distinguished Paper Award and Poster Paper Award in the IDMC'15 & 3DSA 2015

PhD candidates Ms. Su Pan, Mr. Ken Tseng, Mr. Guijun Li and MPhil students Mr. Ronald Ching, who are supervised by Prof. Hoi-sing Kwok and Prof. Chigrinov, won 4 Paper Awards in the International Display Manufacturing Conference & 3D Systems and Applications 2015 (IDMC'15 & 3DSA 2015) held in Taiwan.

Papers titled "Low-Temperature Processed Color-Tunable Hybrid Perovskite Light Emitting Diodes" and "Photo-Stable Azo Dye Photoalignment Surface for Liquid Crystal Display", written by **Mr. Guijun Li** and **Mr. Ken Tseng** respectively, have been awarded **the Distinguished Paper Award.**

Mr. Ronald Ching and **Ms. Su Pan**, who wrote "The Growth of Conducing ZnO: Al Nanostructure by aqueous method for Enhancing Light Out-Coupling in Electronic Light Device" and "Spatial Temporal Color Separation System Based on Polarization Dependent 2D Grating" respectively, their papers have been awarded **the Poster Paper Award**.

IDMC' 15 & 3DSA 2015 set totally 4 Paper Awards this year. Winners of the Distinguished Paper Award and Poster Paper Award have received cash prizes NT$5,000 and NT$2,000 correspondingly.

February 03, 2015

The paper by Prof. Chigrinov, Prof. HS Kwok and Prof. Abhishek Srivastava's Research Team was the second most downloaded paper in Optics Letters in Nov 2014 and was cited by Liquid Crystals Today in Jan 2015


Liquid Crystals Today, 2015
Vol. 24, No. 2, 45–46, http://dx.doi.org/10.1080/1358314X.2014.1001609

NEWS
Industry and applications news

Low-power 3D displays

A new type of liquid crystal display (LCD), capable of maintaining a 3D image, without power, has been developed. The device detailed in a recent Optics Letters paper [1], an optically rewritable LCD (ORWLCD), contains no electrodes to switch the image, unlike a conventional LCD. The display is instead optically addressed by flashing a desired image onto it. The device is bistable and will maintain an image without power, thus making it ideal for low-energy applications such as signage.

Crucial to how optically rewritable displays work is the alignment layers used. Two different layers are found within the device: one, which is insensitive to light, and another layer, which is optically active when irradiated with polarized light. Exposure to polarized light causes the photosensitive layer to undergo photoisomerization, which causes it to reorientating light. This provides the alignment direction for the LC within the device, allowing the arrangement to be changed between planar and twisted nematic modes. Light printers are used to write an image onto such a display, and the intensity of a pixel is simply determined by the length of exposure to light.

The key innovation in this research is that a 3D image can be generated on the display in a single step. Previous ORWLCD designs had severe limitations with regard to 3D images: two displays would have to be overlapped to create a stereoscopic 3D effect – where a left and right image is projected to each eye separately. Overlapping of the displays and crosstalk is a major concern with this previous configuration, which has been overcome by the new display design, pseudonyly. This new display is separated into three sections to create a 3D image. Two segments have orthogonal twists of +45° and –45° to hold the left and right pictures, while the third segment simply displays the foreground or background of an image. The inclusion of a quarter wave plate separates light into two orthogonally polarized, left and right handed polarizations. While the 3D image in this article was written in three separate stages, the authors detail that it could be performed in a single step if the light printer used was of sufficiently high resolution.

Although it may be considered non-trivial to update an image on this device due to the required light printing technique, there are many applications for a bistable 3D display such as this in areas such as security. Manufacturing of these displays is also straightforward, since conducting layers are not required.

While updating an image requires light printing technique, there are many applications for a bistable 3D display such as this in areas such as security. Manufacturing of these displays is also straightforward, even compared to currently mass-produced devices, since conducting layers are not required. This also means that ORWLCDs can be extremely thin in profile.

Highly efficient polarizers

Efficient polarizers are crucial to many aspects of LC work; from fundamental research using polarized light microscopes to LCD applications which incorporate polarizers in the display panel. Conventional polarizers work by absorbing one polarization of the incident unpolarized light, so they work by injecting light not polarized in the desired direction. In reality, transmission is even less due to losses in the material such as absorption or reflections.

A new metamaterial developed by a team at the University of Utah has been developed, which surpasses the theoretical limit of conventional polarizers by 10%. This new metamaterial not only allows the desired polarization to be transmitted unhindered, but also rotates light from the orthogonal polarization by 90°. Experimental results have shown that transmission of the desired polarization occur at efficiencies of ~74% in the new material, twice the efficiency of many conventional films.

A nonlinear optimization algorithm was used to design the metamaterial. The metamaterial was then fabricated by etching silicon using focused-ion-beam lithography, allowing precise control over the etching depths. The initial device is only 20 × 20 μm and

© 2015 Taylor & Francis

The paper titled "Optically rewritable 3D liquid crystal displays" by ECE Ph.D. students Mr. Jiatong Sun and **Mr. Wanlong Zhang**, ECE MPhil graduate Mr. Lu Wang, **Prof. Abhishek Srivastava, Prof. V. Chigrinov, and Prof. H.S. Kwok,** was the second most downloaded paper in Optics Letters in November 2014.

The paper was also cited by Industry and Applications News, Liquid Crystals Today (Volume 24, Issue 2, 2015), which was published on 30 Jan 2015.

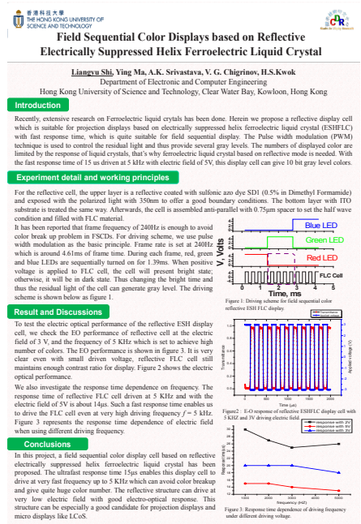
Furthermore, an article on the paper including an interview with Prof. Srivastava was featured on apptheneum.

Read the Full News via the QR Code or the link below:

http://www.tandfonline.com/doi/pdf/10.1080/1358314X.2014.1001609

May - June, 2015

Outstanding Poster Award won in 2015 SID International Symposium


Field Sequential Color Displays based on Reflective Electrically Suppressed Helix Ferroelectric Liquid Crystal

Liangyu Shi, Ying Ma, A.K. Srivastava, V. G. Chigrinov, H.S.Kwok
Department of Electronic and Computer Engineering
Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

Introduction

Experiment detail and working principles

Result and Discussions

Conclusions

Prof Vladmir Chigrinov and **Prof Abhishek Srivastava** were awarded a Distinguished Poster Award at the 2015 Society for Information Display (SID) International Symposium together with **Prof Hoi-sing Kwok**, Director of the PSKL, and our PhD candidate **Liangyu Shi**. The poster was based on the paper titled "Field-Sequential-Color Displays Based on Reflective Electrically Suppressed Helix Ferroelectric Liquid Crystal".

A poster by Prof Chigrinov and Prof Srivastava, both Electronic and Computer Engineering (ECE), and collaborators from National Chiao Tung University, Taiwan, also won the Outstanding Poster Award at the 2014 Taiwan Liquid Crystal Society Conference. The poster focused on the paper titled "A Bistable Negative Lens by Integrating a Polarization Switch of Ferroelectric Liquid Crystals with a Passively Anisotropic Focusing Element".

(Adopted from *IN FOCUS*, Issue No.27, SENG)

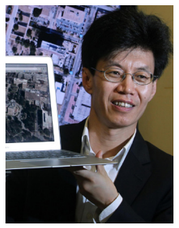
The PSKL research team conducts experiment and explores the 5 display research trends, in the Centre of Display Research (CDR) with cutting-edge equipment.

Projects

Developing advanced display technologies is always the PSKL's top mission. Research team uses cutting-edge equipment to explore the 5 major aspects:

1. **Thin-film transistors (TFTs);**
2. **Organic light-emitting diodes (OLEDs);**
3. **Liquid-crystal displays (LCDs)**
4. **Video information processing and circuit design;**
5. **Flexible, high-resolution silicon LED and nano optoelectronic displays.**

Vectorized 3D Representation for 3D Displaying and Editing



Prof. Long QUAN
Professor, Dept. of Computer Science & Engineering, HKUST

Figure 1

Figure 2

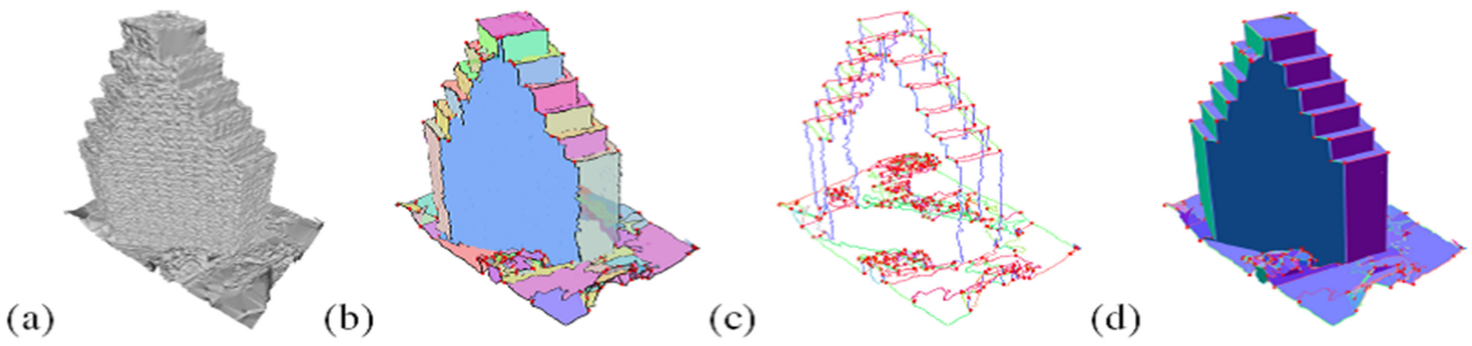


Fig. 1 Large-scale 3D segmentation and recognition for 3D displaying and editing.
Fig. 2 Vectorized 3D representation for 3D displaying

We start from an initial two-manifold surface in triangular meshes reconstructed from multi-view stereo methodology, our goal is to generate a minimalist vectorized 3D representation while preserving highest fidelity to the original input data, as shown in the preliminary results in Figure 2. This vectorized representation is not only desirable for most large-scale 3D on-line display and navigation on diverse platforms, but also for object-based simulation and analysis in governmental and environmental applications.

We first segment the initial mesh-based manifold surface into regions by integrating both photometric and geometric characteristics. Then, we build up a high-level object-oriented representation of the surfaces in what we call a PBC network. After that, we carry out geometric optimization with a variational principal for different representations.

Finally, we optimize this large-scale networked objects by regularizing the shape geometry of interacting objects from a set of geometrical and topological constraints derived from the urban priors.

Be Unlimited to 3D Online Display and Navigation on diverse platforms. It Expands to Object-based Simulations & Environment Analysis for the Government.

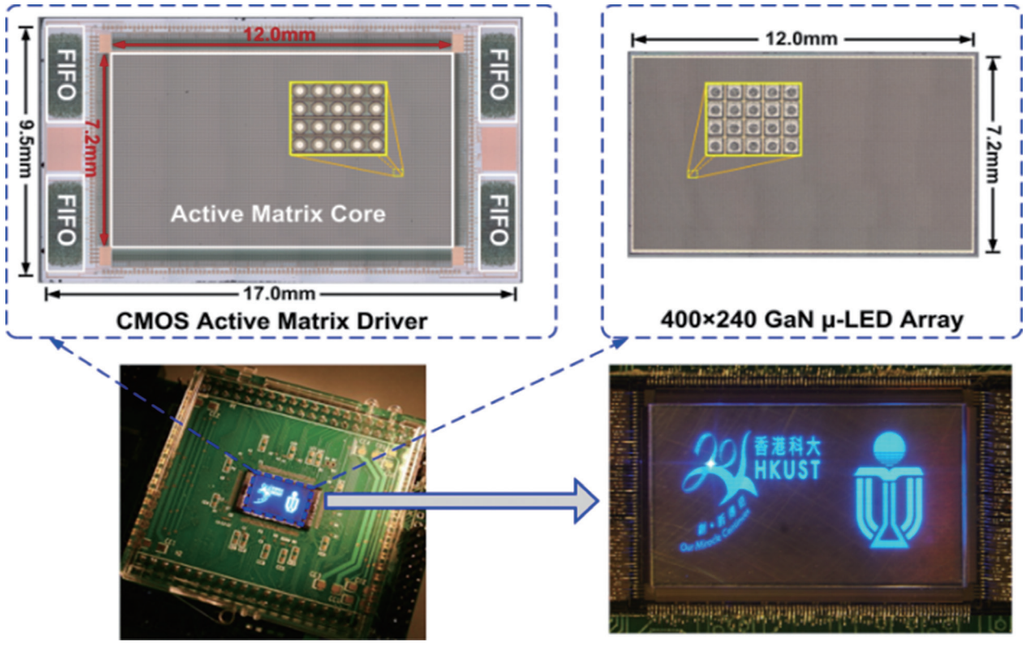


Fig. 1. Photographs of the SoC, the GaN μLED array and the smart microdisplay module.

Visible Light Communication Modulator SoCs

Prof. Patrick YUE
Professor,
Dept. of Electronics & Computer Engineering, HKUST

During 2015, the PSKL research team has developed an active matrix LED microdisplay with embedded visible light communication (VLC) function.

The miniaturization and integration of inorganic LED display modules have attracted significant research efforts due to their superior brightness and reliability compared to organic LED microdisplay.

Combining these two technology trends, an active matrix LED (AMLED) driver SoC with built-in VLC modulation capability [1]-[3] to demonstrate a WQVGA smart microdisplay featuring 1.25-Mb/s VLC for enabling LED digital signage as location-based information broadcaster and indoor positioning beacons.

Our team has successfully demonstrated the LED microdisplay with embedded VLC modulator.

The SoC demonstrated the importance and advantages of integration for realizing low-power, cost-effective VLC system using standard LEDs.

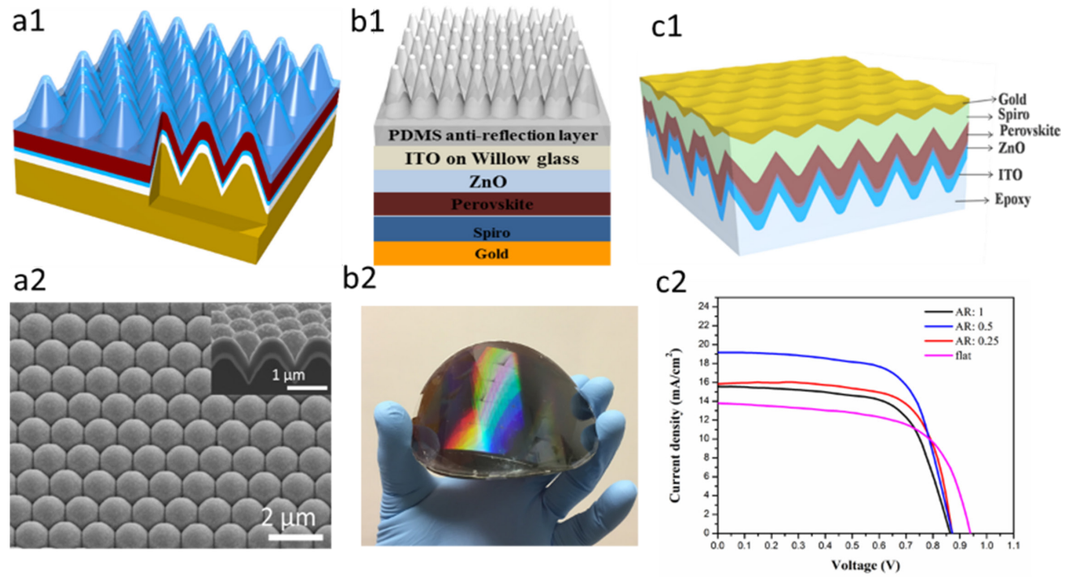


Figure 1. (a1) Schematic of nanocone amorphous Si solar cell. **(a2)** SEM images of nanocone amorphous Si solar cell. **(b1)** Schematic of lead halide perovskite thin film solar cell on flexible glass substrate. **(b2)** A photograph of large scale device shown in (b1). **(c1)** Schematic of inverted nanocone perovskite thin film solar cell. **(c2)** Current-voltage characteristics of inverted nanocone solar cell showing improved performance with nanostructures

Nanostructured Photovoltaic and Touch Sensor Devices

Prof. Zhiyong FAN
Associate Professor,
Dept. of Electronics & Computer Engineering, HKUST

In year of 2015, we have performed investigations on performance improvement of optoelectronic devices with various nanostructures.

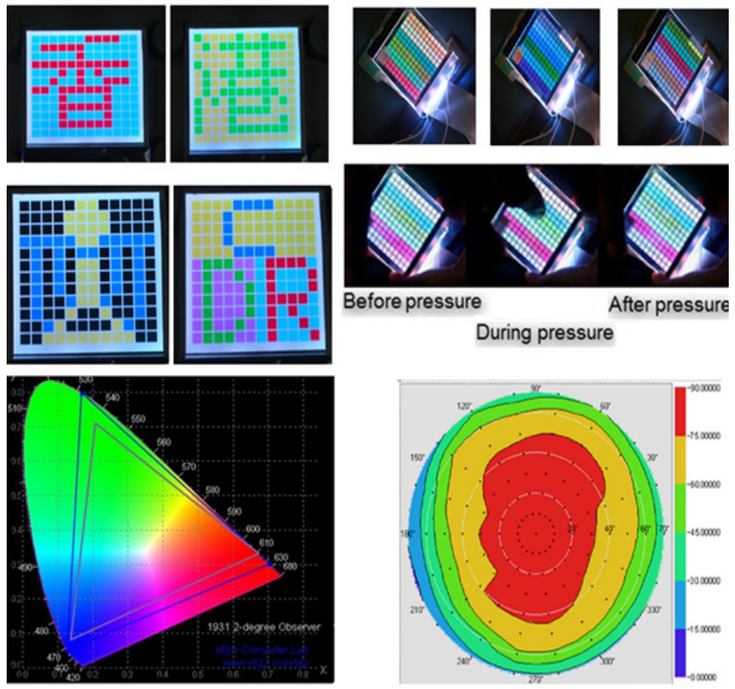
Particularly, we have developed three approaches to combine thin film photovoltaic materials with nanostructures to fabricated efficient solar cells.

Figure 1a1, 1b1 and 1c1 demonstrate the schematics of nanocone amorphous Si thin film solar cell on plastic substrate, lead halide perovskite thin film solar cell on flexible glass substrate and inverted nanocone perovskite thin film solar cell, respectively.

We have discovered that the nanostructures cannot only improve light harvesting of the devices, but also improve device mechanical flexibility. The conclusion was supported by experiments and modeling.

Electrically Suppressed Helix Ferroelectric Liquid Crystals (ESHFLCs)

Prof. Abhishek SRIVASTAVA
Research Assistant Professor



The latest demands of the optoelectronics industry, which has undergone drastic change in recent years, include increasingly high-resolution displays and cost-effective photonic devices with reduced power consumption. Ferroelectric liquid crystals (FLCs), which are capable of fast switching speeds at low driving voltages, represent a promising candidate for the realization of such devices.

However, due to several limitations (e.g., geometrical, optical, and mechanical instabilities), FLC struttures are currently less popular than other LCs.

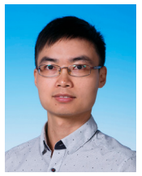
At SKL, we have recently developed a new FLC electro-optical mode (called as electrically suppressed helix FLCs (ESHFLCs)) with good optical quality for FLCs by mean of optimized photo-alignment technology.

The developed ESHFLCs are characterized by high contrast ratio >10k: 1 at a driving frequency up to 3 kHz under an extremely small applied voltage of 1-3 Volts and without any diffraction lobes.

Most importantly the ESHFLCs are completely shock stable unlike other FLCs. Therefore, it could find application in modern LCDs like field sequential color displays (e.g. fig), various photonic elements and has a potential to offer better alternative for the ADS/IPS/FFS based high-resolution displays.

Optimization of the Fabrication Process for Bridged-Grain Metal Induced Crystallization TFTs

Prof. Wei ZHOU
Research Assistant Professor



Dr. Rongsheng CHEN
Research Associate

Great Potentials to Begin the Next Large Size Flat-Pannel Generation.

The required time for Metal induced crystallization (MIC) process of amorphous silicon (a-Si) thin film is typically about 10 hours, which increase the takt time of production in flat panel display industry. Increasing the nickel amount can reduce the required time of crystallization process.

In this project, we study the effect of nickel amount on the crystallization time of a-Si thin film and the electrical performance of the resulting Bridged-Grain (BG) MIC TFTs.

The effect of the number and width of the BG lines on the electrical properties of the BG MIC TFTs are also investigated.

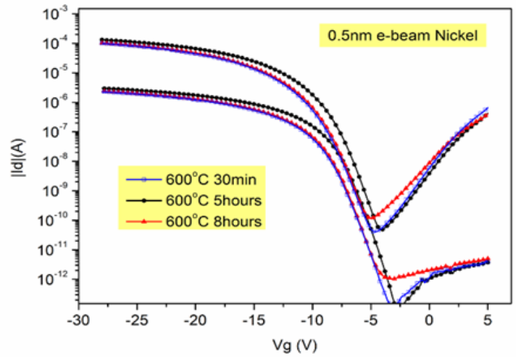


Figure. 1 Transfer characteristics of the poly-Si MIC TFTs with 0.5 nm nickel for different annealing time.

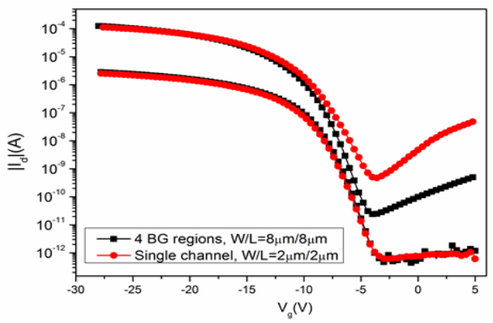


Figure. 2 Comparison of transfer characteristics for the MIC TFTs with and without BG.

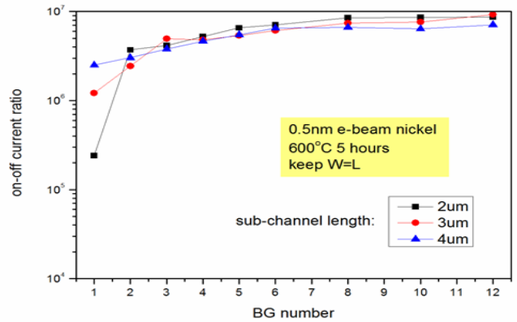


Figure. 3 On-off current ratio vs. BG number

High Resolution Optical Paper Display



Dr. Ken TSENG
Research Associate

Dr. Michael LEE
Research Associate

Wanlong Zhang
Ph.D. Candidate

The optical paper display can update the image content by using a light projector or scanner. By using special photoalignment material, the liquid crystal molecules can be reoriented by using external light source.

Hence the image content can be updated from the outside of the display easily. As the optical paper display does not require electronic components inside, it can have 100% aperture ratio, zero power consumption and no wire connection.

The optical paper display has excellent transmittance and extreme high resolution. It is a good candidate for transparent display and advertisement


Fig. 1 Prototype of the optical paper display.

3D Grayscale Optically Rewritable Liquid Crystal Displays

Wanlong Zhang
Ph.D. Candidate

High Contrast Ratio, Low Cost and Just Like Printing on a Real paper.

Optically Rewritable Liquid Crystal Display (ORW LCD) is based on the optically addressed bi-stable display which needn't any power to display the image after being uploaded. ORW LCD can also give high contrast ratio, low cost and reflect like real paper. Moreover, it can be easily transferred to plastic substrate without ITO layer and then to be flexible.

In this work, we explore an easy and practical method to generate 3D grayscale images on the ORW LCD by using a grating mask and printed transparent films and written by polarized blue LED light.

Applications:
1. Name Cards;
2. Price Tags;
3. Large Advertisement Board and so on.

Fig. 1 3D Grayscale ORW LCD Samples

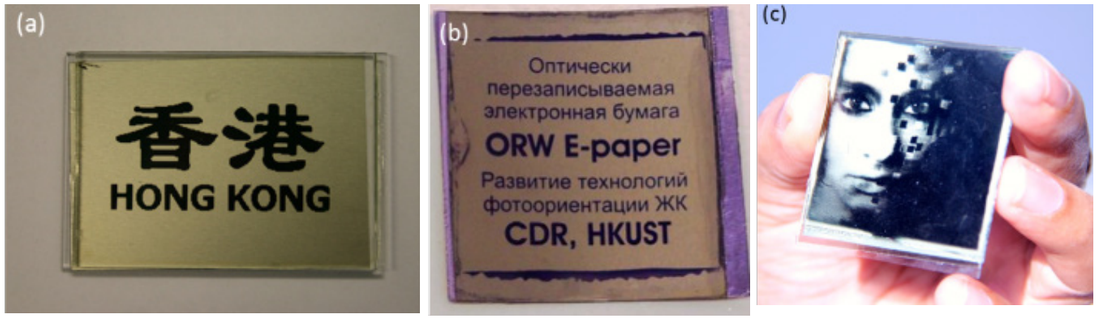
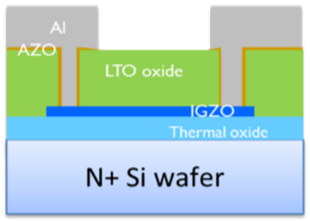


Fig. 2 ORW LCD Samples: (a) Sample on Glass, (b)Flexible Sample, (c) Grayscale Sample

Performance enhancement of Metal-Oxide Thin-Film Transistors using Thermal Annealing Processes



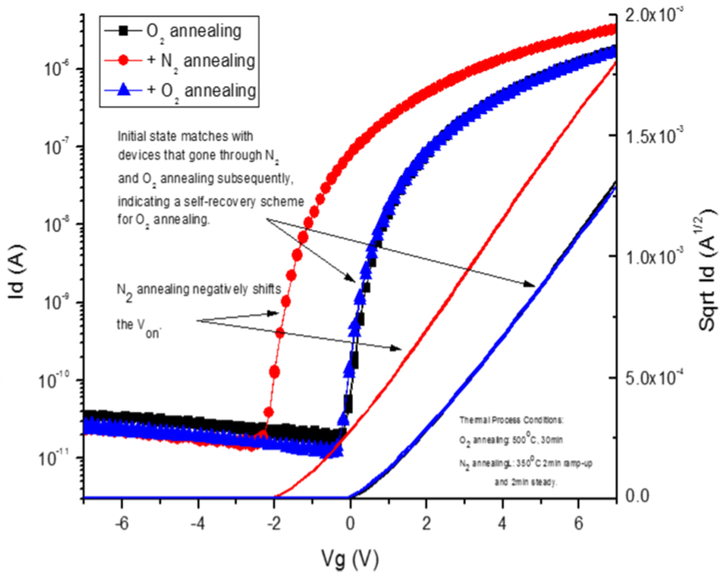


Fig. 1
Schematic plot of the thermally annealed devices

Fig. 2
Von shift through different atmosphere in thermal annealing processes.
2 volts of negative shift after nitrogen annealing is clearly observed.


Dr. Lei LU
IAS Post-doctoral Fellow

Zhuoqun FENG
Ph.D. Candidate

Various types of Zinc-oxide based semiconductor materials for the fabrication of thin-film transistors with low process temperature, reasonable mobility, higher on-off ratio and high transparency, are being intensively studied as promising alternatives to low-temperature polycrystalline silicon TFTs for the application of the next-generation flat-panel displays.

The characteristics of metal-oxide-based TFTs are known to have strong relations with the thermal processes they have gone through. Particularly, the resistivity of the IGZO film is sensitive to the annealing atmosphere, temperature and stack permeability. In our lab, we proposed a way of controlling the Von shift by controlling the annealing processes of the transistors. The devices will change from enhancement mode to depletion mode with several volts negative Von shift if they are annealed in N2, due to the decreased channel resistivity. And such shift can be recovered in an oxidizing annealing. Considering the absence of high performance p-type metal oxide TFTs, this new method can be used to construct logic circuit based on enhancement and depletion mode n-type TFTs, exhibiting great potential in assembling system-on-panel application.

Pixel Design of Electrically-Suppressed-Helix Ferroelectric Liquid Crystal for Flat Panel Display

By recent progress in electrically suppressed helix (ESH) ferroelectric liquid crystal (FLC) mode, a novel pixel design employing pulse width modulated (PWM) grayscale scheme, focusing on TFT flat panel display applications is proposed. Such design has a 3T1C structure, which is compact enough to preserve reasonable pixel aperture in practice.

Incorporating an innovative driving scheme, the proposed architecture successfully demonstrates a fully digital and TFT compatible AMFLC pixel architecture, possessing uniform and continuous grayscale.


Dr. Leo HO
Research Associate

Dr. Ken TSENG
Research Associate

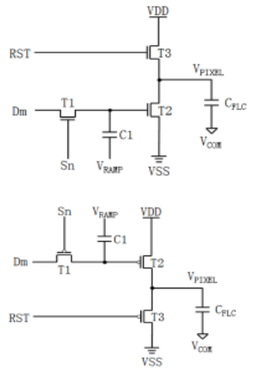


Fig. 1 The schematic diagram of the proposed 3T1C pixel with ramp: (a) in N-type and (b) in P-type transistors.

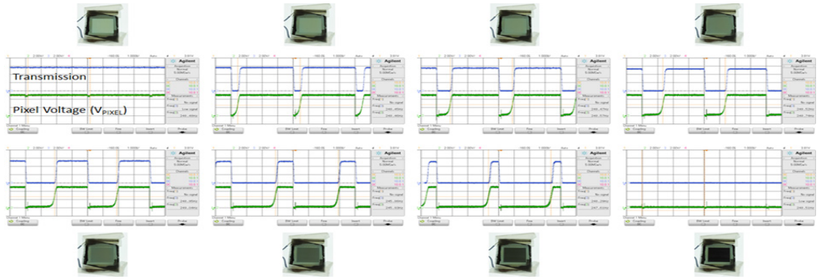


Fig 2. Transmission and pixel voltage characteristic of FLC pixel incorporated with the 3T1C pixel with ramp showing different grayscale

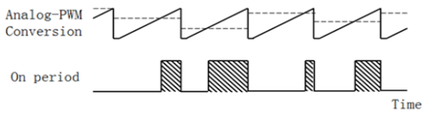


Fig. 3 Schematic drawing of analog-PWM conversion and the pixel On/Off

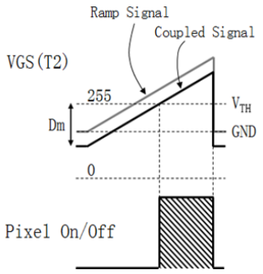


Fig. 4
Relation between data (Dm), gate voltage of T2 (VGS), threshold voltage of T2 (VTH) and the corresponding pixel on period for N-type transistors design

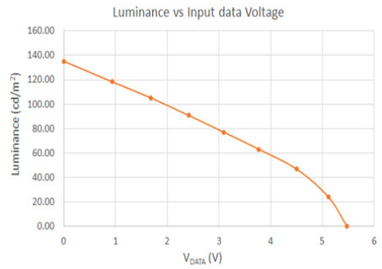


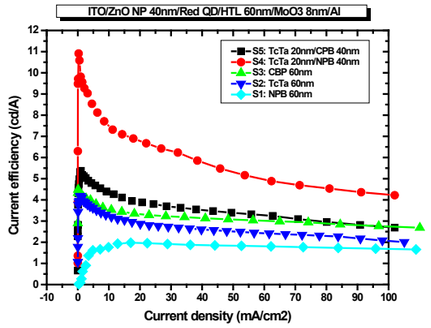
Fig. 5
Measurement result of Transmission voltage characteristic of the proposed 3T1C pixel with ramp

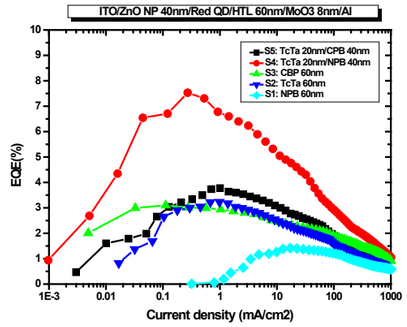
Optimization of the hole transportation layers (HTL) for inverted quantum dot light-emitting diodes (QDLED)

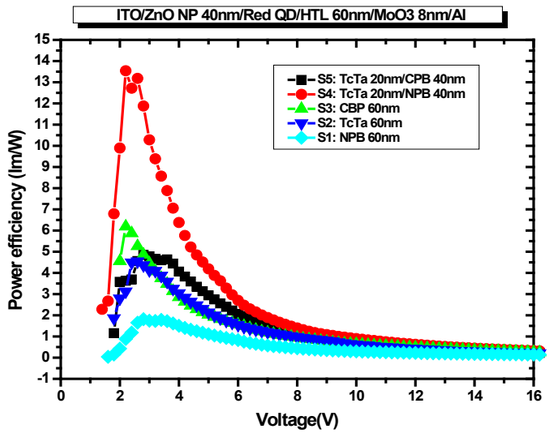
Yibin JIANG
Ph.D. Candidate

In this study, different hole transportation materials with different highest occupied molecular orbital (HOMO) were investigated in order to improve the hole injection into the quantum dots (QD). NPB (HOMO: -5.4eV), TcTa(HOMO: -5.7eV) and CBP (HOMO: -6eV) were applied as single HTL or combined HTL.

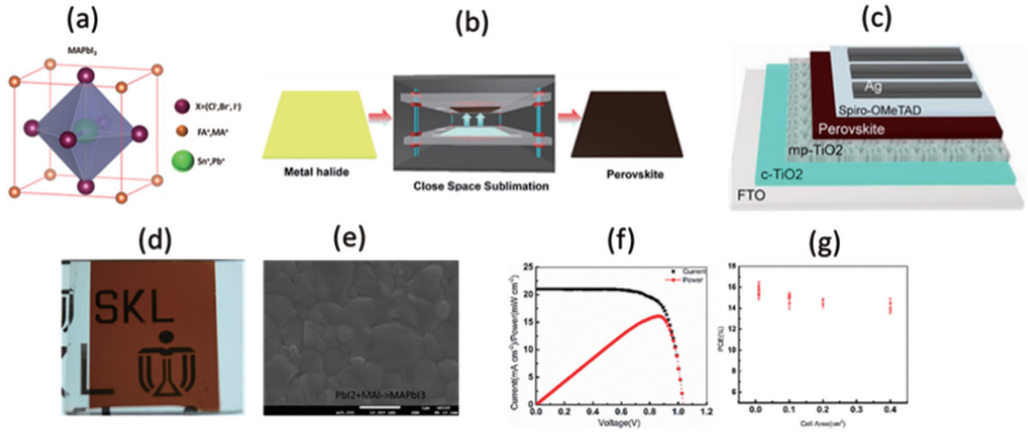
Although the device using CBP showed the highest efficiency among the QDLEDs with single HTL, the devices with combined HTL exhibited even higher efficiency. The device with TcTa&NPB combined HTL achieved 11cd/A current efficiency, 7.5% external quantum efficiency (EQE) and 13.5lm/W power efficiency. This combined HTL can separate the excitons and the accumulated charges so that quench of excitons can be suppressed.







Toward Large Scale Fabrication of Hybrid Perovskite Solar Cells by Industrial Close Space Sublimation



(a) The crystal structure of the perovskite; (b) The schematic of Close Space Sublimation (CSS) process for perovskite; (c) schematic of perovskite solar cell structure; (d) photography; (e) SEM images of perovskite film;(f) C-V curve and J-V curve of the champion cell; (g) area effect on the cell performance

Photovoltaics potentially becomes an inexpensive, renewable energy technology by converting sunlight into electricity. Over the past few years, one of the fastest growing areas of photovoltaic research that has sprung to the forefront of the scientific community involves a material called hybrid halide perovskites. The power conversion efficiency of solar cells using these hybrid perovskite compounds as the absorbing layer leaped from 3.8% as a forerunner in 2009 to a certified 20.1% in current versions, rivalling most of the leading thin film solar cell technologies. The next challenge in the field will be translating the lab-scale process to a large-scale production process, which will preferably include a cost-competitive, industrial close vapor sublimation.

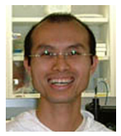
We report on a perovskite fabrication method that has the potential for large-scale production by low temperature closed space vapor transport process (CSVT). The closed space vapor transport is a scalable, high throughput technique for making semiconductors. It is already a well-established industrial technology for cost-competitive, commercial-scale manufacturing of polycrystalline CdTe solar cells, along with explored device efficiencies of 19.6%.

With CSVT process, we are able to make efficient CH3NH3PbI3 and CH3NH3PbBr3-xIx solar cells with power conversion efficiencies of 16.1% and 5%, respectively.

Moreover, this technique also takes advantages of relatively simple, inexpensive, high throughput and efficient precursor transport/utilization.

These features are significant because in order to utilize perovskites for photovoltaic application, the process must be potential in large-scale and low cost.

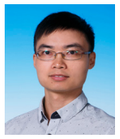
Guijun LI
Ph.D. Candidate



Jacob HO
Laboratory Manager

Fabrication of High-Performance Bridged-Grain Polycrystalline Silicon TFTs by Laser Interference Lithography Technology

Sunbin DENG
Ph.D. Candidate



Dr. Rongsheng CHEN
Research Associate

Dr. Wei ZHOU
Research Assistant Professor

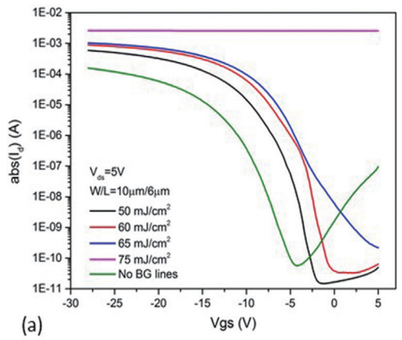
In order to minimize extra manufacturing costs from BG structure, a kind of maskless and large-area applicable laser interference lithography (LIL) technology is introduced to pattern the periodic submicron BG structure. So the expensive conventional photolithography technology can be replaced.

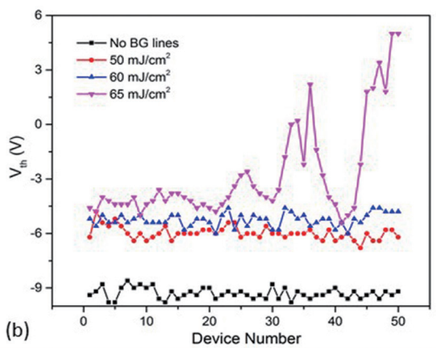
Here BG metal-induced crystallization (MIC) poly-Si TFTs involving LIL technology have been fabricated, which show dramatically improved electrical performance compared with normal MIC poly-Si TFTs.

Furthermore, as an optical lithography technique, the relationship between LIL exposure energy density and device performance is investigated, and an optimal LIL exposure energy density range can be found out to realize high performance while maintaining spatial uniformity of our BG-MIC TFTs.

All Key Electrical Parameters of BG-MIC TFTs Fabricated with Different LIL Exposure Energy Density

Key Parameters	0 mJ/cm^2	50 mJ/cm^2	60 mJ/cm^2	65 mJ/cm^2	75 mJ/cm^2
PR line width (μm)	N/A	0.568	0.475	0.425	0.221
(period=1 μm) V_{th} (V)	-9.52	-6.04	-5.08	-1.87	
μ_{fe} (cm^2/V·s)	23.51	74.49	104.51	135.55	
On-off Ratio (×10^7)	0.297	3.90	4.21	0.536	N/A
GIDL (pA/μm)	7480	5.65	33.3	50600	





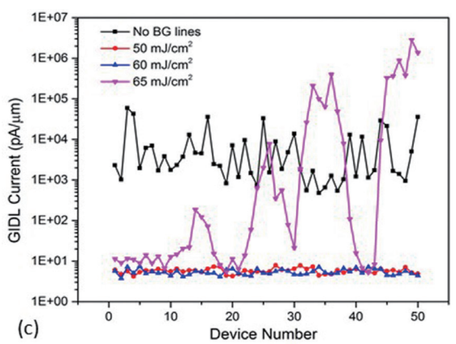
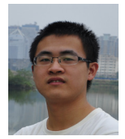


Fig. 1 (a) Transfer characteristics, (b) Vth and (c) GIDL current spatial uniformity of BG-MIC TFTs with different LIL exposure energy density.

Deposition of CAAC IGZO Film for Thin Film Transistors Application

C-Axis Aligned Crystal (CAAC) IGZO, first reported by Yamazaki et al, is a homologous structure of crystalline IGZO. As there is no clear grain boundary in a-b plane and multilayer overlap alignment in c-axis, CAAC IGZO oxide semiconductor performs extremely low off-state current and high reliability, which makes a promising candidate for future display and VLSI industry.

In our lab, we have successfully deposited the CAAC IGZO film. The optimization process on various parameters, such as substrate temperature, deposition atmosphere and target quality, is in progress to improve the crystallization extent of the film in c-axis.



Zhihe XIA
Ph.D. Candidate

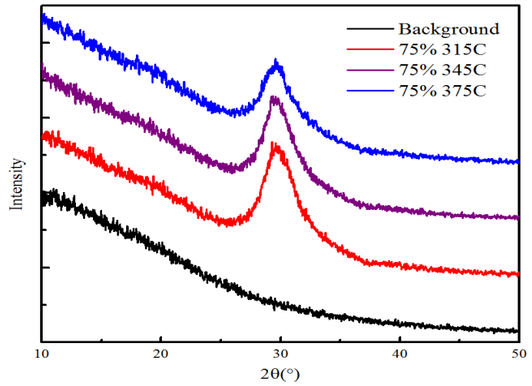


Fig. 1
XRD results with different substrate temperature

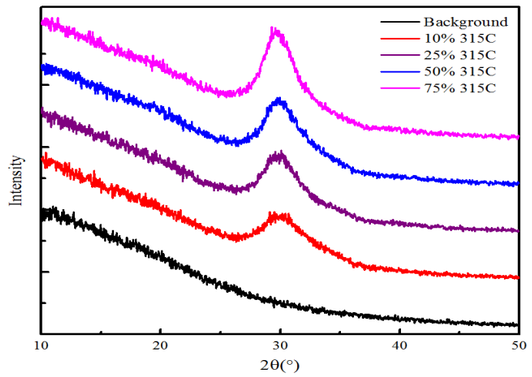


Fig. 2
XRD results with different O2 ratio

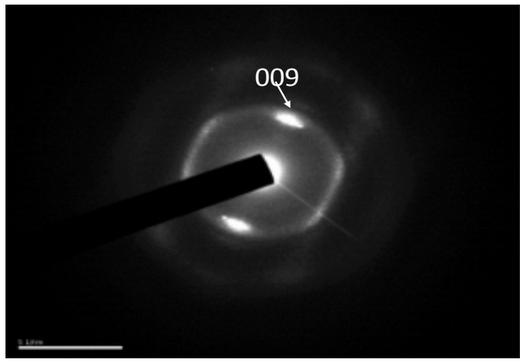


Fig. 3
SAED patterns of cross section of IGZO film
(Tsub=315 ℃ , O2 ratio=75%)

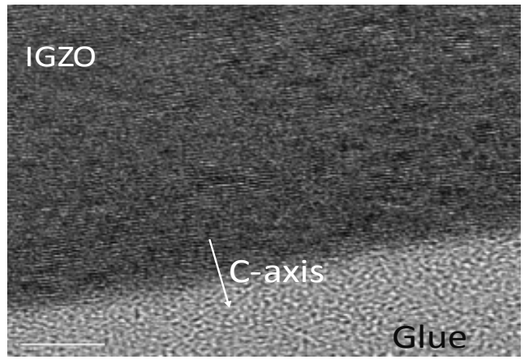


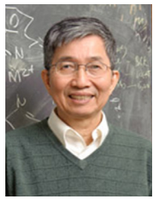
Fig. 4
TEM image of cross section of IGZO film
(Tsub=315 ℃ , O2 ratio=75%)

Research Team

Prof. Hoi-sing KWOK
Director

Prof. Man WONG
Vice-Director

Prof. V. G. CHIGRINOV
Research Team Leader



Prof. Ching W. TANG
Research Team Leader

Prof. Long QUAN
Professor,
Dept. of Computer Science & Engineering, HKUST

Prof. Patrick YUE
Professor,
Dept. of Electronics & Computer Engineering, HKUST

Prof. Zhiyong FAN
Associate Professor,
Dept. of Electronics & Computer Engineering, HKUST

Prof. Wei ZHOU
Research Assistant Professor

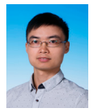
Prof. Abhishek SRIVASTAVA
Research Assistant Professor

Mr. K.M. FUNG
Chief Technician

Mr. Jacob HO
Senior Technician

Dr. Fion YEUNG
Manager

Dr. Lei LU
IAS Post-doctoral Fellow



Dr. Rongsheng CHEN
Research Associate

Dr. Thomas TANG
Research Associate

Dr. Ken TSENG
Research Associate

Dr. He LI
Research Associate

Dr. Michael LEE
Research Associate

Dr. Leo HO
Research Associate

2015-2016 Visiting Scholars

Mainland China

Mr. Kai Wong (Jinan University)
Dr. Yue Shi (University of Colorado - Boulder, USA)
Dr. Hongbo Lu (HeFei University of Technology)

Russia

Dr. Vashchenko Valerii V. State Scientific Institution "Institute for Single Crystals" of National Academy of Sciences of Ukraine
Dr. Pozhidaev Evgueni P. Russian Academy of Sciences, Moscow
Dr. Oleg Yaroshchuk National Academy of Sciences of Ukraine
Mr. Kyselov Oleksiy Institute of Philosophy of the National Academy of Sciences of Ukraine

Research Assistants:

Mr. Alex Yuk Lung CHEUNG | Mr. Ronald Kwong Lung CHING | Mr. Liu XI

Ph.D. Candidates:

Mr. Sunbin DENG | Mr. Zhuoqun FENG | Mr. Yibin JIANG | Mr. Guijun LI | Mr. Jiapeng LI | Ms. Cuiling MENG | Ms. Su PAN | Ms. Liangyu SHI | Mr. Ali TAIMOOR | Mr. Ming Wai Alwin TAM | Miss Sisi WANG | Mr. Zhihe XIA | Mr. Chenxiang ZHAO | Mr. Meng ZHANG | Mr. Wanlong ZHANG

Industrial Collaborators

DALTON Focus On Display 深圳市道尔顿电子材料有限公司 SHENZHEN DALTON ELECTRONIC MATERIAL CO.,LTD

华星光电 CSOT

AUO 友達光電 AU Optronics

DIC Color & Comfort by Chemistry

Contact Us

State Key Laboratory on Advanced Displays and Optoelectronics Technologies

Hong Kong University of Science and Technology (HKUST),
Department of Electronics and Computer Engineering (ECE),
Clear Water Bay, Kowloon, HK

TEL : +852 3469 2276
FAX : +852 2358 1485
EMAIL : skl@ust.hk
WEB : http://www.pskl.ust.hk/

For More,
Visit the PSKL Website :