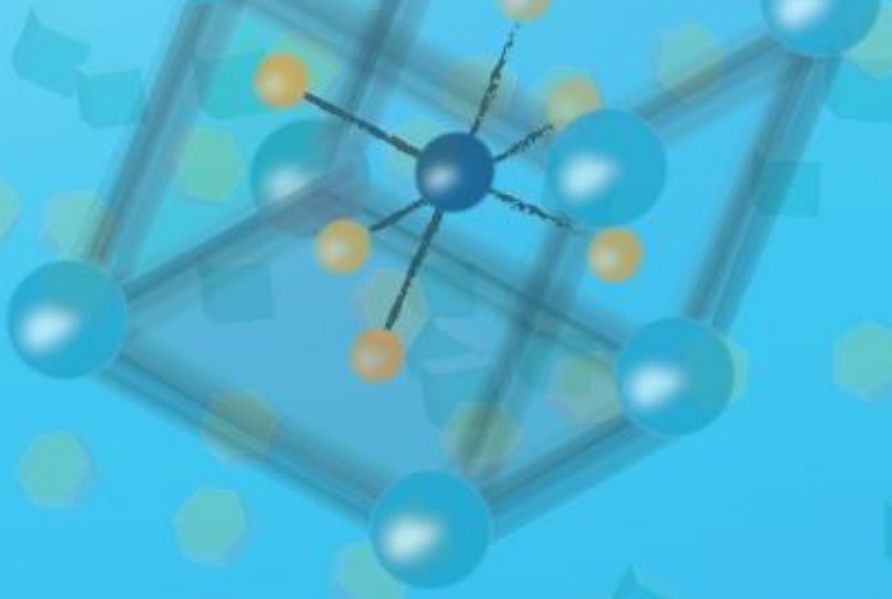
International Conference on Molecular Electronic Materials and Devices

5 - 8 January 2015

City University of Hong Kong

Hong Kong

Program & Abstracts Book



超金剛石及
先進薄膜研究中心
Center Of Super-Diamond
and Advanced Films

香港城市大學
City University
of Hong Kong

Department of Physics
and Materials Science

香港浸會大學
HONG KONG BAPTIST UNIVERSITY

香 港 大 學
THE UNIVERSITY OF HONG KONG

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City University of Hong Kong, Hong Kong
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Co-Chair: CHE, Chi-Ming
Department of Chemistry,
The University of Hong Kong

Co-Chair: CHEAH, Kok-Wai
Department of Physics,
Hong Kong Baptist University

Committee Members:

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The organizers gratefully acknowledge financial support from:-

The Croucher Foundation

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RGC Theme-Based Research Scheme
(Challenges in Organic Photo-Voltaics and Light Emitting Diodes – A Concerted Multi-Disciplinary and Multi-Institutional Effort - Influences of Interfacial Charge Transfer on Organic Electronics Devices)

PLENARY* & INVITED SPEAKERS: (IN ALPHABETICAL ORDER)

**** ADACHI, Chihaya**, Kyushu University, Japan*
***CHEN, Chin-Ti**, Institute of Chemistry, Taiwan*
***CHI, Yun**, National Tsing Hua University, Taiwan*
***FAHLMAN, Mats**, Linköping University, Sweden*
**** FORREST, Stephen**, University of Michigan, USA*
***GUO, Tzung-Fang**, National Cheng Kung University, Taiwan*
***HAO, Yuying**, Taiyuan University of Technology, China*
***ISHII, Hisao**, Chiba University, Japan*
***KIM, Jang Joo**, Seoul University, Korea*
***KOCH, Norbert**, Humboldt-Universität zu Berlin, Germany*
***LEE, Jun Yeob**, Dankook University, Korea*
***LI, Wenlian**, Changchun Institute of Optics, Fine Mechanics and Physics, CAS, China*
***LI, Yongfang**, Institute of Chemistry, CAS, China*
***LIAO, Liang-Sheng**, Soochow University, China*
***LIU, Yunqi**, Institute of Chemistry, CAS, China*
***MA, Dongge**, Changchun Institute of Applied Chemisty, CAS, China*
***MA, Yuguang**, South China University of Technology, China*
***ONG, Beng**, Hong Kong Baptist University, Hong Kong*
***PARK, Nam-Gyu**, Sungkyunkwan University, Korea*
***PARK, Jongwook**, Catholic University of Korea, Korea*
***TANG, Jianxin**, Soochow University, China*
***TANG, Benzhong**, Hong Kong University of Science and Technology, Hong Kong*
***TAO, Yu-Tai**, Institute of Chemistry, Academia Sinica,, Taiwan*
***TUNG, Chen-Ho**, Technical Institute of Physics and Chemistry, CAS, China*
***UENO, Nobuo**, Chiba University, Japan*
***V.A.L., Roy**, City University of Hong Kong, Hong Kong*
***WAN, Li-Jun**, Institute of Chemistry, CAS, China*
***WONG, Raymond Wai-Yeung**, Hong Kong Baptist University, Hong Kong*
***WONG, Ken-Tsung**, National Taiwan University, Taiwan*
***WU, Chung-Chih**, National Taiwan University, Taiwan*
***XU, Jianbin**, The Chinese University of Hong Kong, Hong Kong*
***YAM, Vivian Wing Wah**, The University of Hong Kong, Hong Kong*
***YAN, Feng**, Hong Kong Polytechnic University, Hong Kong*
***ZHU, Furong**, Hong Kong Baptist University, Hong Kong*
***ZOU, Dechun**, Peking University, China*

CONFERENCE INFORMATION

Venue	*Lecture Theatre 13, 15 &17,* 4/F. Podium, Academic Building 1, City University of Hong Kong
Phone No.	+852 3442 4204
Fax. No.	+852 3442 0541
Mailing Address	Center Of Super-Diamond and Advanced Films (COSDAF), & Department of Physics and Materials Science City University of Hong Kong Tat Chee Avenue, Kowloon Tong Hong Kong SAR
E-mail	MEMD2015@cityu.edu.hk / apcosdaf@cityu.edu.hk
Website	http://www.cityu.edu.hk/cosdaf/MEMD2015/Index.html

CONFERENCE BANQUET

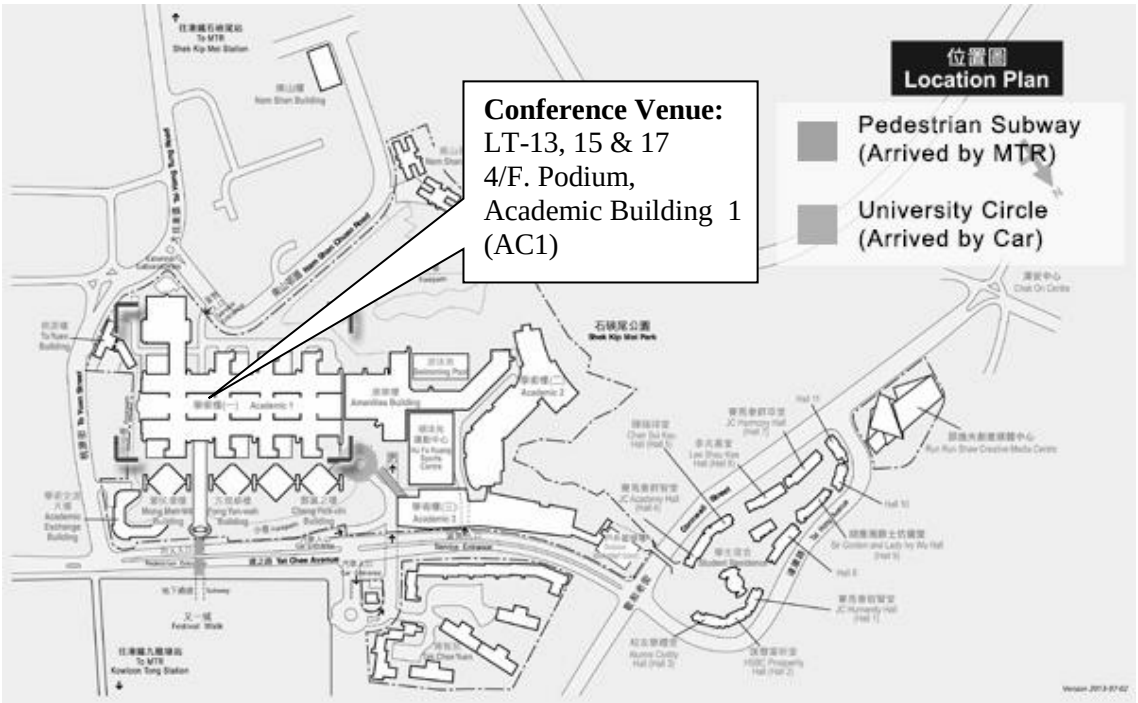
Wednesday, January 7, 2015 – SHANGHAI MIN

The conference banquet will be held at Shanghai Min in Tsim Sha Tsui, Kowloon. Shanghai Min is originated and developed in Shanghai. You will savor the endless flavors of Shanghai cuisine there. Also, you will enjoy one of "A Symphony of Lights" the nightly multimedia show, which involves more than 40 buildings on both sides of the harbour.

The cost is HK$700 per person (the cost is included in the regular registration fee). Please go to the Registration Desk for more information.

CONFERENCE VENUE DIRECTION:

Venue: **Lecture Theatre 13, 15 & 17**
4/F. Podium, Academic Building 1,
City University of Hong Kong



City University is located near the Kowloon-Tong Mass Transit Railway (MTR) station and can be easily accessed via the #3M entrance of the Academic Building by the following transportation means:

- MTR
- Taxis

Arrived at Pedestrian Subway

1. Take MTR East Rail Line or MTR Kwun Tong Line to "Kowloon Tong" station.
2. Exit at "Festival Walk" Exit C2
3. Find **Shop LG1-10,** take the escalator next to it, which bring you to a **pedestrian subway** leading to CityU.
4. Pass through the pedestrian subway, go straight, and enter Academic 1.
5. Turn right and take the escalator to level 4 to the Podium
6. You will find the Signage to Lecture Theatre 13, 15 & 17.

Arrived at University Circle (U-Circle)

1. When you drop off at the University Circle, go along the covered walkway which will lead you to the Academic Building 1.
2. Walk through the red doors, you will be on the 4th floor of Academic Building 1.

PROGRAM SUMMARY

Monday, January 5, 2015			
17:00 – 20:00	**Registration with Welcoming Reception** (LT-15, 4/F Podium, Academic Building 1)		
Tuesday, January 6, 2015			
07:45 – 08:45	**Registration** (LT-15, 4/F Podium, Academic Building 1)		
08:45 – 09:00	**Opening Remarks** (LT-17, 4/F Podium, Academic Building 1)		
09:00 – 10:15	**Session I:** **OLED Device and Materials** (LT-17) *With Plenary Talk by Prof. ADACHI Chihaya*		
10:15 – 10:30	*Tea Break*		
10:30 – 12:00	**Session II:** **Applications of Nano-Materials in Organic Optoelectronics** (LT-17)		
12:00 – 12:15	*Group Photo-Taking*		
12:15 – 13:30	*Lunch (City Top Restaurant, 9/F, Amenities Building)*		
13:30 – 15:30	**Session III A:** **Transistor and Memory** (LT-13)	**13:30 – 15:30**	**Session III B:** **Novel Device and Materials I** (LT-15)
15:30 – 15:45	*Tea Break*		
15:45 – 18:25	**Session IV A:** **OLED Device and Materials II** (LT-13)	**15:45 – 18:25**	**Session IV B:** **Novel Device and Materials II** (LT-15)

Wednesday, January 7, 2015			
09:00 – 10:30	**Session V: Perovskite and Organic Solar Cell I** (LT-17)		
10:30 – 10:45	*Tea Break*		
10:45 – 12:15	**Session VI: OLED and Organic Solar Cell** (LT-17)		
12:15 – 13:30	*Lunch (City Top Restaurant, 9/F, Amenities Building)*		
13:30 – 15:00	**Session VII A: Perovskite and Organic Solar Cell II** (LT-13)	**13:30 – 15:00**	**Session VII B: OPV Device and Materials I** (LT-15)
15:00 – 16:30	**Poster Session**		
16:30 – 18:20	**Session VIII A: OPV Device and Materials II** (LT-13)	**16:30 – 18:20**	**Session VIII B: OPV Device and Materials III** (LT-15)
Thursday, January 8, 2015			
09:00 – 10:15	**Session IX: OPV and OLED** (LT-17) *With Plenary Talk by Prof. FORREST Stephen*		
10:15 – 10:45	*Tea Break*		
10:45 – 12:15	**Session X: Organic Device and Interface** (LT-17)		
12:15 – 13:30	*Lunch (City Top Restaurant, 9/F, Amenities Building)*		
13:30 – 15:30	**Session XI: OLED Device and Materials III** (LT-17)		
15:30 – 15:45	*Tea Break*		
15:45 – 17:15	**Session XII: Novel Device and Materials III** (LT-17)		
17:15 – 17:30	**Closing Ceremony with Best Poster Award Presentation** (LT-17)		

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DETAILS OF TECHNICAL PROGRAM

MONDAY
January 5, 2015

17:00 – 20:00	**Registration** [Venue: LT-15, Academic Building 1]
18:00 – 20:00	**Welcoming Reception** [Venue: LT-15, Academic Building 1]

TUESDAY
January 6, 2015

07:45 **Registration**
[Venue: LT-15, Academic Building 1]

08:45 **Welcome & Opening**
[Venue: LT-17, Academic Building 1]
LU Jian
Vice President (Research & Technology)
City University of Hong Kong, Hong Kong

Session I – OLED Device and Materials I

Venue: LT-17, Academic Building 1

Chairman: CHE Chi-Ming (The University of Hong Kong, Hong Kong)

09:00 1.1 **Nearly 100% electron-photon conversion by using novel strategy of harvesting triplet excitons in organic light emitting devices**
ADACHI Chihaya,
Kyushu University, Japan [Plenary]

09:45 1.2 **Emitting Dipole Orientation of Phosphorescent Dyes in OLEDs**
KIM Kwon-Hyeon, MOON Chang-Ki and KIM Jang Joo,
Seoul University, Korea [Invited]

10:15 BREAK & POSTER VIEWING

Session II – Applications of Nano-Materials in Organic Optoelectronics

Venue: LT-17, Academic Building 1

Chairman: ADACHI Chihaya (Kyushu University, Japan)

10:30 2.1 **Adjusting the work function of inorganic semiconductors and graphene with molecular donors and acceptors**
KOCH Norbert,
Humboldt-Universität zu Berlin, Germany [Invited]

11:00 2.2 **Preparation of high-quality single-crystal graphene and boron nitride and their application in field-effect transistors**
LIU Yunqi,
Institute of Chemistry, CAS, China [Invited]

11:30 2.3 **Relaxed Anion-State in OLED Films Studied by High Sensitivity Photoemission: Electron Injection Supported by Spontaneous Orientation Polarization**
KINJO Hiroumi, LIM Hyunsoo, SATO Hyungun Kim, T., NOGUCHI Y., NAKAYAMA Y., and ISHII Hisao,
Chiba University, Japan [Invited]

12:00 GROUP PHOTO TAKING

12:15 LUNCH *(City Top Restaurant, 9/F, Amenities Building)*

Session III A – Transistor and Memory

Venue: LT-13, Academic Building 1

Chairman: KIM Jang Joo (Seoul University, Korea)

13:30	3.1.1	**Improving performance of photosensitive organic field-effect transistors by device structure innovations** *PENG Yingquan, LV Wenli , YAO Bo, LI Yao, LUO Xiao, SUN Lei, ZHONG Junkang,WANG Ying* Lanzhou University, China
13:50	3.1.2	**Advances in Polymer Semiconductors for Printed Transistors** *ONG Beng S.,* Hong Kong Baptist University, Hong Kong [Invited]
14:20	3.1.3	**Solution-Processed High-k Dielectric and Interface Engineering for Low-Voltage Organic Thin Film Transistors (OTFTs)** *XU Yaorong, XIE Weiguang and XU Jianbin,* The Chinese University of Hong Kong, Hong Kong [Invited]
14:50	3.1.4	**Funtional materials for organic flash memories** *HAN Suting, ZHOU Ye, V.A.L. Roy* City University of Hong Kong, Hong Kong
15:10	3.1.5	**Carbon-based Nonvolatile Memory Devices** *LIU Juqing, HUANG Wei* Nanjing Tech University, China

Session III B – Novel Device and Materials I

Venue: LT-15, Academic Building 1

Chairman: UENO Nobuo (Chiba University, Japan)

13:30	3.2.1	**Multi-Color Emitting Devices** *ZHEN Changgua, WANG Fuzhi, DAN Xiangnan, ZOU Dechun,* Peking University, China [Invited]
14:00	3.2.2	**Research on Interface Modification of White OLED** *WANG Hua, MIAO Yanqing, HAOYuying, SHI Heping, XU Bingshe* Taiyuan University of Technology, China
14:20	3.2.3	**Solution Processed Flexible Nanocomposite Electrode with Efficient Light Extraction for Organic Light Emitting Diodes** *LI Lu, LIANG Jiajie, PEI Qibing* Chongqing University of Art and Science, China
14:40	3.2.4	**Functional Organic Materials for Efficient Solution-Processed Organic Solar Cells Exhibiting High Open-Circuit Voltage** *WONG Raymond Wai-Yeung,* Hong Kong Baptist University, Hong Kong [Invited]
15:10	3.2.5	**UPS and XPS Investigation on Energy Level Alignment at C8-BTBT/Ni (100)** *ZHANG Hong, LYU Lu, LIU Peng, XIE Haipeng, ZHANG Yuhe, NIU Dongmei, GAO Yongli* Central South University, China

15:30	BREAK & POSTER VIEWING

Session IV A – OLED Device and Materials II

Venue: LT-13, Academic Building 1

Chairman: LIU Yunqi (Institute of Chemistry, CAS, China)

15:45 4.1.1 **High efficiency white organic light-emitting diodes using thermally activated delayed fluorescent emitters**

CHO Yong Joo, KIM Bo Seong, YOOK Kyoung Soo and LEE Jun Yeob,

Dankook University, Korea [Invited]

16:15 4.1.2 **Study of red fluorescent OLED utilizing delayed fluorescent exciplex as the host**

LI Wenlian, ZHAO Bo, SU Zisheng, CHU Bei

Changchun Institute of Optics, Fine Mechanics and Physics, CAS, China [Invited]

16:45 4.1.3 **Development of Host and Dopant Materials for Phosphorescent Organic Light-Emitting Diodes**

LI Jiuyan, LI Wei, WANG Feng

Dalian university of technology, China

17:05 4.1.4 **Novel Bipolar Host Materials for Phosphorescent and TADF OLEDs**

LIU Di, WANG Miao, YAO Ruijuan

Dalian University of Technology, China

17:25 4.1.5 **Solution-Processable Hosts Constructed by Carbazole/PO Substituted Tetraphenylsilanes for Efficient Blue Electrophosphorescent Devices**

LIU He, HU Dehua, LU Ping, MA Yuquang

Jilin University, Hong Kong

17:45 4.1.6 **High efficiency OLED based on ultra-thin emission layer**

HE Gufeng, LIU Jun, SHI Xindong

Shanghai Jiao Tong University, China

Session IV B – Novel Device and Materials II

Venue: LT-15, Academic Building 1

Chairman: ISHII Hisao(Chiba University, Japan)

15:45 4.2.1 **Graphene oxide derivatives as interface materials for polymer solar cells**

ZHANG Jian, YANG Dong, ZHOU Lingyu, LI Can

Guilin University of Electronic Technology, China

16:05 4.2.2 **Foldable composite circuit on paper toward stable operation of top-emitting organic light emitting diodes**

JO Sung Min, CHIN Byung Doo,

Dankook University, Korea

16:25 4.2.3 **Interfacial Engineering with Biomolecules for High Performance Organic and Hybrid devices**

NIE Riming, LI Aiyuan, WANG Yangyang, ZHOA Zejia, DENG Xianyu,

Harbin Institute of Technology Shenzhen Graduate School, China

16:45 4.2.4 **High-performance biosensors based on organic thin film transistors**

YAN Feng,

Hong Kong Polytechnic University, Hong Kong [Invited]

17:15 4.2.5 **The smallest (so far) pure-carbon logic operators**

YAN Xiao-Hong, GUO Yan-Dong, XIAO Yang, LIU Chun-Sheng

Nanjing University of Posts and Telecommunications, China

17:35 4.2.6 **Engineering of Materials for Flash Memory and Sensors**

V.A.L. Roy,

City University of Hong Kong, Hong Kong [Invited]

WEDNESDAY
January 7, 2015

Session V – Perovskite and Organic Solar Cell I

Venue: LT-17, Academic Building 1

Chairman: YAM Vivian Wing Wah (The University of Hong Kong, Hong Kong)

09:00 5.1 **Perovskite Solar Cell**
PARK Nam-Gyu,
Sungkyunkwan University, Korea [Invited]

09:30 5.2 **Nickel oxide p-type electrode interlayer in CH3NH3PbI3 perovskite/fullerene planar-heterojunction hybrid solar cells**
JENG Jun-Yuan, CHEN Kuo-Cheng, CHIANG Tsung-Yu, GUO Tzung-Fang, and CHEN Peter
National Cheng Kung University, Taiwan [Invited]

10:00 5.3 **Electrode Buffer Layer Materials for High Performance Polymer Solar Cells**
LI Yongfang,
Institute of Chemistry, CAS, China [Invited]

10:30 BREAK & POSTER VIEWING

Session VI – OLED and Organic Solar Cell

Venue: LT-17, Academic Building 1

Chairman: PARK Nam-Gyu (Sungkyunkwan University, Korea)

10:45 6.1 **Unlocking Full Potential of Conducting Polymers for Highly Efficient OLEDs and Solar Cells**
WU Chung-Chih, HUANG Yi-Hsiang, LU Chun-Yang, LEE Wei-Kai, TSAI Wei-Lung, JIAO Min
National Taiwan University, Taiwan [Invited]

11:15 6.2 **Thermochromism Study of Low Band-Gap Photovoltaic Polymers**
CHEN Chin-Ti,
Institute of Chemistry, Taiwan [Invited]

11:45 6.3 **Functional Molecular Materials – From Design to Functions and Applications**
YAM Vivian Wing Wah,
The University of Hong Kong, Hong Kong [Invited]

12:15 LUNCH *(City Top Restaurant, 9/F, Amenities Building)*

Session VII A – Perovskite and Organic Solar Cell II

Venue: LT-13, Academic Building 1

Chairman: GUO Tzung-Fang (National Cheng Kung University, Taiwan)

13:30 7.1.1 **Morphological Control and Interfacial Modification of Planar Heterojunction Perovskite Solar Cells**
WANG Zhao-Kui, LIAO Liang-Sheng,
Soochow University, China [Invited]

14:00 7.1.2 **Optical Constants Measurements of Organometal Halide Perovskite Thin Films and Their Application in the Solar Cell Structure Design**
LIN Hao-Wu,
National Tsing Hua University, Taiwan

14:20 7.1.3 **Formation chemistry of perovskite and photoconversion mechanism in perovskite/fullerene heterojunctions**
NG Tsz-Wai Karen, LO Ming-Fai, LEE Chun-Sing
City University of Hong Kong, Hong Kong

14:40 7.1.4 **Interface engineering from Organic Solar cells to Perovskite Solar Cells via Incorporation of a Polyelectrolyte Interlayer**
ZHANG Hong, MIN Jie, AMERI Tayebeh, SCHERF Ullrich, BRABEC Christoph J.
Friedrich-Alexander-University Erlangen-Nuremberg, Germany

Session VII B – OPV Device and Materials I

Venue: LT-15, Academic Building 1

Chairman: LI Yongfang (Institute of Chemistry, CAS, China)

13:30 7.2.1 **Efficiency enhancement in inverted organic solar cells using a dual cathode interlayer**
TAM Hoi Lam, CHOI Wing Hong, WANG Xizu, ZHU Furong
Hong Kong Baptist University, Hong Kong

13:50 7.2.2 **Improved Performance of Organic Solar Cells by Incorporation of Coated Gold Nanorods at different positions**
CUI Yanxia, ZHAO Haoyang, TONG Peiqian, SUN Qinju, HAO Yuying, ZHU Furong
Taiyuan University of Technology, China

14:10 7.2.3 **Aggregation and morphology control enables multiple cases of >10% efficiency polymer solar cells**
YAN He,
Hong Kong University of Science and Technology, Hong Kong

14:30 7.2.4 **Light Manipulation for Organic Optoelectronics Using Micro/Nanostructures**
TANG Jianxin,
Soochow University, China [Invited]

15:00 POSTER SESSION

Session VIII A – OPV Device and Materials II

Venue: LT-13, Academic Building 1

Chairman: WU Chung-Chih (National Taiwan University, Taiwan)

16:30	8.1.1	**Effect of film drying condition on performance of polymer solar cells for bis-PCBM/P3HT** *MASARU Nagai, HUANG Wei, YOSHIDA Yuji* Nanjing Tech University, China
16:50	8.1.2	**Efficiency enhancement in inverted organic solar cells using a dual cathode interlayer** *WU Bo, WU Zhenghui, LAM Tam Hoi, ZHU Furong, NG Tsz-Wai, LEE Chun-Sing* Hong Kong Baptist University, Hong Kong
17:10	8.1.3	**Printing Fabrication and Interface Materials for Solution-Processed Organic Photovoltaics** *YANG Junliang, XIONG Jian, HU Qiao, GAO Yongli* Central South University, China
17:30	8.1.4	**Interface Engineering and Morphology Control for High Performance Perovskite/Fullerene Planar Heterojunction Solar Cells** *YIP Hin-Lap Angus, XUE Qifan, CHEN Sun, HU Zhicheng, HUANG Fei, CAO Yong* South China University of Technology, China
17:50	8.1.5	**Improved organic photovoltaics by surface plasmon effect** *HAO Yuying, CUI Yanxia, ZHANG Ye, WANG Wenyan, TIAN Ximin, HAO Yang, ZHU Furong* Taiyuan University of Technology, China [Invited]

18:20	DINNER *(Shanghai Min, Tsim Sha Tsui)*

Session VIII B – OPV Device and Materials III

Venue: LT-15, Academic Building 1

Chairman: CHEN Chin-Ti (Institute of Chemistry, Taiwan)

16:30 8.2.1 **Contrary interfacial exciton dissociation at metal/organic interface in regular and inverted organic solar cells**

WU Bo, WU Zhenghui, YANG Qingyi, LIU Hanxiao, TAM Hoi Lam, ZHU Furong,

Hong Kong Baptist University, Hong Kong [Invited]

17:00 8.2.2 **Photovoltage Loss in Excitonic Solar cells**

TSANG Sai Wing Stephen,

City University of Hong Kong, Hong Kong

17:20 8.2.3 **High-efficiency all-polymer solar cells based on a pair of crystalline low-bandgap polymers**

MU Cheng, LIU Peng, MA Wei, JIANG Kui, ZHAO Jingbo, ZHANG Kai, CHEN Zhihua, WEI Zhanhua, YI Ya, WANG Jiannong, YANG Shihe, HUANG Fei, FACCHETTI Antonio, ADE Harald, YAN He

Hong Kong University of Science and Technology, Hong Kong

17:40 8.2.4 **A Small-MoleculePhenanthroline Derivative as Cathode Interfacial Material for Organic Photovoltaics**

ZHU Xu-Hui,

South China University of Technology, China

18:20 DINNER *(Shanghai Min, Tsim Sha Tsui)*

THURSDAY
January 8, 2015

Session IX – OPV and OLED

Venue: LT-17, Academic Building 1

Chairman: CHEAH Kok-Wai (Hong Kong Baptist University, Hong Kong)

09:00 9.1 **Efficiency and Reliability of Small Molecule Organic Photovoltaics**
FORREST Stephen,
University of Michigan, USA [Plenary]

09:45 9.2 **Structural details and measurements related to organic nanodevice by STM**
WAN Li-Jun,
Institute of Chemistry, CAS, China [Invited]

10:15 BREAK & POSTER VIEWING

Session X – Organic Device and Interface

Venue: LT-17, Academic Building 1

Chairman: FORREST Stephen (University of Michigan, USA)

10:45 10.1 **Interface effects in organic photovoltaics**
BAO Qinye, SANDBERF Oskar, DAGNELUND Daniel, SANDÉN Simon, GAO Feng, BRAUN Slawomir, AARNIO Harri, LIU Xianjie, CHEN Weimin M., ÖSTERBACKA Ronald and FAHLMAN Mats,
Linköping University, Sweden [Invited]

11:15 10.2 **Photocatalytic Reduction of Protons to Hydrogen**
TUNG Chen-Ho, WU Li-Zhu, CHEN Bin, LI Zhi-Jun
Technical Institute of Physics and Chemistry, CAS, China [Invited]

11:45 10.3 **Origin and control of gap states: A striking mobility improvement of C60 OFET**
YANG Jin-Peng, BUSSOLOTTI Fabio, HINDERHOFER Alexander, KERA Satoshi, and UENO Nobuo,
Chiba University, Japan [Invited]

12:15 LUNCH *(City Top Restaurant, 9/F, Amenities Building)*

Session XI – OLED Device and Materials III

Venue: LT-17, Academic Building 1

Chairman: WAN Li-Jun (Institute of Chemistry, CAS, China)

13:30 11.1 **Transition Metal Phosphors and OLED Fabrications**
CHI Yun,
National Tsing Hua University, Taiwan [Invited]

14:00 11.2 **Universal Bipolar Host Materials And Exciplex For White OLEDs**
WONG Ken-Tsung,
National Taiwan University, Taiwan [Invited]

14:30 11.3 **New Schemes for Enhancing the Optical Management and Carrier Transport Properties of Organic Optoelectronic Devices**
CHOY C.H. Wallace
The University of Hong Kong, Hong Kong [Invited]

15:00 11.4 **Reverse Intersystem Crossing from Upper Triplet Levels to Excited Singlet: A "Hot excition" Path for OLEDs**
MA Yuguang,
South China University of Technology, China [Invited]

15:00 BREAK & POSTER VIEWING

Session XII – Novel Device and Materials III

Venue: LT-17, Academic Building 1

Chairman: V.A.L. Roy (City University of Hong Kong, Hong Kong)

15:45 12.1 **Highly Efficient New Emitting Materials Based on Multi-Core Chromophores for Blue Fluorescence OLEDs**
PARK jongwook, LEE Hayoon, KIM Beomjin, KIM Seungho, LEE Jaehyun, SHIN Hwangyu
Catholic University of Korea, Korea [Invited]

16:15 12.2 **Aggregation-Induced Emission**
TANG Benzhong,
Hong Kong University of Science and Technology, Hong Kong [Invited]

16:45 12.3 **Pentacene-Based Organic Transistor Memory Devices with Charge-Storage Floating Gate**
TSENG Chia-Wei, HUANG Ding-Chi, TAO Yu-Tai,
Institute of Chemistry, Academia Sinica,, Taiwan [Invited]

17:15 CLOSING REMARKS & BEST POSTER AWARD PRESENTATION

----- End -----

WEDNESDAY
January 7, 2015

Poster Session

Venue: Outside LT-15, Academic Building 1
Time: 15:00-16:30

P-01 **A-D-A Type Organic Dyes Employing Coplanar Heteroarene for Efficient Small Molecule Organic Solar Cells**
CHUNG Chin-Lung,CHEN Chien-Yu, KANG Hao-Wei, LIN Hao-Wu, WONG Ken-Tsung
National Taiwan University, Taiwan

P-02 **Highly flexible bending deformation in single crystalline diamond nanoneedles for biomedical applications**
BENERJEE Amit, ZHANG Hongti, YUEN Muk Fung, ZHANG Wenjun, LU Yang
City University of Hong Kong, Hong Kong

P-03 **Efficient emitters based on neutral Ir(III) complexes with bis-tridentate chelates**
TONG Bihai, CHI Yun
National Tsing Hua University, Taiwan

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LAI Shiu-Lun, WANG Lin, YANG Chen, CHAN Mei-Yee, GUAN Xiangguo, KWOK Chi-Chung, CHE Chi-Ming
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Abstract of Talks

1.1

Nearly 100% electron-photon conversion by using novel strategy of harvesting triplet excitons in organic light emitting devices

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Keywords: OLED, TADF, Delayed fluorescence, upconversion, FRET

Organic light emitting diodes (OLEDs) have been anticipated to exhibit highly efficient, stable emission aimed for displays and lighting applications. Here, we report the design rules for increasing the electroluminescence efficiency based on thermally activated delayed fluorescence (TADF). We show that a large delocalization of the highest occupied molecular orbital and lowest unoccupied molecular orbital in these charge transfer compounds enhances the rate of radiative decay considerably by inducing a large oscillator strength even when there is a small overlap between the two wavefunctions. Further, through computational simulation, we identified intramolecular charge-transfer (CT) molecules with small singlet-triplet CT state splitting but different energy relationships between 3CT and locally-excited triplet (3LE) states. Systematic comparison of excited-state dynamics revealed that CT molecules can emit efficient and short-lifetime (a few μs) TADF when the emission peak energy is high enough and the 3LE state is higher than the 3CT state. The OLEDs with TADF emitters offer an external quantum efficiency over 20% and reduced efficiency roll-off characteristics at high luminance. Also, we mention the importance of molecular orientation for enhancing light outcoupling efficiency. Some critical molecular design and processing condition will be discussed.

Further, we report fluorescence-based OLEDs that realize external quantum efficiencies as high as 20% for blue, green, yellow, and red emission, indicating that the exciton production efficiency reached nearly 100%. The high performance was enabled by utilization of TADF molecules as assistant dopants that permit efficient transfer of all electrically generated singlet and triplet excitons from the assistant dopants to the fluorescent emitters. OLEDs employing this novel exciton harvesting process provide freedom for the selection of emitters from a wide variety of conventional fluorescent molecules.

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Emitting Dipole Orientation of Phosphorescent Dyes in OLEDs

(1 line spacing)

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(1 line spacing)

Keywords: oreientation, emitting dipoles, phosphorescent dyes, OLEDs**.**

(2 line spacing)

Molecular orientation in organic semiconductor is an important factor influencing electrical and optical properties. In organic light emitting diodes (OLEDs), it has long been recognised that orienting the transition dipole moment of an emitter along the horizontal direction (parallel to the substrate) can enhance the outcoupling efficiency beyond that achieved under isotropic orientation, as demonstrated in polymer-based and vacuum evaporated fluorescent molecule-based OLEDs. Nonetheless, the orientation of the transition dipole moments of iridium complexes used as phosphorescent emitters in efficient OLEDs is typically considered to be isotropic because they are near-globular and small enough to have configurational diversity in their orientational states. Therefore, it is believed that the theoretical EQE limit of phosphorescent OLEDs is 25~30%. Recently, however, some heteroleptic iridium complexes (HICs) have been reported to have transition dipole moments oriented preferentially along the horizontal direction. The outcoupling efficiency of the emitted light from the horizontally oriented emit-ting dipoles in an OLED can reach 45% which is much higher than isotropically oriented transition dipoles. Unfortunately, the origin of the preferred orientation of some phosphorescent dyes and factors influencing the orientation of the transition dipole moments is not fully understood yet.

In this talk, we will firstly present the influence of the molecular structure of iridium complexes and host materials on the orientation of the TDM in organic semiconductor layers in phosphorescent dye doped organic layers. Secondly we will show through quantum chemical calculations that the heteroleptic structure and the strong intermolecular interactions between HICs and their host molecules lead to preferred dipole orientations in the HICs.

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(4) Chang-Ki Moon, et al., submitted (2014)

2.1

Adjusting the work function of inorganic semiconductors and graphene with molecular donors and acceptors

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Keywords: semiconductors; graphene; interface electronic structure; work function**.**

Hybrid heterostructures of inorganic and organic semiconductors offer new possibilities for obtaining enhanced functionality by combining the advantageous properties of the individual components, e.g., towards efficient interfacial energy and charge transfer. To optimize the energy levels at a given hybrid heterojunction one must have means to move the frontier energy levels without compromising the targeted function. It will be shown how this can be achieved with either dipolar self-assembled monolayers or strong molecular donors and acceptors as interlayers. The underlying mechanism is based on modifying the inorganic semiconductor surface work function by the interlayer, which leads to concomitant energy shifts of the organic semiconductor deposited on top. However, the details of the charge density rearrangement due to interlayers, which results in a changed work function, depend strongly on the doping level of the inorganic component.

A similar strategy, i.e., the use of strong molecular donors and acceptors, can be followed to modify the work function of graphene, e.g., in order to optimize its use as electrode material for charge injection in devices. The nature of charge transfer between molecules and graphene is very different from that of inorganic semiconductors. Moreover, the material that serves as solid support for a graphene layer (e.g., glass versus metal) strongly impacts the charge density rearrangement and the electronic structure of graphene itself. This is demonstrated through a combined experimental and theoretical approach.

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Preparation of high-quality single-crystal graphene and boron nitride and their application in field-effect transistors

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Keywords: preparation, graphene, boron nitride, field-effect transistor

Chemical vapor deposition (CVD) is widely used in the synthesis of graphene. In this method, the graphene samples grown on metals need to be transferred onto insulating materials for use in electronic devices, which results in loss of material, and furthermore it is difficult to avoid corrugation, contamination, and breakage of the graphene samples. The direct metal-catalyst-free growth of graphene on insulating substrates is thus important to the development of graphene nano-electronics.[1,2]

Recently, we demonstrated that regular micrometer-size high-quality single domain graphene can be directly grown on various dielectric substrates via a small-carbon-flow near-equilibrium CVD process.[3] The near-equilibrium CVD method allows C adatoms to reach the optional positions at the edge of graphene sheets with minimum energy to form stable crystalline phases with regular hexagonal and dodecagonal patterns. The maximum size of the graphene grains is about 11 μm, which is a factor of ~30 times larger than those previously reported on boron nitride (BN) substrates. The graphene grains show high crystalline quality with clean, wrinkle-free and breakage-free morphology, and a carrier mobility of greater than 5000 $cm^2 V^{-1} s^{-1}$.

We also report for the first time that by using a system of h-BN growth on Cu surface under low-pressure CVD conditions,[4] the nucleation density of h-BN can be significantly modulated in a large range, resulting in an effective control of h-BN grain sizes. These h-BN grains are single-layered, single crystals with a triangular shape, and the size can reach up to ca. 20 μm, 4–5 times larger than that in previously achieved results. We further discovered that h-BN grains can be directly visualized by optical microscopy by oxidizing Cu surface in air. Finally, we demonstrated that the oxidation of h-BN film at high temperatures in air can effectively clean monolayer h-BN film interface, leading to reliable and much enhanced graphene mobility.

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2.3

Relaxed Anion-State in OLED Films Studied by High Sensitivity Photoemission: Electron Injection Supported by Spontaneous Orientation Polarization

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Keywords: High-Sensitivity Photoelectron Spectroscopy, Photoelectron Yield Spectroscopy, Negative Ion Photoelectron Spectroscopy, Alq_3, Orientation Polarization

Organic EL materials often show spontaneous orientation polarization in evaporated films with giant surface potential (GSP)[1]. This polarization induces positive and negative fixed charges on both ends of the polarized layer, leading to interface charges at organic/organic and organic/electrode interfaces in organic light-emitting devices. These interface charges often attract and repel carriers, and significantly affects the device performance. In this study, by focusing on Alq_3-based OLED, the impact of orientation polarization was investigated from the viewpoints of carrier behavior and electronic structures.

Displacement current measurement (DCM) was performed for ITO/α-NPD/Alq_3/Al and ITO/α-NPD/Al(7-prq)$_3$/Ca devices. Al(7-prq)$_3$ is a derivative of Alq_3; the position 7 is replaced by propyl group. These two molecules show opposite polarity of polarization; the cathode side of Alq_3 has positive interface charge, but negative for Al(7-prq)$_3$. DCM results suggested that positive interface charge near the cathode can support electron injection, while negative charge increases the resistance [2]. This trend was also supported by photoemission experiments as below.

By using high-sensitivity photoelectron spectroscopy (HS-PES) and photoelectron yield spectroscopy (PYS), we have found unusual photoemission from films of Alq_3 with GSP. Even if the photon energy is smaller than their ionization energy, photoelectrons are clearly observed. As shown in Fig.1, the ionization energy of Alq_3 is about 5.6eV, but we observed that PYS spectrum has a threshold around 2.8eV, and HS-PES measurement indicates the existence of some state 2eV above the Fermi level of the substrate. On the other hand, for Al(7-prq)$_3$, the unusual photoemission was not observed. Due to the opposite polarity of polarization, anion and cation are expected to be accumulated at the surfaces of Alq_3 and Al(7-prq)$_3$, respectively. From these results, we suggest that the observed unusual photoemission is ascribed to photoemission from negative carriers that are captured only for the surface of Alq_3 film. Usually electron affinity has been observed by inverse photoemission spectroscopy (IPES), in which radiation damage and poor energy resolution are serious problems. Our finding can be extended to develop as a method to determine electron affinity of various organic EL materials with high resolution and less damage. The electron affinity obtained in this work seems larger than that reported by IPES, suggesting the positive interface charge near the cathode effectively stabilizes the anion states, leading to the reduction of electron injection barrier. Therefore, the control of orientation polarization and GSP of organic semiconductors is essential to improve the performance of OLEDs.

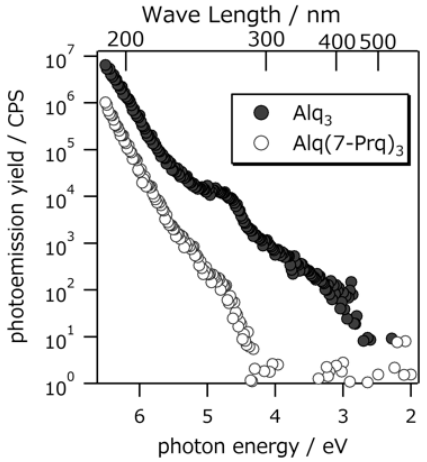

Fig.1 PYS of Alq_3 and Al(7-Prq)$_3$ films

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Improving performance of photosensitive organic field-effect transistors by device structure innovations

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Keywords: structure innovation; photosensitive; organic field-effect transistor; photoresponsivity**.**

Structure innovation is an important way to improve device performances. We demonstrate that by utilizing buffer layer under source / drain electrodes or hybrid planar-bulk heterojunction the performance of photosensitive organic field-effect transistors (photOFETs) could be significantly improved. We fabricated characterized top-contact pentacene photOFETs with C60 buffer layer under Au source/drain (S/D) electrodes (shown in Fig. 1(a)). It showed an improvement of 125% for mobility, and 600% for photoresponsivity at zero gate voltage compared with that of the device without buffer layer, which is already higher than the most recent reports on the photoresponsivities of pentacene photOFETs [1, 2].

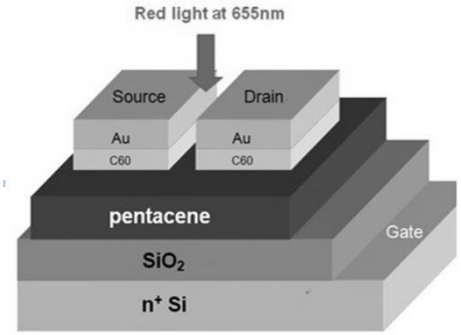

FIG. 1. Structure of pentacene OPTs with C60 electrode buffer layer

We fabricated a high performance photOFET structure of hybrid shown in Fig. 2(a), copper

and lead concluded that the showed superior other structures, nm, the photOFET photoresponsivity efficiency of photosensitivity of

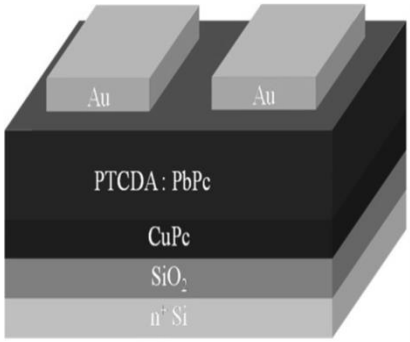

FIG. 1.(a) structure of hybrid planar-bulk heterojunction; (b) Measured dependence of drain current in the dark and photocurrent on the thickness of PbPc:PTCDA layer for HPBHJ devices

operating in NIR region with a planar-bulk heterojunction (HPBHJ), as where CuPc, PTCDA and PbPc, denote phthalocyanine, 3,4,9,10-perylenetetracarboxylic dianhydride phthalocyanine, respectively. It is photOFET with HPBHJ structure performance compared to that with and for NIR light of wavelength 808 with HPBHJ structure exhibited a large of 322 mA/W, a high external quantum around 50%, and a maximal 9.4×10^{2}.

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3.1.2

Advances in Polymer Semiconductors for Printed Transistors

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Printed electronics offers excellent opportunities for creating novel low-cost, large-area, lightweight and flexible electronics. To realize this technology vision, manufacture of semiconductor devices by high-throughput roll-to-roll printing, instead of traditional batch-wise photolithographic processes, would be paramount. Printed electronics is innovative, potentially low-cost and eco-friendlier in manufacturing, and enables inspiring device architectural design. Foremost among critical enablers to propel this paradigm shift in manufacturing is a stable, solution-processed semiconductor for fabricating functionally capable transistors. This presentation discusses the challenges and advances in semiconductor development for printed transistors over the last decade and the outlook for this emerging technology moving forward. Special emphasis will be devoted to recent advances in ambient stable, solution-processed polymer semiconductors with high field-effect mobility, together with excellent device shelf-life and operational stability characteristics.

Solution-Processed High-k Dielectric and Interface Engineering for Low-Voltage Organic Thin Film Transistors (OTFTs)

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Keywords: high-*k*, solution processed, low voltage, OTFTs, interface engineering, flexible

Albeit huge progress has been made in improving the performance of organic thin film transistors (OTFTs), the high operation voltage resulting from the low gate dielectric of traditional SiO_2 remains a severe limitation that impedes OTFTs' development for practical applications. In this aspect, to develop new high-k gate dielectrics at low cost is of great scientific and technological importance in both academia and industry. Here, we report on a facile solution-based technique to fabricate high-*k* metal oxide dielectric system (ATO) at low-temperature, which can be used effectively to realize low-voltage operation of OTFTs. On the other hand, it is well known that the properties of the dielectric/active channel and electrode/active channel interfaces are critical in controlling the electrical properties of OTFTs. By optimizing the above two interfaces with octadecylphosphonic acid (ODPA) self-assembled monolayer (SAM) and properly modifying low-cost Cu, improved device performance is unequivocally attained among our low-voltage OTFTs. Moreover, organic electronic devices on flexible substrates have attracted much attention due to their low-cost, roll-to-roll capability, large-area processability, and so on. With the preceding techniques mentioned, good electrical characteristics of OTFTs are achieved on flexible substrates. Our work demonstrates an effective way to realize low-voltage, high-performance OTFTs at low-cost.

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3.1.4

Funtional materials for organic flash memories

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Keywords: printed electronics, flash memory, floating gate, organic semiconductor, transistors

The next-generation electronic systems are expected to be light, flexible and portable for applications in large area displays, integrated circuits (ICs), organic light emitting diodes (OLEDs), radio frequency identification (RFID) tags, solar cells and so on. Memory is an essential part of advanced electronic systems for data processing, storage and communication. Among many types of memories such as ferroelectric, electret, resistive and floating gate, nano-floating gate flash memory devices have gained a great deal of attention due to the simple device structure, non-destructive read-out and controlled trap capacity. In this presentation, we will demonstrate recent works based on solution processable or printable materials for organic flash memories.

Carbon-based Nonvolatile Memory Devices

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Keywords: Carbon materials, Graphene, Carbon Nanotube, Conducting films, Memory devices**.**

Low-dimensional carbon materials, such as graphene, carbon nanotubes (CNTs), fullerene, and their derivatives, have attracted great attention in future electronics due to their unique electrical properties. Herein, a series of memory electronic devices based on low-dimensional carbon materials, mainly including all-reduced graphene oxide (rGO) memory and all-carbon fiber-based memory [1,2], will being demonstrated. In the all-rGO memory device [1], both of top and bottom electrodes are made of highly reduced GO (hrGO) films by high-temperature annealing of GO film, and the active material is made of lightly reduced GO (lrGO) by low-temperature annealing of GO film. The diode exhibits a nonvolatile WORM memory effect. In the all-carbon fiber memory, aligned multi-walled carbon nanotube (MWCNT) fibers as conducting electrodes are coated by a thin layer of GO as active layer. By simply cross-stacking two MWCNT@GO fibers, the fabricated memory cell also shows WORM effect. The novel structure of MWCNT@GO fibers and facile device fabrication process enable these memory cells promising for future smart e-textile applications. In particular, our all-rGO component and full-solution process enable a low-cost, environment-friendly, and mass-production of devices. Furthermore, highly conductive rGO films as electrodes were introduced in flexible polymer memory diodes, e. g., bulk heterojunction polymer memories and MoS_2-based polymer memories using rGO electrodes exhibit WORM and Flash memory effect, respectively [3,4]. Our study paves a way of employing low-dimensional carbon materials as both electrical bistable materials and conductive materials for future data storage.

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3.2.1

Multi-Color Emitting Devices

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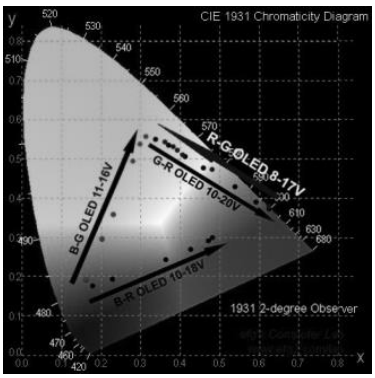
Keywords: Electroluminescence, Electrochemiluminescence, Emitting device, Multi-color



The color of an emitting device is basically determined by the emitting centers. In an OLED, the emitting centers are the emissive molecules which exist in the carrier recombination zone and have the narrowest band gap (Eg). Generally, once the emitting device was fabricated, the carrier recombination zone was fixed, so we can get only one color from one emitting device. If different color is needed, the emissive molecules must be changed; this can be done by fabricating a device with different emissive molecules. For example, in a traditional RGB displays, one display pixel composes of multiple emitting points, each of which emits one basic color. But this makes the panel structure and the fabricating process be very complicated. In this talk, we introduce a new type of multi-color emitting devices, in which different colors can be emitted from the same device point.

We found that by a proper combination of electroluminescent layers and solid-state electrochemiluminescent layers and electrodes, the injection and transportation of carriers can be dynamically controlled, and thus the carrier recombination zone is controllable. **Fig. 1** is a typical two-color emitting device structure and **Fig. 2** shows the emitted spectrum under different bias. By changing the polarity or the magnitude of driving bias, the carrier recombination zone can be switched to different layer in the device; we can also change the emission proportion between different layers as shown above.

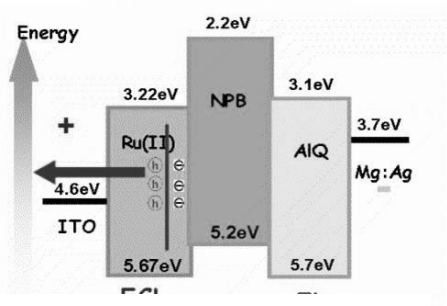


Figure 1. A typical two-color emitting device structure

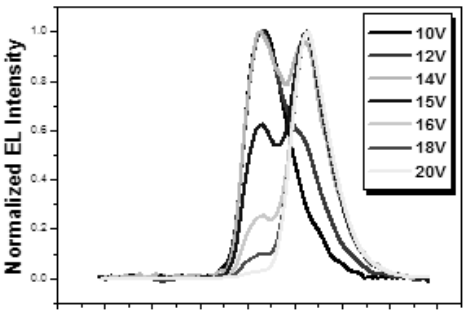


Figure 2. The emission spectra under different bias Magnitude

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Research on Interface Modification of White OLED

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Keywords: White, OLED, Interface

White OLED has acquired great attention due to unique properties, e.g. thin, light, flexible, energy saving, which had been utilized as backlight of LCD display and indoor illumination. But, the device performance of white OLEDs is rather poorer relative to LED, especially in device lifetime and color stability, which hold back utilization progress of white OLED. In our early work [1-5], it has been identified that the existence of plenty of interface in white OLED induce in degradation of device performance. The interface is usually unstable in chemical and physical properties, owing to different material structure or molecular structure in both sides of interface. Hence, it is demonstrated by our group that optimization and modification of interface structure can improve device performance. In our work, white-light phosphorescence polymers with hyperbranced structure were designed and synthesized, which can be utilized in white OLED with single emission layer for decreasing multilayers interface; homogeneous interface of AlQ_3 were modified by SiO_2 coating for avoiding invasion of moisture and oxygen, resulting in prolonging device lifetime; ultra-high color stable three color fluorescent-phosphorescent hybrid white OLED was designed and fabricated by lowering heterogeneous interface number in emitting layers, which exhibit ideal CCTs around 3810 K and stable CIE coordinates of (0.40, 0.41) with high CRI of 85-86 upon variation in brightness from 100 to 5000 cd/m^2 (as shown in the). In one word, it is suggested that interface research is very important for enhancing performance of white OLED.

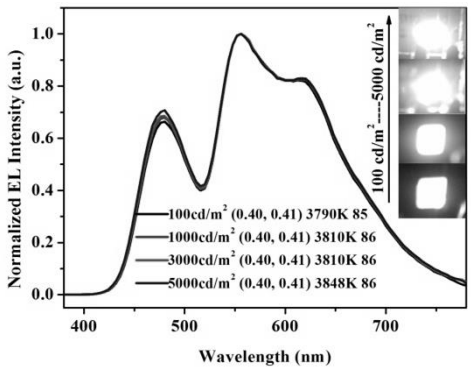

Fig. 1 The EL spectra of the hybrid WOLED at different luminance

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3.2.3

Solution Processed Flexible Nanocomposite Electrode with Efficient Light Extraction for Organic Light Emitting Diodes

(1 line spacing)

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(1 line spacing)

Keywords: Flexible organic light-emitting diodes, solution process, nanocomposite, light extraction

(2 line spacing)

The application of organic LEDs (OLEDs) to reduce the energy consumption for lighting and display has attracted tremendous interest in academic research and technology development. The nearly quantum yield of electron-to-photon conversion efficiency in OLEDs has been largely un-utilized as the external quantum efficiency are limited to 20% due to light trapping in the sandwich device structure. Flexible and solution-processed OLEDs have even worse performance. Here we report a solution-processed flexible nanocomposite electrode with efficient light extraction. The nanocomposite comprises a bilayer stack of carbon nanotubes and silver nanowires inlaid in the surface of a nanoparticle-polymer composite membrane. The nanocomposite is designed to exhibit high surface conductivity, low surface roughness, and high light extraction efficiency. Flexible polymer OLEDs based on the nanocomposite substrate exhibit external quantum efficiency as high as 38.9%, which is significantly higher than the reported highest efficiency for any OLEDs without the use of an external light collection structure, including small molecule OLEDs comprising multiple layers of vacuum-deposited organic compounds to increase the internal quantum efficiency to unity. The viewing angle of the PLEDs is also improved such that the emission color from the 90 degree angle is identical to the normal angle.

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Functional Organic Materials for Efficient Solution-Processed Organic Solar Cells Exhibiting High Open-Circuit Voltage

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Keywords: Organic photovoltaics, Open-circuit voltage, 2D-conjugated molecules, Donor-acceptor molecules

Organic solar cells (OSCs) have drawn great interest over the past decade since they possess unique advantages such as low cost, light-weight and good mechanical flexibility. To date, the power conversion efficiency (PCE) of polymer-based OSCs has exceeded 10%. Meanwhile, solution-processed small molecule bulk heterojunction OSCs are emerging as a competitive alternative to their polymer counterparts. Compared to polymers, small molecular semiconductors possess the intrinsic advantages of well-defined structure, good synthetic reproducibility, alleviated batch-to-batch variation and easier band structure control. Much effort is still required to develop new materials and understand the relationship between chemical structures of the materials and device performance factors such as open-circuit voltage (V_{oc}), short-circuit current (J_{sc}) and fill factor (FF). Here, various approaches towards developing 1D- or 2D-conjugated organic molecules as electron donor materials (Fig. 1) for OSCs exhibiting high V_{oc} are described.

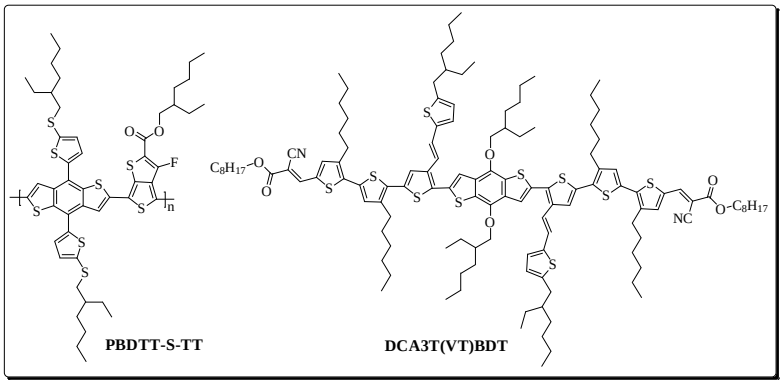

Fig. 1 Chemical structures of new 2D-conjugated molecules

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3.2.5

UPS and XPS Investigation on Energy Level Alignment at C8-BTBT/Ni (100)

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Key Words: C8-BTBT, HOMO, work function, XPS, UPS

C8-BTBT (2,7-dioctyl[1]benzothieno[3,2-b][1]benzothiophene) has been widely used in various organic field-effect transistor devices as a high carrier mobility and good transparency organic semiconductor. Ultraviolet photoelectron spectroscopy (UPS) and X-ray photoelectron spectroscopy (XPS) are used to study the effect of the film thickness of C8-BTBT on the energy level alignment of C8-BTBT / Ni (100). It is found that the highest occupied molecular orbital level and the work function decrease from -1.37 eV and 4.60 eV to -2.52 eV and 3.60 eV respectively with the film thickness increasing from 1Å to 100Å, which indicates that the C8-BTBT semiconductor thin films change from p-type to n-type. This work may account for the disagreement with types of C8-BTBT by different research groups and provide a new method to manipulate the types of organic semiconductor. The XPS indicates the peak of Ni disappears at 32 Å and the ratio of C/S increases from 11:1 up to 15:1 with the increasing thickness, which calls for further investigation.

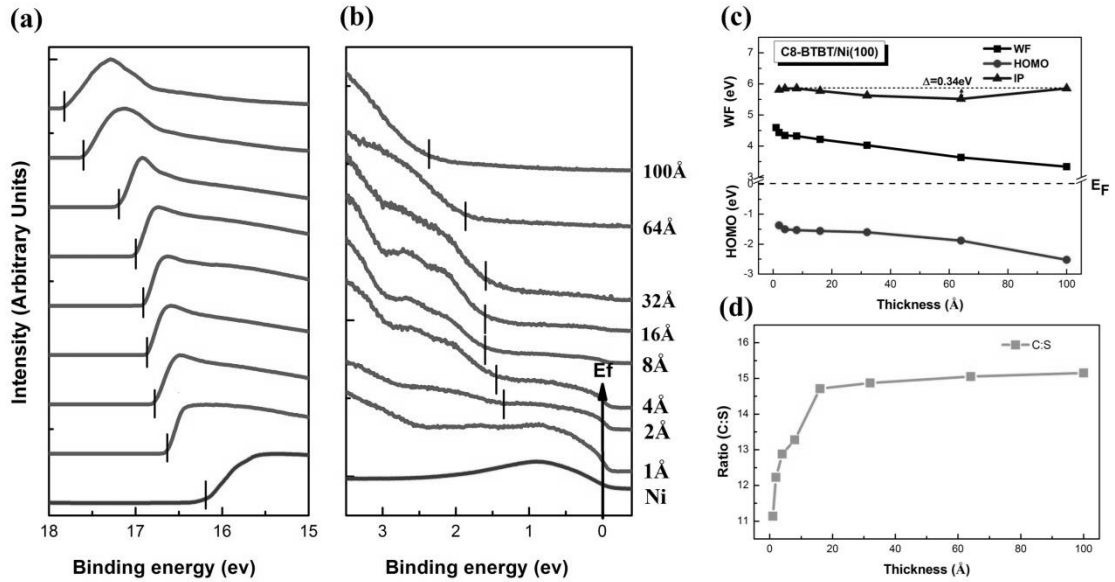

Fig. 1 Evolution of the cutoff (a) and the HOMO region (b) of the UPS spectra as C8-BTBT is deposited on Ni (100). The ionization potential (c) and the ratio of C/S (d) as a function of C8-BTBT layer thickness.

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High efficiency white organic light-emitting diodes using thermally activated delayed fluorescent emitters

(1 line spacing)

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(1 line spacing)

Keywords: high efficiency, thermally activated delayed fluorescence, white device, blue device,**.**

(2 line spacing)

Thermally activated delayed fluorescent devices have been actively developed for the last couple of years because of the merit of high efficiency of the thermally activated delayed fluorescent emitters. High efficiency close to 30% has been already demonstrated by optimizing the host materials and device structure of the thermally activated delayed fluorescent devices. Therefore, the thermally activated delayed fluorescent devices can catch up with state of the art phosphorescent organic light-emitting diodes in terms of external quantum efficiency. The high quantum efficiency of the thermally activated delayed fluorescent device can diversify the application and high efficiency white organic light-emitting diodes can be fabricated using the thermally activated delayed fluorescent emitters because the thermally activated delayed fluorescent emitters are compatible with phosphorescent emitters.

In this work, we developed white organic light emitting diodes by combining a thermally activated delayed fluorescent emitter with phosphorescent emitters. Various device structure containing both the thermally activated delayed fluorescent emitters and phosphorescent emitters were designed to optimize the device performances of the white organic light-emitting diodes. High quantum efficiency above 20% was demonstrated using the newly developed blue thermally activated delayed fluorescent emitter in the cool and warm white devices.

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4.1.2

Study of red fluorescent OLED utilizing delayed fluorescent exciplex as the host

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Keywords: DCJTB, delayed fluorescence, exciplex, host

In recent years, delayed fluorescent OLEDs have developed a organic EL new research field. Basing such a mechanism T_1 energy could be transferred to S_1 level via efficient RISC. Thus could achieve theoretically 100% S_1 exciton could be used and a new application of RISC based materials is to be used as host of an emitter due to its intrinsic small ΔE_{S-T}.[1,2] In this report we have selected the highly efficient RISC D:A exciplex as the host and traditional fluorescent DCJTB as the red emitter, which differs from a series of phosphorescent OLED by utilizing the exciplex host system.[3-6].

We achieved a pure red OLED its maximal current efficiency, power efficiency and EQE are 22.7 cd A^{-1}, 21.5 lm W^{-1} and 10.15% respectively. Figure 1 depicts the schematic diagram and the supposed energy transfer process from exciplex host to red DCJTB emitter. From Fig.1 we speculated that under elctrical excitation firstly D:A exciplex with a small ΔE_{S-T} was formed and RISC process of the exciplex must firstly was taken place in our DCJTB doped exciplex system. Because S_1 and T_1 levels of DCJTB lie at below exciplex excited states an energy transfer from S_1 of the exciplex to S_1 of DCJTB would be resulted and finally red delayed fluorescence by electron transition from S_1 to S_0 of DCJTB was successfully realized. This EL parameter is the best result based on resemble DCJTB emission spectrum to our best knowledge.

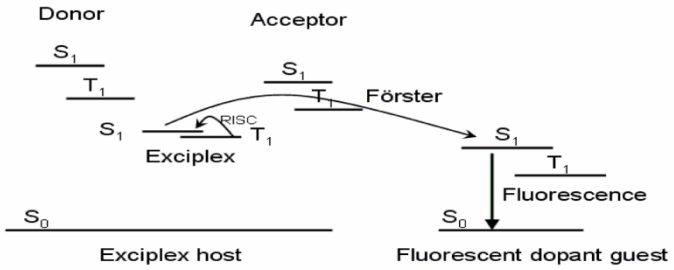

Figure 1 The schematic diagram and supposed energy transfer process from exciplex host to red DCJTB emitter

Acknowledgements
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Development of Host and Dopant Materials for Phosphorescent Organic Light-Emitting Diodes

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Keywords: OLEDs, electrophosphorescence, host materials, iridium phosphors, dopant

Electrophosphorescence is advantageous over the traditional electrofluorescence in terms of emission efficiency since all triplet and singlet excitons generated by charge recombination in phosphorescent organic light-emitting diodes (OLEDs) can be harvested for light emission. Organometallic iridium(III) complexes have been established as the most efficient phosphors for use in OLEDs. In order to avoid emission quenching in neat films, the phosphorescent devices usually adopt host-dopant configuration in the emitting layer. The doped phosphor is typically excited through energy transfer from host or direct charge trapping by dopant. Therefore, both host materials and the iridium phosphors play essential role in determining the overall device performance. In this lecture, both organic host materials and novel iridium complexes developed in author's group in recent years will be reported.

For iridium phosphors, the molecular structures are designed and modified for the purpose of optimizing emission efficiency. It was observed that the decoration of the cyclometalating ligands by fluorine atom (F) and trifluoromethyl groups (CF_3) are effective strategy to improve phosphorescent efficiency of the iridium complexes.[1] Extremely high efficiencies were achieved for both the single color and white OLEDs using those F and CF_3 decorated iridium phosphores as light emitters.[1,2] Furthermore, multi-fluorination of the cyclometalating ligands was demonstrated as a powerful strategy to achieve highly efficient tris-cyclometalated iridium phosphors. A high efficiency of over 90 cd/A was obtained for the green phosphorescent OLEDs at an extremely high brightness of 10000 cd/m^2. In addition, the color-tuning behavior of iridium phosphors was also studied.

The host materials in doped phosphorescent OLEDs not only contribute to the overall device performance, but also determine the fabrication technique. Three types of host materials, i.e., high-triplet-energy hosts, bipolar hosts, and solution processible hosts, will be mainly discussed in this report. To possess as high triplet energy is the prerequisite for the host materials to guarantee the efficient forward energy transfer in phosphorescent OLEDs. How to control the molecular conjugation by adjusting the molecular conformation will be the most import issue to lead to high triplet energies.[3] For bipolar host materials, the selection of appropriate groups as the n-type units still remains as the most important challenge. We have explored various CN-decorated aromatic groups and the triazole and benzotriazole as the ideal n-type units to build up novel bipolar host materials for phosphorescent OLEDs.[4] Solution processing seems to be the most ideal and final device fabrication technique for practical applications due to its easiness and low-cost. A series of carbazole-based dendrimers have been developed as solution processible host materials for use in phosphorescent OLEDs. The influence of the generation of dendrimer hosts to the device performance will be focus of discussion.[5]

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4.1.4

Novel Bipolar Host Materials for Phosphorescent and TADF OLEDs

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Keywords: Organic Light-Emitting Diodes (OLEDs), thermally activated delayed fluorescence (TADF), electrophosphorescence, bipolar host materials

Organic light-emitting diodes (OLEDs) technique is drawing more and more research attentions from both academic and industrial fields due to their promissing applications as new-generation flat-panel display and solid-state lighting source. In order to fulfill the demand of practical applications, the most important issues of OLEDs research for the time being include to further increase the energy conversion efficiency, to improve the device stability, and to reduce the device fabrication cost. Electrophosphorescence is well known for its advantage over the conventional electrofluorescence in terms of emission efficiency since all triplet and singlet excitons generated by charge recombination can be harvested for light emission. In recent years, the thermally activated delayed fluorescence (TADF) phenomenum has emerged as a hot-spot in OLEDs research field.[1] The OLEDs based on TADF emitters are as attractive as electrophosphorescent devices due to their theoretical internal quantum efficiency limit of unity by counting both prompt fluorescence and thermally activated delayed fluorescence via efficient reverse intersystem crossing. However, TADF emitters are superior and have more sustainability since they avoid to use noble rare metals. In both phosphorescent and TADF OLEDs, doping strategy is necessary to avoid unwanted triplet-triplet annihilation quenching. The host matrix is as important as the doped emitter to determine the overall device performance since it occupies the majority of the emitting layer in the OLEDs.[2]

Bipolar host materials have been proved to be capable of balancing charge transportation in the emitting layer and consequently leading to high emission efficiency and suppressing efficiency roll-off.[3] Since the electron transporting mobility of most of the concurrent organic n-type materials or functional groups are lower by two to three orders of magnitude than those of the p-type materials, to select appropriate n-type functional units always remains as one of the challenges to construct ideal bipolar host materials. In this presentation, the author will report the latest progress of designing novel bipolar host materials in the author's group. The focus will be placed on the exploration of various n-type units to construct bipolar molecules. Three types of functional groups have been explored to act as n-type units in bipolar host materials, i.e., cyano-decorated aromatic groups, triazole and benzotriazole, and pyridyl or composite pyridyl with other strong electron-withdrawing groups. All these novel bipolar host materials have been used to fabricate phosphorescent OLEDs with various iridium phosphors as doped emitters and most of them exhibited satisfied electroluminescence performance. And most of them have also been used as host materials for TADF OLEDs with commercial available TADF molecules as emitters, some of which then gave excellent emission efficiency. It was proved that CN-decorated aromatic groups and trizaole and substituted pyridyl are all ideal n-type units for bipolar host materials. In particular, it was observed that benzotriazole, in comparison with triazole, is not a good candidate to build up bipolar molecules since they tend to decompose as shown in mass spectra and OLED study.

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Solution-Processable Hosts Constructed by Carbazole/PO Substituted Tetraphenylsilanes for Efficient Blue Electrophosphorescent Devices

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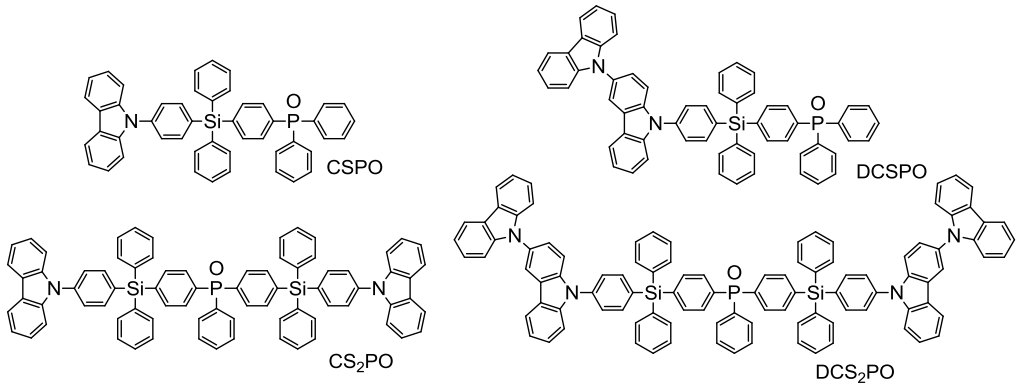
Keywords: wide bandgap, silane, carbazole, phosphine oxide, OLED

Wide bandgap materials that emit violet or ultraviolet light are of great importance since such devices can be used to generate light of all colors, either by energy transfer or by the irradiation of luminescent dyes. [1–3] In recent years, tetra-arylsilane derivatives have emerged as an attractive class of host material, due to their ultrahigh energy gap and high triplet energy level, and some of them have achieved a high quantum effi ciency in host/blue-phosphorescent OLEDs. Here, solution-processable wide bandgap materials, bis(4-((4-(9-Hcarbazol-9-yl)phenyl)diphenylsilyl)phenyl)(phenyl)phosphine oxide (CS_2PO) and bis(4-((4-(9-H-(3,9'-bicarbazol)-9-yl)phenyl)diphenylsilyl)phenyl)(phenyl)phosphine oxide (DCS_2PO), have been developed for blue phosphorescent light-emitting diodes by coupling an electron-donating carbazole moiety and an electron-accepting PO unit via double-silicon bridges. Both of them have been characterized as having high glass transition temperatures of 159–199 °C, good solubility in common organic solvent (20 mg mL^{-1}), wide optical gap (3.37–3.55 eV) and high triplet energy levels (2.97–3.04 eV). As compared with their corresponding single-silicon bridged compounds, this design strategy of extending molecular structure endows CS_2PO and DCS_2PO with higher thermal stability, better solution processability and more stable film morphology without lowering their triplet energies. As a result, DCS_2PO/FIrpic doped blue phosphorescent device fabricated by spin-coating method shows the best electroluminescent performance with a maximum current efficiency of 26.5 cd A^{-1}, a maximum power efficiency of 8.66 lm W^{-1}, and a maximum external quantum efficiency of 13.6%.



Scheme 1. The chemical structures of CSPO, DCSPO, CS_2PO and DCS_2PO.

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4.1.6

High efficiency OLED based on ultra-thin emission layer

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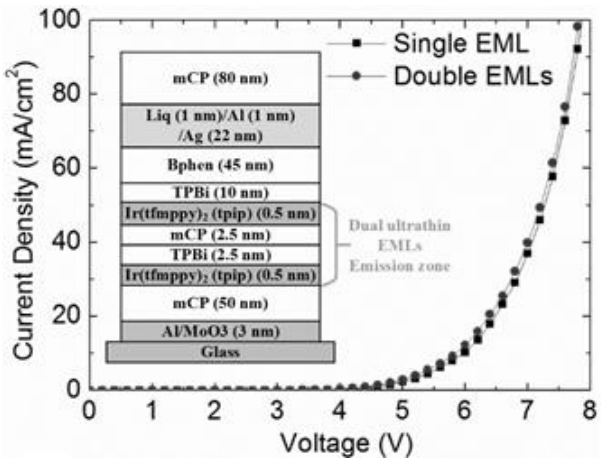
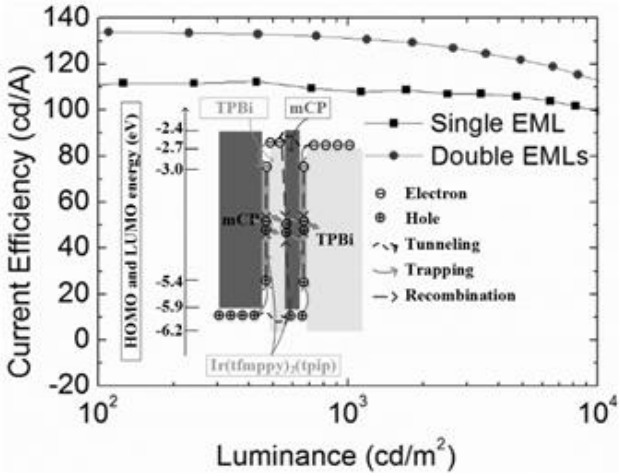
Keywords: ultra-thin, high efficiency, organic light-emitting diodes, inverted, top-emission

Ultrathin non-doped emission layer (EML) has been employed in both inverted and top-emission organic light-emitting diodes (OLEDs). Compared to conventional device, the inverted OLED with 0.5 nm undoped EML exhibits significantly larger external quantum efficiency (EQE), due to effective energy transfer from the excited host to the emitter. According to the atomic force microscopy image of EML, the 0.5 nm emitter sandwiched by two hosts can be considered as the emitter doped in two hosts. The inverted device with intentionally doped ultrathin EML (1.5 nm) exhibits the maximum EQE of 31.1%, which is attributed to optimized charge balance and preferred horizontal orientation of emitter. However, such inverted device has large efficiency roll-off at high brightness because of triplet-triplet annihilation process within the ultrathin EML. This can be improved by broadening the doped EML.

In top-emission OLED, an ultrathin EML can take full advantages of the cavity standing wave condition in a microcavity structure. Much higher out-coupling efficiency has been observed compared to conventional doped EML with relatively wide emission zone. A further investigation on dual ultrathin non-doped EMLs separated by a special bi-layer structure demonstrates better charge carrier balance and improved efficiency. The resulting device exhibits a high efficiency of 125.0 cd/A at a luminance of 1000 cd/m^2 and maintains to 110.9 cd/A at 10,000 cd/m^2.





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4.2.1

Graphene oxide derivatives as interface materials for polymer solar cells

(1 line spacing)

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(1 line spacing)

Keywords: graphene oxide, derivatives, work function, interface material, polymer solar cell**.**

(2 line spacing)

Polymer solar cells (PSCs) represent an exciting class of renewable energy technology, and are under intensive investigation in both academic institutions and industrial companies due to their potential to enable mass production of flexible and cost-effective devices through roll-to-roll techniques. The proper choice of interface materials is a must for highly efficient and stable PSC devices and has become a significant part of the PSC research today. Interface materials are either non-conducting, semiconducting or conducting layers which not only provide selective contacts for carriers of one sort, but can also determine the polarity of PSC devices, affect the open-circuit voltage, and act as optical spacers or protective layers.

Owing to their solution processability, unique two-dimensional structure, and functionalization-induced tunable electronic structures, graphene oxide (GO) and its derivatives have been used as a new class of efficient interface materials in polymer solar cells (PSCs). Highly efficient and stable PSCs have been fabricated with GO and its derivatives as interface materials. In this talk, we will summarize recent progress in this emerging research field. And then present our rational concepts for the design and development of the GO-based interface materials for high performance PSCs.

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Foldable composite circuit on paper toward stable operation of top-emitting organic light emitting diodes

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Keywords: paper, top emission, OLED, foldable.

Foldable and flexible electronics are not only an important but also a promising issue for the convenient transportation and diverse deployment of mobile displays. Composite electrodes with metallic patterns [1] and graphene nanoplate-based circuits prepared on the paper substrate by simple transfer printing [2] showed an unique, small change in conductance under various folding angles, retaining more than 80% of initial conductance. In this paper, improved uniformity and printability of the flexible electrode on the surface of commercial paper substrates are illustrated. Due to the lack of transparency for this paper-based substrate, we have fabricated top-emitting organic light emitting diode (TOLED), where its light emitting behavior and efficiency was investigated in terms of the surface composition of paper and its functionality. In order to realize a foldable and deformable display, printed circuits should be also robust under repeated operation. Therefore, such paper surfaces were planarized by using several polymeric over-coating layers [poly vinyl alcohol (PVA), poly(4-vinylphenol)(PVP), etc.] in order to reduce the roughness as well as provide a good deposition and printing condition for the electrode patterns. Silver electrode was fabricated onto paper either by thermal evaporation or inkjet printing. Complex electrode of silver nanowires and graphene was fabricated onto planarized paper. It was confirmed that stability of electrode at repeated folding test was obtained with a $-180^{o} \sim +180^{o}$ folding angles, showing the possibility of its application as a foldable electrode. We have investigated the improvement of conductance of graphene electrode by the addition of silver nanowires. Top emitting OLED was prepared by thermal evaporation on paper, with Al/ molybdenum oxide (MoO3)/ N,N-di(naphthalene-1-yl)-N,N-diphenyl-benzidine(NPB)/ Tris-(8-hydroxy-quinoline)aluminum (Alq3) / LiF/ Al/ Ag. OLEDs with evaporated silver, printed Ag interconnecting circuit, and graphene composite electrode were characterized in terms of the condition of modified paper surface and corresponding circuits. Our approach will be a facile and cost-effective strategy for foldable and flexible OLEDs toward application such as disposable electronics and digital signages.

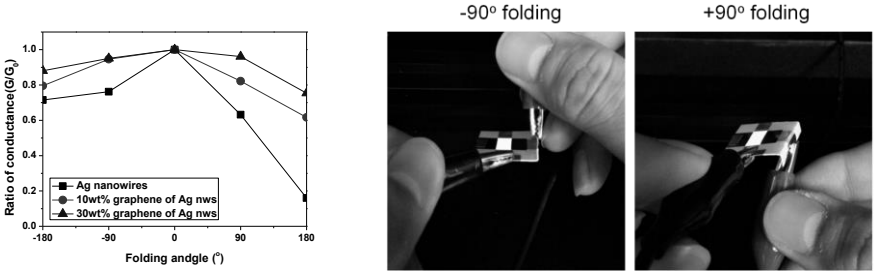

Fig 1. Ratio of conductance vs. folding angles of interconnecting electrode, and image of top emitting OLED at folded substrate

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4.2.3

Interfacial Engineering with Biomolecules for High Performance Organic and Hybrid devices

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Keywords: Organic Electronics, Hybrid Electronics, Interfaces, Biomaterials, Metal Oxides

Biomolecules of amino acids and peptides act as an ideal interfacial material on the surface of metal oxides, such as indium tin oxide (ITO) and titanium dioxide (TiO_2). Work function of these modified surfaces shows an effective reduction to promote electron transfer at organic/metal oxide interfaces in organic or organic-inorganic hybrid devices. These lead to a significant enhancement on performance for various organic based devices, including organic light-emitting diodes, solar cells and photodetectors.

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High-performance biosensors based on organic thin film transistors

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Keywords: Organic thin film transistor, biosensor, cell, DNA**.**

Solution-gated organic thin film transistors have shown promising applications in biosensors due to the high sensitivity, low working voltage and the simple design of the devices. Solution-gated transistors normal have no gate dielectric and the gate voltages are applied directly on the solid/electrolyte interfaces or electric double layers near the channel and the gate, which lead to very low working voltages (about 1 V) of the transistors. On the other hand, the devices can be easily prepared by solution process or other convenient methods because of the much simpler device structure compared with that of a conventional field effect transistor with several layers. Many biosensors can be developed based on the detection of potential changes across solid/electrolyte interfaces induced by electrochemical reactions or interactions. The devices normally can show high sensitivity due to the inherent amplification function of the transistors. Here, I will introduce several types of biosensors studied by our group recently, including DNA[1], glucose[2], dopamine, uric acid, cell[3], and bacteria sensors, based on solution-gated organic electrochemical transistors or graphene transistors[4]. The biosensors show high sensitivity and selectivity when the devices are modified with functional nano-materials (e.g. graphene, Pt nanoparticles) and biomaterials (e.g. enzyme, antibody, DNA) on the gate electrodes or the channel. Furthermore, the devices are miniaturized successfully for the applications as sensing arrays. It is expected that the solution-gated transistors will find more important applications in the future..

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4.2.5

The smallest (so far) pure-carbon logic operators

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Keywords: molecular device; electronic transport; pure-carbon device; logic operator

The pure-carbon nanoscale device is a promising research area in the next-generation nano devices. Recently, the pure-carbon structures of graphene(benzene)–chain–graphene(benzene) have been synthesized experimentally. Based on first-principles calculation, we investigate the electronic transport properties of such two–one–two dimensional carbon systems. Switching behavior induced by conformational changes is observed, even for the systems with curved and quite long carbon chains. The spatial asymmetry of transmission channels between one- and two-dimensional carbon structures is found to be the physical mechanism behind this behavior, and it can be extended to metal systems. It is also found that the orientation of a transmission channel is able to be rotated by a nanotube (or curved graphene) through the non-planar *p*-conjugated orbitals to modulate the switching behavior. Based on these structures, a kind of extremely-small pure-carbon logic operators and some other devices are proposed. As atomic motion could process information directly, the switching behavior and those devices show great application potential in nanomechanics.

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Engineering of Materials for Flash Memory and Sensors

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Keywords: Flash memory, Floating gate and TFT sensors**.**

The next-generation electronic systems are expected to be light, flexible and portable for applications in large area displays, integrated circuits (ICs), radio frequency identification (RFID) tags, solar cells and so on. Memory is an essential part of advanced electronic systems for data processing, storage and communication. Among many types of memories such as ferroelectric, electret, resistive and floating gate, nano-floating gate flash memory devices have gained a great deal of attention due to the simple device structure, non-destructive read-out and controlled trap capacity. In this presentation, we will explain our recent work on non-volatile flash memories and its prototypes. In addition, we discuss on CMOS based sensors for the sensitive and selective detection of bio-genic amines for food safety.

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Perovskite Solar Cell

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Keywords: organolead halide, perovskite, solar cell, high efficiency, size control

Perovskite solar cell based on organo lead halide light harvester is an emerging photovoltaic technology due to extremely low cost and superb photovoltaic performance. In this talk, fundamentals and technologies for high efficiency perovskite solar cells are discussed. Since the first report on a long-term durable perovskite solar cell with a poer conversion (PCE) of 9.7% in 2012, researches on perovskite solar cells are triggered. As a result PCE approaches 20% in 2014. $CH_3NH_3PbI_3$ (MALI) and $HC(NH_2)_2PbI_3$ (FALI) are typical materials for high efficiency perovskite solar cells. Due to the unbalanced diffusion length between free electrons and holes, mesoporous TiO_2 layer is found to extend diffusion of electrons in both MALI and FALI. However, difference in electron mobility between TiO_2 and perovskite may lead to poor charge collection. ZnO nanorod is found to be better than TiO_2 in terms of electron collection. Photovoltaic parameters depend significantly on perovskite crystal size. Large size is beneficial to charge extraction and dipole relaxation. Morphology and size are critical in achieving high performance. PCEs of 17% and 16% are achieved from MALI and FALI, respectively, by controlling morphology and crystal size. Interfacial nanoengineering is also found to be important in terms of charge recombination control and charge collection.

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5.2

Nickel oxide p-type electrode interlayer in $CH_3NH_3PbI_3$ perovskite/fullerene planar-heterojunction hybrid solar cells

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Keywords: perovskite, nickel oxide, p-type, planar-heterojunction, solar cells

The work presented the application of nickel oxide as the p-contact to fabricate the decent perovskite-based photovoltaics.[1-3] The p-type nickel oxide exhibits several optical, electrical, and chemical advantages being the potential electrode-interlayer. A respectful solar to electrical PCE of 7.8% with a V_{OC} = 0.92 V, a J_{SC} = 12.43 mA/cm^2, and a FF = 0.68 has been achieved with the device configuration of the glass/ITO/NiO_x/$CH_3NH_3PbI_3$ perovskite/PCBM/BCP/Al structure under standard 1 sun AM 1.5G simulated solar irradiation.[1] In addition, the device composed of the mesoscopic nanocrystalline NiO/peroskite/PCBM configuration exhibits a V_{OC} = 0.96 V, a J_{SC} = 19.8 mA/cm^2, and a FF = 0.61, corresponding to a higher magnitude of PCE to 11.6%.[3]

NiO electrode interlayer is a p-type semiconductor of high work function of 5.4 eV, which is close to the valence band edge level of $CH_3NH_3PbI_3$ perovskite (5.4 eV). The alignment of energy level minimizes the interfacial energy losses for the hole transfer and optimizes the photovoltage output of device. Additionally, the higher magnitude of J_{SC} and PCE also results from the better surface coverage of $CH_3NH_3PbI_3$ perovskite film on the glass/ITO/NiO_x substrate.[1] The efficient hole transfer at perovskite/NiO heterojunction was verified by photo-induced absorption spectroscopy, showing a broad spectral feature above 800 nm, the long-lived charge-separation state of NiO^+/P^-.[2] The success of this new style device configuration of p-type metal oxide material has the advantages of providing robust perovskite-based thin film solar cells in future. Our findings reveal the design principle for enhancing the photovoltaic performance of $CH_3NH_3PbI_3$ perovskite/PCBM hybrid PHJ[4,5] solar cells through the judicious selection of the metal oxide electrode interlayer.

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5.3

Electrode Buffer Layer Materials for High Performance Polymer Solar Cells

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Keywords: polymer solar cells, cathode buffer layer, anode buffer layer.

Bulk-heterojunction polymer solar cells (PSCs) have attracted great attention in recent years, because of their advantages of low cost fabrication, light weight and flexibility. For achieving higher power conversion efficiency of the PSCs, great efforts have been devoted to the design and synthesis of new donor and acceptor photovoltaic materials, [1] new cathode and anode buffer layer materials, and new device structures. In this presentation, I will talk about our recent progress on the solution-processable cathode and anode buffer layer materials. The cathode buffer layers we developed include metal chelates TIPD[2] and ZrAcac[3], hyperbranched polymer[4], C_{60} derivatives[5] and *n*-type organic molecules[6] with side chains containing amine end groups. The anode buffer layer materials are a series of metal oxides[7] obtained by thermal annealing their solution-processed precursors at lower temperature. The PSCs with the anode or cathode buffer layers showed improved photovoltaic performance and high stability. In addition, some buffer layer materials mentioned above have been successfully applied in high performance organic-inorganic hybrid perovskite solar cells.

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6.1

Unlocking Full Potential of Conducting Polymers for Highly Efficient OLEDs and Solar Cells

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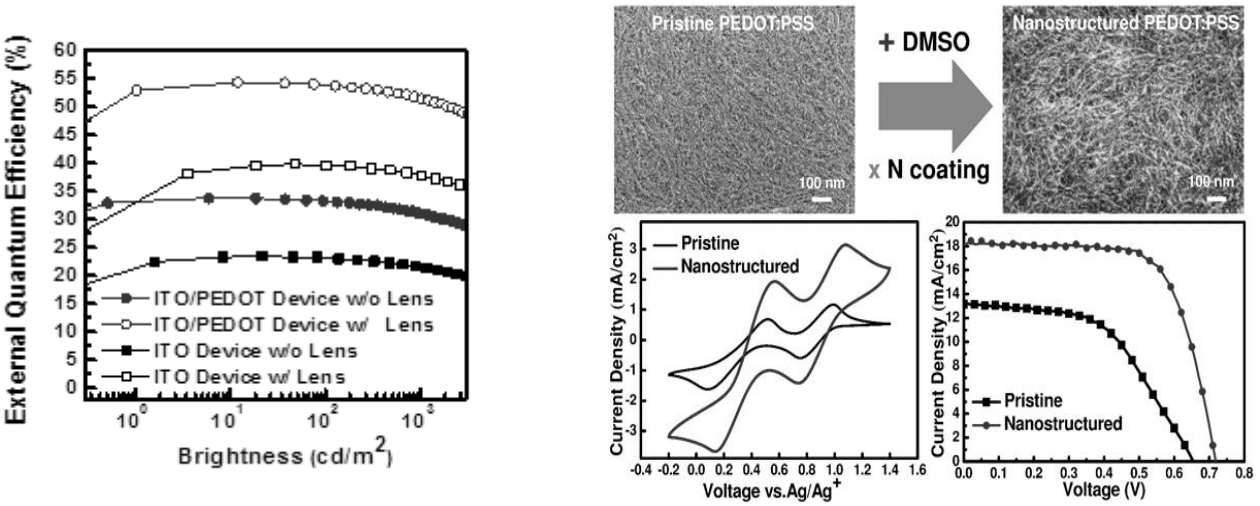
Keywords: conducting polymer, OLED, solar cells

The transparent conducting polymer poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) has been long and widely used as the hole-conducting layers in various organic optoelectronics such as organic light-emitting devices (OLEDs) and organic solar cells (OSCs). In recent years, tremendous progresses have also been made on enhancing the conductivity of PEDOT:PSS, making it capable of replacing the widely used but less cost-effective and mechanically flexible indium tin oxides (ITO) as alternative transparent electrodes for organic OLEDs and OSCs. Although PEDOT:PSS had been widely studied, our recent studies, however, reveal that the capability of PEDOT:PSS to enhance optical performance and efficiency of organic optoelectronic devices has been long underestimated, mainly due to unawareness of its unique optical properties and its capability of spontaneously forming nanostructures during film deposition.

First, by utilizing its unique optical properties, phosphorescent OLEDs using PEDOT:PSS as the hole-injection/hole-conducting layers show significantly enhanced external quantum efficiencies (EQEs) of up to ~34% photon/electron without applying any external out-coupling schemes and of >54% with applying external out-coupling. Second, phosphorescent OLEDs utilizing high-conductivity PEDOT:PSS as the ITO-free transparent electrode give EQEs similar to ITO-based OLEDs and yet give much more enhanced EQEs of >46% (than ITO-based devices) when in combination with external out-coupling. Third, judicious conditions for film casting of high-conductivity PEDOT:PSS can induce spontaneous formation of nanofibrillar, nanoporous, and PEDOT-richer surface structures, giving high conductivity and significantly enhanced electrocatalytic activity. Such nano-structured high-conductivity, electrochemically active PEDOT:PSS can serve as the Pt-free/FTO-free counter electrodes to replace conventional cost-ineffective Pt-containing and FTO-containing counter electrodes of dye-sensitized solar cells (DSSCs) and gives conversion efficiency similar to conventional Pt-based DSSCs.



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Thermochromism Study of Low Band-Gap Photovoltaic Polymers

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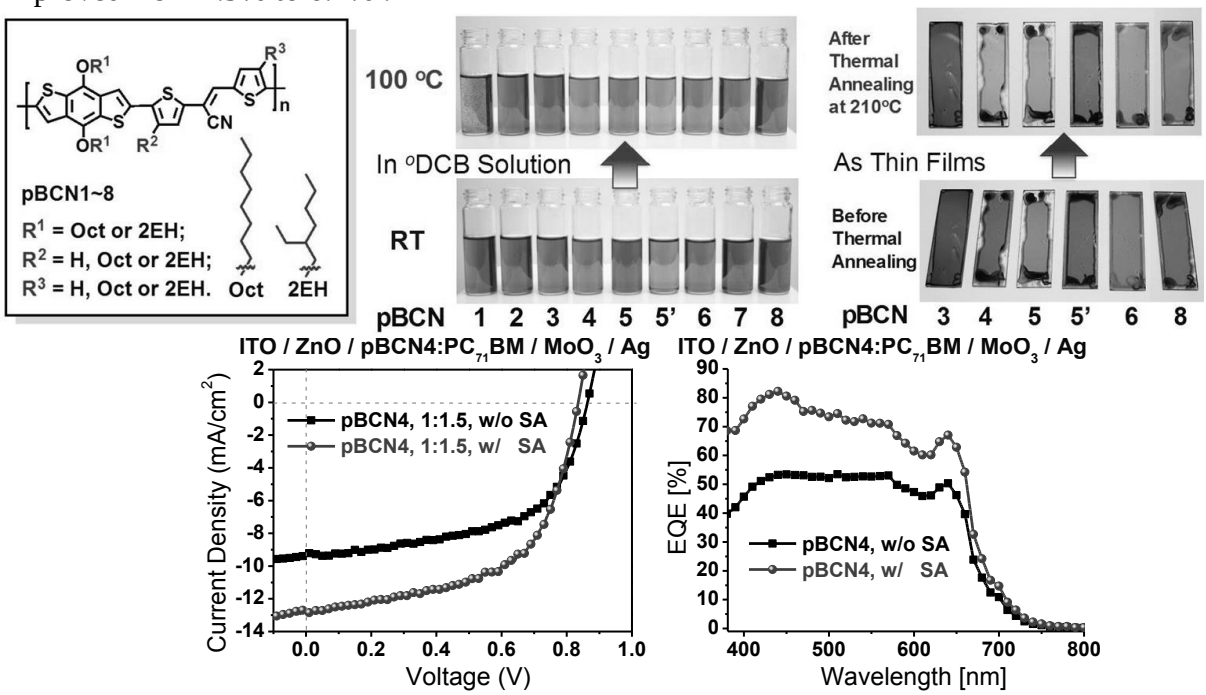
A series of low band-gap copolymers (pBCN copolymers) based on benzo(1,2-*b*:4,5-*b*')dithiophene donor and thienylcyanovinyl acceptor anchored with different number and shape of solubilizing alkyl chains were designed and synthesized. The implication of alkyl chains and π-π interaction on polymer aggregations was investigated by temperature-dependent UV-visible absorption and IR spectroscopy. Via grafting appropriate alkyl side-chain substituent on different position of the copolymer main chain, thermochromic phenomena are controllable both in the solution and in the thin film state. The results from the thermochromism study of these copolymers agrees with the enhancement of photovoltaic performances through the solvent annealing treatment reported previously.[1] Currently, by extending solvent annealing time to 60 minutes and adopting inverted device structure, power conversion efficiency of pBCN4/$PC_{71}BM$ bulk heterojunction OPV has been improved from 4.9% to 6.2% .



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6.3

Functional Molecular Materials – From Design to Functions and Applications

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Keywords: metal complexes, OLEDs, solar cells

There has been considerable growth of interest in new functional molecular materials with unique properties for technological developments. Functional molecular materials can be found in all classes of materials for specific applications, including optoelectronics, electronics, photonics, sensors, magnetics, memories and others. Of particular interest is the design of metal-organic compounds with interesting luminescence properties for the applications in organic light-emitting devices (OLEDs) as well as organic and metal-organic materials with strong light-harvesting properties for the applications in organic photovoltaic (OPV) devices. In this work, various design and synthetic strategies to generate new classes of functional molecular materials will be described. Through a proper understanding of structure-property relationships, metal-organic and organic molecules can be rationally designed and engineered to tune their electronic absorption and emission characteristics for various optoelectronic applications. Particularly, new classes of solution-processable alkynylgold(III) complexes with tunable emission spanning the entire visible spectrum have been designed and synthesized. Highly efficient phosphorescent OLEDs with small efficiency roll-offs at high brightness level have been demonstrated. New classes of metal-organic and organic derivatives with light harvesting properties have also been explored. The spiro derivatives has been shown to exhibit high hole mobilities and are promising candidates to serve as donor materials for small molecule-based OPV devices. Bulk heterojunction devices with high open-circuit voltage and power conversion efficiencies have been realized.

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Morphological Control and Interfacial Modification of Planar Heterojunction Perovskite Solar Cells

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Keywords: Perovskite solar cells; Planar heterojunction; Morphological control; Interfacial modification.

Perovskite solar cells (PSCs) have recently drawn much attention owing to their remarkable increase in power conversion efficiency (PCE) from less than 4% to over 15% in the past five years.[1-3] Recently, a theoretical calculation by Yan et al. demonstrates that the maximum PCE of the perovskite solar cells can approach 26%,[4] which indicates PSCs are economically viable with very fascinating prospect for their commercialization.

Planar heterojunction structure (similar to that of organic solar cells) has been proven to be efficient and convenient in fabricating low-temperature and solution-processible PSCs.[5,6] In a typical planar heterojunction PSC, the perovskite light-absorbing layer is sandwiched between the hole- and electron- transporting layers. To obtain high PCE, it is essential to manipulate the carriers along the whole pathway from the active layer to electrodes through the hole- and the electron- transporting layers. Therefore, device architecture engineering are very important for obtaining excellent carrier transport pathway in the entire device. Among them, materials for light-absorbing layer, interfacial modification, and processing techniques are regarded as the most important factors to obtain high-performance PSCs. In this work, we carried out a structure optimization engineering of planar heterojunction PSCs in order to improve the device efficiency and prolong the cell stability. We mainly focus on the optimization of hole and electron interfacial layers, crystal film growth of perovskite materials, and fabrication processes. Up to date, a best performance with 15.75% PCE and a fill factor of 72% has been achieved from the PSCs with a regular structure of ITO/HTL/$CH_3NH_3PbI_{3-x}Cl_x$/PCBM/ETL/Ag in our lab. Further work on improved efficiency and stability is in progress.

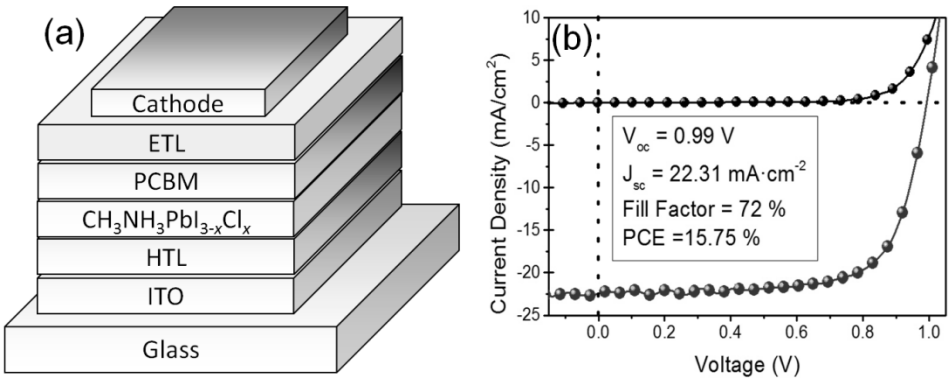

Figure 1. (a) Device structure of a pervoskite solar cell; (b) *J-V* characteristics and cell parameters of the best performance pervoskite solar cell we made.

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7.1.2

Optical Constants Measurements of Organometal Halide Perovskite Thin Films and Their Application in the Solar Cell Structure Design

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Keywords: Organometal halide perovskites, Perovskite solar cells, Optical constants, Optical field simulation, Tandem solar cells

We developed a new sequential layer-by-layer deposition method for fabricating organometal halide perovskite thin films. The resulting films exhibit a homogenous morphology with a low root mean squared roughness. The optical constants including refractive index and extinction coefficient of organometal halide perovskites in the wavelength range of 300 to 1100 nm were determined. These data were used for designing the optical structures of thin-film type perovskite solar cells. The calculations suggest that power conversion efficiency of up to 20% and 29% are feasible without any antireflection and light scattering structures in single and perovskite/CIGS tandem cells given a proper device structure design. The calculation also indicates that even in optically optimised cells, an average reflection of ~10% existed in both single and perovskite/CIGS tandem cells. A proper integration of an antireflection optical structure to lower the reflection of the devices can most likely further increase the device performance.

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Formation chemistry of perovskite and photoconversion mechanism in perovskite/fullerene heterojunctions

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Keywords: Interface energetics, XPS, formation chemistry, methylammonium iodide, lead chloride

General studies believed that organometal halide perovskite form type II P-N junctions with fullerene derivatives (C_{60} or PCBM), which provide sufficient driving force for exciton dissociation. To the best of our knowledge, there is so far no experiment proof on this assumption. On the other hand, whether photo-generated excitons in perovskites can intrinsically dissociate without any assistance from a P-N junction is still controversial. Although perovskites have attracted much attention in recent years, current understanding to perovskites such as formation chemistry and photovoltaic behavior are indeed very limited.

To address these issues, we directly examine the formation chemistry and the surface energetics of a vacuum-deposited perovskite/C_{60} and a solution-processed perovskite/PCBM junctions via x-ray and ultraviolet photoelectron spectroscopic (XPS/UPS) studies. We showed with evidence that the Cl would readily leave the Pb when lead chloride meets the methylammonium iodide molecules such that negligible Cl could be observed in the resulting perovskite film. Also contrary to the common believes, both junctions of perovskite/C_{60} and perovskite/PCBM are found to be type I N-N junctions with bandgap of the perovskites embedded by that of the fullerene. Meanwhile, device with such a charge inert junction can still effectively functions as a solar cell. These results directly showed that excitons can dissociated to free carriers in the perovskite film even without any assistance from a P-N junction.

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7.1.4

Interface engineering from Organic Solar cells to Perovskite Solar Cells via Incorporation of a Polyelectrolyte Interlayer

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Keywords: interface engineering, organic solar cells, perovskite solar cells, polyelectrolyte interlayer, solution processing**.**

The physical process involved in charge injection, extraction, transfer and recombination at an electrode–semiconductor interface were found to be a most critical factor determining device characteristics and stability. To minimize the contact barrier, the interface between the electrode and the organic semiconductor layer should be a quasi-ohmic contact. Such a requirement has led to efforts in interfacial engineering, including the use of thermally deposited LiF or bathocuproine (BCP), self-assembled monolayers (SAMs), conjugated polyelectrolytes (CPEs) and polyelectrolytes (PEs). The suitability of the interface opens the opportunity to apply the interface design rules for the organic solar cell to the perovskite solar cell technology.

Regarding organic solar cells, we successfully demonstrate a smart strategy to use aluminum doped ZnO (AZO) and the thiophene-based conjugated polyelectrolyte P3TMAHT as an interfacial layer in small molecule solution-processed inverted solar cells (ITO / AZO / P3TMAHT / N(Ph-2T-DCN-Et)$_3$:$PC_{71}BM$ / MoO_3 / Ag). Modification of AZO with a thin P3TMAHT layer increases the photovoltaic properties of the inverted cell as a result of reduction in the work function of the cathode with well aligned frontier orbital energy levels for efficient charge transport and reduced surface recombination. The inverted device achieved 16% performance improvement dominantly by recapturing part of the V_{oc} losses when going from conventional to the inverted architecture.[1]

Apply the interface design rules for the organic solar cell to the perovskite solar cell technology. Highly efficient hybrid organic/inorganic perovskite planar heterojunction (PHJ) solar cells (ITO / PEDOT:PSS / CH3NH3PbI$_{3-x}$Cl$_x$ / PCBM / polyelectrolyte interlayer /Ag) are fabricated based on the interface layers all solution-processed at low temperature. Relative to the control device, the power conversion efficiency (PCE) increased significantly from 8.53% for the control device to 12.01% (PEIE) and 11.28% (P3TMAHT) via incorporation of a polyelectrolyte interlayer. The improvement in PCE for devices is chiefly assigned to the effective influence of polyelectrolyte interlayers on reducing the work function of the subsequently deposited metal electrode, thereby lowering the electron-injection barriers.[2]

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Monolithic integration of OLED and OPD for sensor application

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Keywords: Organic light emitting diode, Organic photodiode, Organic sensor

Organic electronics semiconductors are gradually revealing potential in photons generation, transmission and detection, such as information and communication technology, bio-sensor and computing. In this work, we propose proximity sensor device based on integration OLED and semi-transparent OPD using simple top and bottom approach. Ag/CFx bilayer electrode is used to enable a good electrical contact and work function matched electrodes in-between the OLED and OPD. The Ag/CFx electrode also acts as a partial reflection mirror to enable the microcavity effect, such that it enhances the forward emission at wavelength 522nm. We find that our design can exhibit high luminance from the microcavity OLED (MOLED) and high respond from the OPD in the integrated device. By changing the thickness of the active layer in the OPD, the signal contrast can be enhanced. It is shown to exhibit the high coupling, based on their optical simulation. It suggests a new way in which organic integrated devices have great potential in optocoupler, smart light source and display, optical switches and smart organic optoelectronics device in organic optical communication.

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7.2.2

Improved Performance of Organic Solar Cells by Incorporation of Coated Gold Nanorods at different positions

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Keywords: Organic solar cells; Surface Plasmons; Gold nanorods; Coating; Absorption

Research on bulk heterojunction organic solar cells (BHJ-OSCs) has become one of the hottest research topics due to their good performances, such as lightweight, flexible, inexpensive to fabricate, and tunable on the molecular level [1, 2]. Recently, metallic nanoparticles (MNPs) with different shape have been frequently used to improve the light trapping capability of OSC active layer, hence increasing the power conversion efficiency (PCE) [3, 4]. The improved performance of OSC devices can be ascribed to the excitation of surface plasmons or the enhancement of scattering. As the synthesized MNPs are water-soluble, most of the present work have doped the MNPs into the buffer layer of OSCs [5, 6]. Here, we present two different ways to introduce MNPs into PTB7:PC70BM based OSCs for improving the device performances. The MNPs are the gold nanorods, displaying two different resonant peaks for broadband enhancement of absorption. The first way is to incorporate silica-coated gold nanorods at the interface between the active layer and the buffer layer. The second way is to use NH2-PEG-SH to modify the surface of gold nanorods so that the MNPs can be dissolved in DCB and hence to be easily mixed with the active blender. The coating process is imported to avoid the quenching of excitons happening when the bare MNP directly contact with the active material. Our experiments have shown that the introduction of coated gold nanorods can greatly improve the device performance and the second way is superior, which can bring as high as 10.5% improvement of PCE. Our research will contribute to the development of high efficiency photovoltaic cells.

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Aggregation and morphology control enables multiple cases of >10% efficiency polymer solar cells

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Keywords: Polymer Solar Cell, Thick Film Polymer Solar Cell, Non-PCBM Solar Cell, Non-fullerene Solar Cell

Although the field of polymer solar cell has seen much progress in device performance in the past few years, several limitations are holding back its further development. For instance, current high-efficiency (>9.0%) cells are restricted to material combinations that are based on limited donor polymers and only one specific fullerene acceptor. Here we report the achievement of high-performance (**efficiencies up to 10.8%**, fill factors up to 77%) thick-film polymer solar cells for multiple polymer:fullerene combinations via the formation of a nearideal polymer:fullerene morphology that contains highly crystalline yet reasonably small polymer domains. This morphology is controlled by the temperature-dependent aggregation behaviour of the donor polymers and is insensitive to the choice of fullerenes. The uncovered aggregation and design rules yield three high-efficiency (>10%) donor polymers and will allow further synthetic advances and matching of both the polymer and fullerene materials, potentially leading to significantly improved performance and increased design flexibility.

A 6.3% Efficient Non-Fullerene Organic Solar Cells Enabled by a Properly Matched Polymer Donor and Small-Molecular Acceptor

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A high-performance non-fullerene acceptor based organic solar cells enabled by the combination of a difluorobenzothiadizole donor polymer named PffBT4T-2DT and a small molecule named SF-PDI_2 was studied. It is found that SF-PDI_2 matches particularly well with PffBT4T-2DT, and non-fullerene organic solar cells with an impressive V_{OC} of 0.98 V and a high power conversion efficiency of 6.3% are achieved. Our study shows that PffBT4T-2DT is a promising donor material for small-molecular acceptor-based organic solar cells and the selection of a matching small – molecular acceptor is also important to achieve the best organic solar cell performance.

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7.2.4

Light Manipulation for Organic Optoelectronics Using Micro/Nanostructures

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Keywords: OLED, OSC, light extraction, light trapping, deterministic aperiodic nanostructure

Organic optoelectronic devices, including organic light-emitting devices (OLEDs) and organic solar cells (OSCs) have been attracting considerable interest as next-generation lighting source and renewable energy applications. Significant progress on the device performance of OLEDs and OSCs with nearly 100% internal quantum efficiency has been made in recent years via the incorporation of new materials, morphology control, interface engineering, and device fabrication processes. However, further improvement in efficiency remains a daunting challenge due to limited light extraction or absorption in conventional device architectures. Here we report a universal method of optical manipulation of light by integrating a dual-side bio-inspired moth's eye nanostructure with broadband anti-reflective and quasi-omnidirectional properties for use in the performance improvement of organic optoelectronic devices of various material systems. Light out-coupling efficiency of OLEDs with stacked triple emission units is over 2 times that of a conventional device, resulting in drastic increase in external quantum efficiency and current efficiency to 119.7% and 366 cd/A at a luminance of 1,000 cd/m^2 without introducing spectral distortion and directionality. Furthermore, an efficient white OLED device structure is demonstrated, yielding an efficiency exceeding 120 lm/W through the combination of optimum light outcoupling and energy-efficient photon generation. Besides a substantial increase in efficiency, this device structure offers an extremely small roll-off in efficiency at high brightness (for example, 106.5 lm/W at 5,000 cd/m^2) and superior angular color stability over the visible range. Similarly, the light in-coupling efficiency of OSCs is increased 20%, yielding an enhanced power conversion efficiency of 9.33%. The light-coupling enhancement in OLEDs and OSCs with MEN is the combined result of both the two-dimensional sub-wavelength structures and the continuously tapered morphology on the patterned surface with a superior gradient refractive index profile at the interface. The light is therefore manipulated in all azimuthal directions over the entire emission wavelength range. The optical simulations provide an understanding of optical manipulation of light out-coupling and in-coupling process in OLEDs and OSCs. Note also that the method developed here brings about an invaluable advantage, which enables the processing compatibility with the high-throughput large-area roll-to-flat and roll-to-roll manufacturing techniques in future mass production of low-cost organic optoelectronic devices.

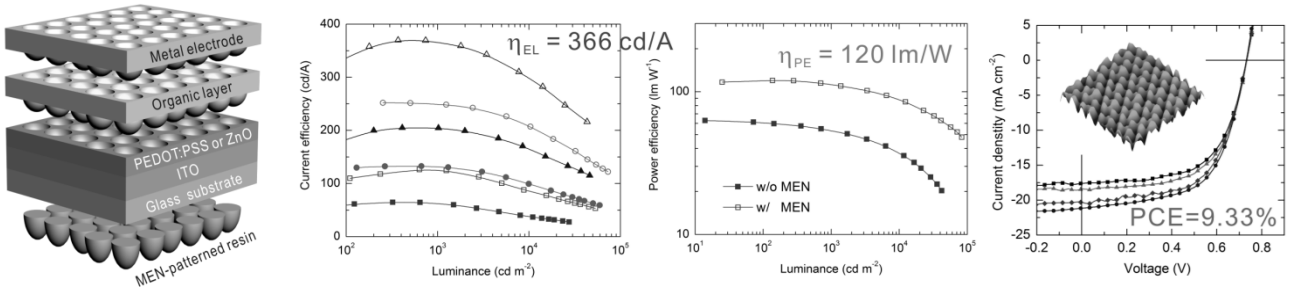

Fig. 1. Device structure and performance characteristics of OLEDs and OSCs.

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Effect of film drying condition on performance of polymer solar cells for bis-PCBM/P3HT

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Keywords: polymer solar cell, bulk-heterojunction, slow dry, bis-PCBM

Polymer solar cells (PSC) have been actively studied as a major candidate for the next-generation of solar cells. The performance of PSCs is affected by the device fabrication condition and various techniques have been proposed, including thermal annealing and solvent annealing methods. A similar method to solvent annealing, the "slow drying method" has been proposed as well [1]. It improves short circuit current density (J_{sc}) by delaying the drying speed of the coated films. However, compared with the first two methods, less research has been reported about slow drying and it is not commonly used as a fabrication method for PSC. In this study, the slow drying method was applied to PSCs consisting of p-type polymers poly(3-hexylthiophene) (P3HT) and n-type fullerene derivative bis-[6,6]-phenyl-C61-butyric acid methyl ester (PCBM), and the effect of drying speed on the cell performance and the method's mechanism were investigated. The prepared devices had a structure, glass/indium tin oxide (ITO) anode/poly(3,4-ethylenedioxythiophene)/poly(styrenesulfonate) (PEDOT/PSS)/bis-PCBM:P3HT (1:1)/Al cathode. The active layers were formed using doctor blade method. The film drying speed was controlled by varying the partial pressure of the solvent used (chlorobenzene). After Al cathodes were formed, thermal annealing 150 ºC, 15 min. was performed using a hot plate. The performance of each (2×2 mm) cell was estimated under AM 1.5 solar simulated illumination. Figure 1 denotes the relation between the cell performance and film drying time. Note that the drying time denotes the period from the solution drop to the timing of phase separation process had been completed. The PSC formed by conventional spin casting method evinced very poor performance, *J*sc=5.85 mA/cm^2, *V*oc=0.69 V, *FF*=0.21, PCE=0.83%. In contrast, J_{sc} of the devices with slow drying clearly increased. The J_{sc} increased to 7.02 mA/cm^2 by setting *t* at 60 seconds and exceeded 8 mA/cm^2 by expanding *t* to 700 seconds. By optimizing the cathode buffer layers and thermal annealing condition, we attained high performance of 4.05% PCE for this system.

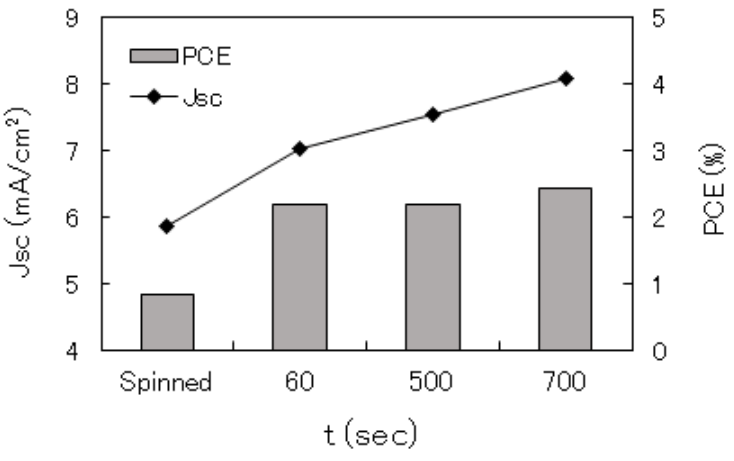

Fig. 1 Performance of polymer solar cells and drying time

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8.1.2

Efficiency enhancement in inverted organic solar cells using a dual cathode interlayer

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Keywords: organic solar cell, cathode interlayer, charge collection, inverted structure**.**

Organic solar cells (OSCs) with inverted structure exhibit higher power conversion efficiency (PCE) and are more stable than similar devices with regular configuration. Although indium tin oxide (ITO) is normally used as an anode, it can also act as a transparent cathode when the surface is modified to lower its work function with an interlayer, such as ZnO or TiO_2, to promote more efficient electron collection. In this work, the effect of a dual cathode interlayer of Al (~1.2 nm)/ZnO on PCE of inverted OSCs based on PTB7:$PC_{70}BM$ system is analyzed. The results reveal that the use of Al (~1.2 nm)/ZnO-modified ITO cathode allows achieving a PCE of 7.2% which is 20% higher than that of a structurally identical control cell made with just a ZnO/ITO cathode. Light intensity-dependent current density–voltage characteristics point out the enhancement of charge collection efficiency due to the presence of Al (~1.2 nm)/ZnO interlayer at the organic/electrode interface. X-ray Photoelectron Spectroscopy (XPS) analysis indicates clearly that the thermally prepared Al layer on ZnO was indeed partially oxidized and should be considered as AlO_x. Ultraviolet photoelectron spectroscopy measurements fully reveal the energy level alignment at the interface between AlO_x and $PC_{70}BM$, which show a removal of the energy level pinning at ZnO/$PC_{70}BM$ interface, leading to less bimolecular carrier recombination and leakage current. Moreover, improved repeatability on the performance of devices is also achieved with this dual cathode interlayer. All the results and analyses above confirm that the surface modification of ITO cathode with an AlO_x (~1.2 nm)/ZnO interlayer is an effective approach for the realization of inverted OSCs with high efficiency and stability.

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Printing Fabrication and Interface Materials for Solution-Processed Organic Photovoltaics

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Keywords: organic photovoltaics; R2R printing; interface; module

Organic photovoltaics (OPVs) continuously attract attention due to their potential as low cost and lightweight sources of renewable energy. The *power conversion efficiency* (*PCE*) of state-of-the-art OPVs, based on bulk heterojuction and tandem structures, can reach over 10.0 %, as result of progress in new materials, device engineering, device physics, *etc.* [1]. Especially, there has been an unexpected breakthrough and rapid evolution of highly efficient solar cells based on organic-inorganic hybrid perovskite materials [2]. However large-area OPVs processed by R2R printing or coating techniques still have many issues, and the *PCE* of large-area OPV modules is much lower than those of smaller, spin-coated devices [3, 4]. In this presentation, we will describe our research on the fabrication of OPV modules by R2R printing techniques and the solution stability of active materials, as well as the solution-processed interface materials for printed OPVs [4-7]. It is very important to optimize printing parameters, ink properties, and interface materials for obtaining high-quality printed thin films and printed OPV modules.

Fig.1 Self-developed R2R multi-function printer/coater
and its application in the fabrication of organic solar cells

Acknowledgements
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8.1.4

Interface Engineering and Morphology Control for High Performance Perovskite/Fullerene Planar Heterojunction Solar Cells

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Keywords: planar heterojunction, perovskite solar cells, interface engineering, morphology control

Solar cells based on organometal trihalide perovskites (eg. $CH_3NH_3PbI_3$) as light absorbers are emerging as a low-cost and high performance photovoltaic technology that may fulfil the requirement for large-scale deployment of solar energy. Over the past few years, significant progress was made in pervoskite solar cells with power conversion efficiencies (PCE) shot up from 3% to 18%. Recent studies revealed that organometal trihalide pervoskites exhibit several desired properties for photovoltaic applications including facile tunable bandgaps, high absorption coefficient, long carrier-diffusion lengths, high ambipolar mobilities and low exciton binding energy, making them a very appealing class of material for new generation photovoltaic technology.

In this talk we will present two strategies to improve the performance of perovskite/fullerene planar heterojunction solar cells.[1] First, the growth kinetic of the perovskite films was tuned by introducing chemically-tailored processing additives. Depending on the choice of the additives, the crystallinity and coverage of the perovskite films can either be enhanced or suppressed and we found that the solar cell performance was strongly depending on the morphology of the perovskite films.[2] Second, novel interfacial materials were introduced to improve the contact between the fullerene electron transport layer and the metal cathode interface, resulted in Ohmic contact with reduced interfacial resistance and a significant improvement on the fill factor. Combining these two strategies high performance perovskite solar cells with over 15% PCE were achieved.[3]

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Improved organic photovoltaics by surface plasmon effect

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Keywords: Organic photovoltaics, surface plasmon effect, nanograting, metal nanoparticles

Organic photovoltaics (OPVs) have great potential as a clean and renewable energy source technology due to their wide material sources, relatively low-cost, light weight, transparency as well as their compatibility with large area flexible substrates. However, the energy conversion efficiencies are less satisfactory at present compared with their inorganic counterparts. In OPV devices, very thin active layers are necessary due to some intrinsic properties of organic materials, such as low carrier mobility and short exciton diffusion length. However, the incident photons could not be absorbed sufficiently in such thin active layers. This incompatibility is one of the main reasons for the low energy conversion efficiency of OPV devices. Therefore, it is necessary to find ways to enhance light absorption effectively in the active layer without increasing its thickness. Different approaches have been reported including incorporating metal nanoparticles (NPs) and periodic surface plasmon structures in OPV devices to boost light absorption. In this talk, we will report some theoretical and experimental investigations on improving the energy conversion efficiency using the surface plasmon effect in our labs: In theory, novel 1D metal nanogratings were designed for achieving high-efficiency, broad-band and wide-angle optical absorption in OPVs; In experiment, the coated metal nanoparticles were incorporated in OPVs for improving the energy conversion efficiencies.

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8.2.1

Contrary interfacial exciton dissociation at metal/organic interface in regular and inverted organic solar cells

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Keywords: organic solar cells, transient photocurrent, metal/organic interface

An investigation of the absorption enhancement and stability of organic solar cells (OSCs) with regular and reverse configurations has been performed. Light absorption in the regular and reverse geometry OSCs was calculated using finite-difference time-domaain simulations over the wavelength range from 400 nm to 800 nm. The simulation reveals that OSCs with reverse geometry possess a higher absorption compared to the structurally identical regular configuration OSCs fabricated using an ITO/PEDOT:PSS anode. The reverse configuration OSCs, have an organic functional stack sandwiched between an Al-modified ITO transparent cathode and an opaque bi-layer MoO_3/Ag anode is more efficient than a control regular OSC. The dissociation of excitons at the Al/organic cathode interface in regular geometry OSCs hampers the electron collection. During the deposition of Al contact on the stack of functional organic layers, the energetic metal atoms can induce interfacial defects in the underlying functional organic layers, resulting in forming an adverse charge collection behavior at the complex organic/Al interface. The origin of unfavorable electron collection is mainly due to the compensation of drifted photo-generated electrons at the organic/cathode (Al) interface, which can be eliminated, e.g., by inserting a thin ZnO interlayer between the organic layer and Al electrode. This work clearly reveals that the removal of the unfavorable interfacial exciton dissociation is a perquisite for a significant enhancement in power conversion efficiency in OSCs.

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Photovoltage Loss in Excitonic Solar cells

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Keywords: Organic solar cell, photovoltaic, energy level, charge transfer state, open circuit voltage**.**

Polymer solar cells with power conversion efficiencies (PCEs) over 8% have been demonstrated in laboratories with advances of novel materials, device processing, and device architectures. However, some critical physical properties of the polymer:fullerene bulk heterojunctions (BHJs) such as the donor-acceptor interface energetics which controls the charge transfer process are not well understood. In a BHJ photovoltaic cell, the open-circuit voltage (VOC) is determined by the energy level difference of the highest-occupied-molecular-orbital (HOMO) of the donor and the lowest-unoccupied-molecular orbital (LUMO) of the acceptor. However, there is lack of experimental approach to directly probe such alignment in a working device.

In this presentation, we will demonstrate a technique—charge modulated electroabsorption spectroscopy (CMEAS) to directly determine the effective bandgap and the interface effective force in a polymer:fullerene BHJ system.[1,2] By measuring the electroabsorption (EA) signal due to charge-modulation (CM) in the polymer, we are able to observe a clear sub-bandgap signal through direct excitation of excitons to the charge transfer states. Such a differential spectrum measured by CMEAS has a much higher signal-to-noise ratio than that measured by linear optical absorption techniques. Compared to the conventional electrochemical method, CMEAS can probe the energy level alignment at the electron donor-acceptor interface in a working BHJ photovoltaic cell. Using CMEAS, for the first time we are able to directly probe the effective bandgap in polymer:fullerene systems. The results also bring insight into the details of the charge transfer states and the origin of VOC in polymer photovoltaic cells.

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8.2.3

High-efficiency all-polymer solar cells based on a pair of crystalline low-bandgap polymers

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Abstract

We have demonstrated high-performance all polymer solar cells (all-PSCs) based on a pair of crystalline low-bandgap polymers. A high J_{sc} of 11.5 mA/cm^2 and a PCE of 5% were achieved due to the low optical bandgap of the donor polymer and the reasonably high EQE of the cell that is the result of the favorable morphology of the NT:N2200 blends. R-SoXS, AFM and TEM characterizations support that the NT:N2200 blend film is smooth and exhibits an average domain size of about 100 nm. GIWAXS and charge transport data combined indicate that NT can maintain its crystallinity with a preferrential face-on orientation in the NT:N2200 blends, which lead to a hole mobility that is reasonably balanced with the electron mobility of N2200. Our morphological characterizations can largely explain the performance of NT:N2200-based all-PSCs. Our results provide important inspirations to develop high-efficiency all-PSCs based on donor polymers with low optical bandgaps.

A New Class of Organic Photovoltaic Materials: Poly(rod-coil) Polymers composed of Alternative Conjugated and Non-Conjugated Segments

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Keywords: Organic Photovoltaic Materials; Organic Solar Cells; Organic Semiconductors; Poly(rod-coil) Polymers; Polyurethanes**.**

Organic photovoltaic donor materials developed so far can be categorized into two main classes: conjugated polymers and small molecular compounds. Conjugated polymers have a one-dimensional π-extended conjugated backbone, which is favor for transportation of photo-generated excitons and charge carriers. Besides, they generally have good film-formation potential. However, since they always have issues of batch-dependent average molecular weight and polydispersity, polymeric photovoltaic materials often suffer from poor batch reproducibility. On the other hand, small molecular compounds does not have batch-dependent problem since they have definite chemical structure and can be purified by a variety of methods. However, for the purpose of promising light absorption and good charge transportation among molecules, this kind of materials usually has a large and rigid π-conjugated core. As a result, small molecular photovoltaic compounds tend to aggregate or crystallize in film state and are hard to form a well-qualified homogenous film, particularly in a large size.

Recently, we proposed a new type of organic photovoltaic materials, which is a kind of poly(rod-coil) polymers composed of alternatively definite conjugated and non-conjugated segments (Fig. 1a). The conjugated segments are opto-electronically active and suggested to be made from donor-acceptor (D-A) conjugated structure for a good solar light acquisition. In this presentation, we report the first five examples based on polyurethane chemistry (Fig. 1b) and highlight their property improvements over the small molecular reference compound due to good film formation. Furthermore, the polymer molecular weight has been found to have less influence on their photovoltaic performance.

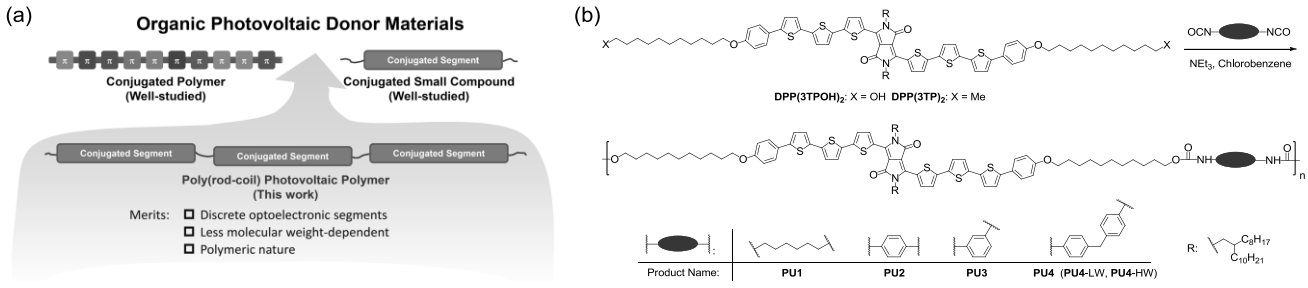

Fig. 1 (a) Schematic representation of proposed poly(rod-coil) photovoltaic polymers. (b) Synthesis of photovoltaic polyurethanes

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9.1

Efficiency and Reliability of Small Molecule Organic Photovoltaics

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Keywords: OPVs, Operational Lifetimes, Device/Material Properties

The viability of any photovoltaic technology rests on meeting three challenges that ultimately impact cost/Watt: (i) Efficiency, (ii) Reliability and (iii) Low cost manufacturability. Organic photovoltaics (OPVs) are attractive due to confidence that the third challenge can be met using low energy, roll-to-roll processing using low cost and environmentally friendly materials. In this talk, therefore, we will concentrate our attention on the recent and very rapid progress in meeting the goals of high efficiency and long-term reliability. We will show work in our laboratory that has resulted in demonstration of multijunction cells with efficiencies >11%, with every indication that soon even higher efficiencies will be achieved. Furthermore, we will examine the fundamental processes leading to device failure, and assess the potential for achieving cells with operational lifetimes >20 years. The talk will consider all of these advances in the context of the physical limits that can be expected based on fundamental considerations of device and materials properties.

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Structural details and measurements related to organic nanodevice by STM

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Abstract

Preparing hybrid or multi-component molecular architectures on solid surface is an important issue in surface molecular science and molecular device fabrication. On the other hand, the questions are always attracted our attention such as (1) what state is it when a molecule stays at a solid surface? (2) how is the interfacial structure when a multilayer was formed? (3) how is the molecular behavior when a multilayer was suffered to such as heat treatment? (4) how to measure the electronic property of a single or monolayer? In this report, I will show you the results on the fabrication and property of functional molecular assembly by using Alq_3, BH-PPV and other donor/acceptor molecules. Since Joule heating effect on electroluminescent efficiency will influence on OLED and other organic nanodevice and result in the degradation of a device, thermal annealing on host-guest complex film was employed to simulate Joule heating effect. STM and photoluminescence measurements were performed on the guest molecule BT, host molecule TPBI, and their mixture deposited on HOPG surface to study the degradation mechanism from thermal heating. The results show that by careful designing of intermolecular and molecule/substrate reaction, various spontaneous and controllable molecular assemblies can be fabricated on solid surface, which are promising candidates for organic molecular nanodevice.

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10.1

Interface effects in organic photovoltaics

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Keywords: Organic Photovoltaics, charge transfer states, doping, recombination, UPS

Organic photovoltaic is under intense development and significant focus has been placed on tuning the donor ionization potential and acceptor electron affinity to optimize open circuit voltage. Here we show that for a series of regioregular-poly(3-hexylthiophene):fullerene bulk heterojunction organic photovoltaic devices with pinned electrodes, integer charge transfer states [1] present in the dark and created as a consequence of Fermi level equilibrium at BHJ have a profound effect on open circuit voltage. The integer charge transfer state formation causes vacuum level misalignment that yields a roughly constant effective donor ionization potential to acceptor electron affinity energy difference at the donor-acceptor interface, even though there is a large variation in electron affinity for the fullerene series. The large variation in open circuit voltage for the corresponding device series instead is found to be a consequence of trap-assisted recombination via integer charge transfer states. Based on the results, novel design rules for optimizing open circuit voltage and performance of organic bulk heterojunction solar cells are proposed [2].

The use of molecule-doped organic semiconductor layers in organic photovoltaics is showing great promise [3] and the energy level alignment at molecule-doped conjugated polymer/electrode interface is thus a topic of interest. We here study the energy level alignment of two molecule-doped systems, rr-P3HT and TQ1, using F4TCNQ as the dopant. We find regular plots with a constant thickness-independent displacement away from the original energy level alignment behavior of the pristine polymer at low to intermediate level for molecule-doped conjugated polymer/conducting substrate interfaces. We proposed that two combined processes control the energy level alignment: (i) equilibration of the Fermi level due to oxidation (or reduction) of polymer sites at the interface as per the integer charge transfer model and (ii) a double dipole step induced by image charge from the dopant-polymer charge transfer complex that cause a shift of the work function. Such behavior is expected to hold in general for low to intermediate level doped organic semiconductor systems.

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Photocatalytic Reduction of Protons to Hydrogen

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Keywords: Photocatalytic splitting of water, Quantum dot, [FeFe] hydrogenase, Transition metal cluster**.**

One of the best solutions for meeting future energy demands is the conversion of water into hydrogen fuel using solar energy. The splitting of water into molecular hydrogen (H_2) and oxygen (O_2) using light involves two half-reactions: the oxidation of water to O_2 and the reduction of protons to H_2. To take advantage of the full range of the solar spectrum, researchers have extensively investigated artificial photosynthesis systems consisting of two photosensitizers and two catalysts with a Z-configuration: one photosensitizer-catalyst pair for H_2 evolution and the other for O_2 evolution. This report reviews advances our laboratory has made in the development of new systems for photocatalytic H_2 evolution that uses earth-abundant materials and is both efficient and durable. We constructed several assemblies of CdTe and CdSe QDs as photosensitizers with [FeFe]-H_2ase mimics as catalysts. These assemblies produced H_2 in aqueous solutions photocatalytically and efficiently, with turnover numbers (TONs) up to tens of thousands. Assemblies of 3-mercaptopropionic acid (MPA)-capped CdTe Qds with Co^{2+} ions formed Co_h-CdTe hollow nanospheres, and (MPA)-capped-CdSe Qds with Ni^{+} ions produced Ni_h-CdSe/CdS core/shell hybrid *in situ* in aqueous solutions upon irradiation. The resulting photocatalytic systems proved robust for H_2 evolution. These systems showed excellent activity and impressive durability in the photocatalytic reaction, suggesting that they can serve as a valuable part of an overall water splitting system.

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10.3

Origin and control of gap states: A striking mobility improvement of C_{60} OFET

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Keywords: gap states, energy level alignment, mobility, pentacene, C_{60}

Charge carrier transport, which is central to the performance of various organic-based devices, is strongly affected by localized electronic gap states originating from various polarons, structural defects, impurities and/or chemical interactions with the gaseous environment. Detailed investigations of gap states energy distribution are therefore of paramount importance to understand the energy level alignment at interfaces and the intrinsic limits of transport in organic semiconductors [1,2]. We use ultrahigh-sensitivity ultraviolet photoelectron spectroscopy (UPS) to demonstrate that even exposure to seemingly innocuous inert gases such as N_2 and Ar can have a significant impact on the electronic properties of pentacene films [1.3], while F_{16}Cu-phthalocyanine films are stable against the gas exposure [4]. We found furthermore that the density of structural defects (thus gap states) of an organic film can be controlled by inserting organic template layer between the organic over layer and the substrate [5]. The defects in organic transistor films diminish also device stability. In this talk we will present results obtained by direct measurements of the density-of-states in the gap and the structural defects, which are produced by *weak physical perturbation*, using the UPS and X-ray scattering, respectively. The inert gas induced gap states are of fundamental importance for a better understanding of the nature of organic semiconductors, but are also of high practical importance because current processing steps in organic devices always include exposure to inert N_2 atmosphere. We will then show a successful application of the gap-state (trap-state) control [5] to fabricate higher performance C_{60} transistor with C_{60} films prepared on diindenoperylene (DIP) template layer (Table 1 and Fig.1) [6]. The C_{60} transistor with the DIP shows much higher electron mobility and device stability due to less trap states [6].

Table 1 C_{60} OFET performance with and without DIP template layer.

Transistors	μ_n[a] ($cm^2\ V^{-1}\ s^{-1}$)	I_{ON}/I_{OFF}	V_T (V)
C_{60} with DIP	2.62 ± 0.32	4×10^5	5
C_{60} without DIP	0.21 ± 0.10	3×10^4	17

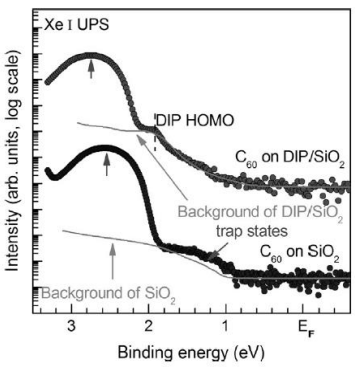

Fig.1. Xe I UPS (log scale) of the C_{60}-HOMO region for C_{60}(15nm) on SiO_2 and C_{60} (15nm) on DIP(3nm)/SiO_2. The spectral difference demonstrates drastic decrease of the density of occupied gap states in the C_{60} film on DIP film, indicating similar decrease of the unoccupied gap states.

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Transition Metal Phosphors and OLED Fabrications

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Keywords: organic light emitting diodes, osmium, iridium, platinum, phosphorescent**.**

Luminescent third-row transition metal Os(II), Ir(III) and Pt(II) based complexes, particularly those with cyclometalating chelates and equivalents, play a key role in the recent development of optoelectronic technologies such as organic light emitting diode (OLED), light emitting electrochemical cells, and solid-state organic lighting applications. The attraction of these complexes comes from their higher chemical stability due to the strong metal-ligand bonding interaction, as well as the longer excitation lifetimes and higher emission quantum yields. Furthermore, the strong spin-orbit coupling induced by the central metal ion promotes an efficient intersystem crossing from the singlet to the triplet excited state manifold, which then facilitates strong electroluminescence by harnessing both singlet and triplet excitons of the as-fabricated optoelectronic devices. As a result, syntheses of these metal complexes were extensively examined. In this presentation, the recently development of new OLED phosphors, particularly those constructed with functionalized pyridyl azolate fragments, as well as those have showed bright blue phosphorescence, will be elaborated in a systematic manner.

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11.2

Universal Bipolar Host Materials And Exciplex For White OLEDs

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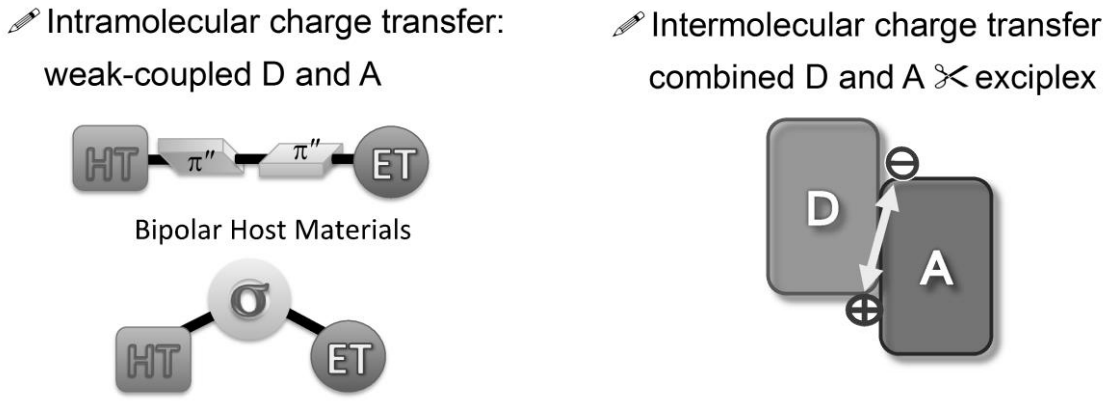
Keywords: electrophosphorescence, bipolar host, exciplex, delayed fluorescence, white OLED**.**

The introduction of heavy metal-based phosphorescent emitters in organic light-emitting diodes (OLEDs) is a major breakthrough for improving the electroluminescence efficiency to achieve 100% internal quantum efficiency (IQE). The high IQE is based on the use of the host-guest strategy with triplet emitter (guest) homogeneously dispersed into a suitable organic matrix (host). This method can suppress the detrimental effects such as aggregation quenching and/or triplet-triplet annihilation of phosphors. As a consequence, the selection of host materials is of great importance for highly efficient OLEDs. Recent research trends have shifted to the development of host materials possessing bipolar property, which can give balance carrier transport, well-defined electron-hole recombination zone within the emitting layer and reduced efficiency roll-off. The physical properties of bipolar host materials can be manipulated by rational molecular design with the judicious selection of hole-transporting (HT) and electron-transporting (ET) subunits and their linking topology. In this conference, our recent efforts on the development of carbazole-based bipolar host materials equipped with various ET-type functional moieties suitable for efficient red, green, blue and white electrophosphorescent devices will be reported. Another emerging strategy to harvest the electrically generated triplet exciton is to take advantage of delayed fluorescence through a reverse intersystem crossing (RISC) process. The essential requirement to give efficient RISC is the low singlet-triplet energy difference, which can be feasibly achieved by the subtle intramolecular and/or intermolecular charge transfer state. In this conference, our progress of using exciplex to generate efficient OLEDs and a new strategy for giving high efficiency (> 10%) pure fluorescence white OLED will also be presented.



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New Schemes for Enhancing the Optical Management and Carrier Transport Properties of Organic Optoelectronic Devices

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Keywords: plasmonic nanostructure, metal oxide, plasmonic-optical effects, plasmonic-electrical effects, enhanced electrical properties

A theoretical and experimental study of plasmonic organic solar cells (OSCs) and organic light emitting diodes (OLEDs) with the metallic nanostructures is presented in this talk. We will firstly discuss the optical effects of the plasmonic structures and materials effects of the metal nanomaterials (i.e. plasmonic-optical effects) on enhancing the light absorption of OSCs and emission of OLEDs. We also study the physics of the performance enhancement is explained by multiphysics model of plasmonic organic devices. Meanwhile, we propose and demonstrate the enhancement of carrier conduction of carrier transport layer by two effects. They are the effects of the plasmonically induced carrier generation and enhanced carrier extraction of the carrier transport layer (i.e. plasmonic-electrical effects) and the effects of carrier accumulation for filling the trap states of carrier transport layers and thus improving electrical conduction. With the understanding, we will propose a new plasmonic-electrical concept to manipulate electrical properties of organic devices including photocarriers recombination, transport and collection. As a proof-of-concept, OSCs comprising metallic planar and grating electrodes are systematically investigated with normal and inverted device structures. Interestingly, although strong plasmonic resonances induce abnormally dense photocarriers around a grating anode, the grating-inverted OSC is exempt from space charge accumulation (limit) and degradation of electrical properties in contrast to the planar-inverted and planar-normal ones. The particular reason is that plasmonically induced photocarriers redistribution shortens the transport path of low-mobility holes, which are collected by the grating anode. The work demonstrated and explained the space charge limit (SCL) breaking with the plasmonic-electrical effect. Our results show that the power conversion efficiency of organic solar cells can be enhanced by over 30% and the value of power conversion efficiency can reach about 9.2% depending on the metallic nanostructures, device structures, and the polymer materials. Details of the improvement will be discussed. Consequently, the plasmonic-optical and plasmonic-electrical effects/concepts will open up a new way to manipulate both optical and electrical properties of semiconductor devices simultaneously.

We will also introduce novel low-temperature solution-based approaches to fabricate novel carrier transport layers for the emerging technologies of low-cost and large area photovoltaics. For hole transport layer, we will demonstrate the common one-step solution approaches applied for MoO_x, V_2O_x and WO_x. With the approach of intercalation, we can tune the workfunction of the metal oxides by over 1.1eV for functioning as both electron and hole transport layers in organic optoelectronic devices. For electron transport layer, we will demonstrate a self-assembly approach to form high quality TiO_2. Our results show that besides OSCs, the carrier transport layer can be applied to other devices such as OLEDs and dye sensitized solar cells (DSSCs) to improve their performances.

For flexible transparent electrode, we propose and demonstrate a new approach through a low-cost, robust, room-temperature and atmosphere process to fabricate conductive silver nano-network comprised of silver nanowires and silver nanoparticles. To be more specific, silver nanoparticles are selectively grown and chemically integrated in situ at the junction where silver nanowires meet. The site-selective growth of silver nanoparticles is achieved by plasmon-induced chemical reaction using a simple light source at very low optical power density. Interestingly, our silver nano-network is readily peeled off in water which can be easily transferred to other substrates and devices for versatile applications. We demonstrate the feasibly transferrable silver conductive nano-network as the top electrode in OSCs.

11.4

Reverse Intersystem Crossing from Upper Triplet Levels to Excited Singlet: A "Hot excition" Path for OLEDs

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Keywords: reverse intersystem crossing (RISC), organic light-emitting diodes (OLED), exciton statistics, hybridized local and charge-transfer state (HLCT), hot exciton.

Since researches on the fate of highly excited triplet states demonstrated the existence of reverse intersystem crossing (RISC) from upper triplet levels to singlet manifold in naphthalene, quinoline, isoquinoline, etc. in 1960s, [1] this unique photophysical process was then found and identified in some other aromatic materials. However, the early investigations mainly focus on exploring mechanism of this photophysical process; no incorporation of specific application was implemented. Until recently, our group innovatively utilized this "sleeping" photophysical process to enhance the efficiency of fluorescent organic light-emitting diodes (FOLEDs) by simultaneously harvesting singlet and triplet excitons. As compared with the RISC from the lowest excited triplet state (T_1) to the lowest excited singlet state (S_1) (for example, TADF and TTA mechanism), here, we define the RISC process involved the low-lying excited states ($T_1 \rightarrow S_1$) as a "cold exciton" process, whereas the high-lying excited states ($T_m \rightarrow S_n$, $m \geq 2$, $n \geq 1$)) is defined as a "hot exciton" process. Efforts are devoted to developing materials with high photoluminescence efficiency and effective RISC from "hot exciton" through appropriate molecular design in a series of donor-acceptor (D-A) material systems.[2-4] The experimental and theoretical results indicate that these materials exhibit hybridized local and charge-transfer excited state (HLCT), which achieve a combination of the high radiation from local excited state and the high $T_m \rightarrow S_n$ ($m \geq 2$, $n \geq 1$) conversion along charge-transfer excited state. As expected, the devices exhibited favorable external quantum efficiency (EQE) and low roll-off, and especially the exciton utilization efficiency exceeding the limit of 25%. Therefore, our strategy with hot exciton RISC provides a new approach to design next-generation organic electroluminescent materials with the low-cost and the high-performance.

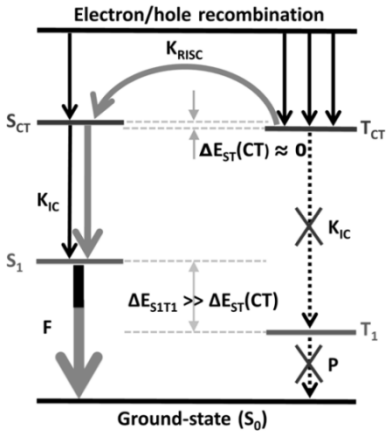

Figure 1. The "hot exciton" RISC in the electroluminescence process.

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Highly Efficient New Emitting Materials Based on Multi-Core Chromophores for Blue Fluorescence OLEDs

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Keywords: OLED, Fluorescence, Blue emitting material, Multi-core, Side groups

We recently reported the syntheses of new dual core chromophore materials containing anthracene and pyrene that exhibit high PL efficiencies.[1] There is a dihedral angle of approximately 90° between the two chromophores in a dual core composed of anthracene and pyrene. Compounds based on dual cores have advantages such as the prevention of excimer formation and improvements in the efficiency and lifetime of devices.

However, there has been a lack of research into such dual core materials; no systematic study of the substitution of side groups onto dual cores has previously been performed. In this study highly efficient blue emitting materials consisting of dual core derivatives with phenyl and/or naphthyl side groups and asymmetric or symmetric structures were designed and synthesized. The asymmetric structures 1-naphthalen-1-yl-6-(10-phenyl-anthracen-9-yl)-pyrene (Ph-AP-Na) and 1-(10-naphthalen-1-ylanthracen-9-yl)-6-phenyl-pyrene (Na-AP-Ph), and the symmetric structures 1-phenyl-6-(10-phenylanthracen-9-yl)-pyrene (Ph-AP-Ph) and 1-naphthalen-1-yl-6-(10-naphthalen-1-yl-anthracen-9-yl)-pyrene (Na-AP-Na) were synthesized.

Of the synthesized compounds, Na-AP-Na was found to exhibit the highest EL device efficiency of 5.46 cd/A. The lifetime of the Na-AP-Na device was more than three times longer than that of the AP dual core (1-anthracen-9-yl-pyrene) device.

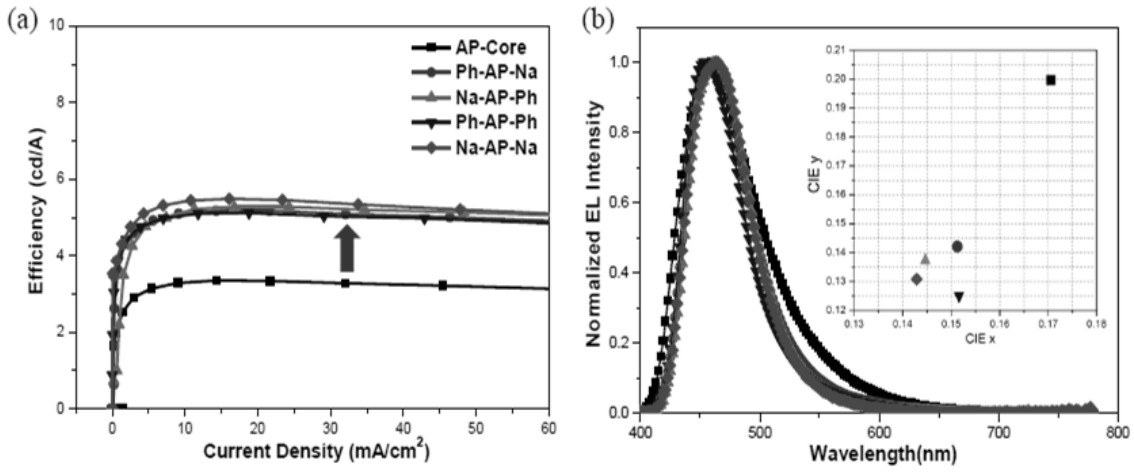

Fig.1 (a) Luminance efficiency versus current density, (b) EL spectra and CIE diagram.

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12.2

Aggregation-Induced Emission

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Typical chromophores usually suffer from weakening or quenching of light emission caused by aggregation. This notorious photophysical effect is practically harmful, as luminophores are commonly used for real-world applications in solid state or aqueous media, where chromophores tend to form aggregates. We have discovered a diametrically opposite phenomenon that chromophores are non-emissive when molecularly dissolved and induced to luminesce by aggregate formation. We termed this unusual process as aggregation-induced emission (AIE) and identified the restriction of intramolecular motion (RIM) as the main cause for the AIE effect. Based on the RIM mechanism, we have developed a wide variety of AIE luminogens with broad emission range covering visible and near-IR region and high luminescence quantum yields. We have demonstrated the great utility of the AIE systems and explored their high-tech applications in such areas as optoelectronic devices, chemo/biosensing and biological imaging.

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Pentacene-Based Organic Transistor Memory Devices with Charge-Storage Floating Gate

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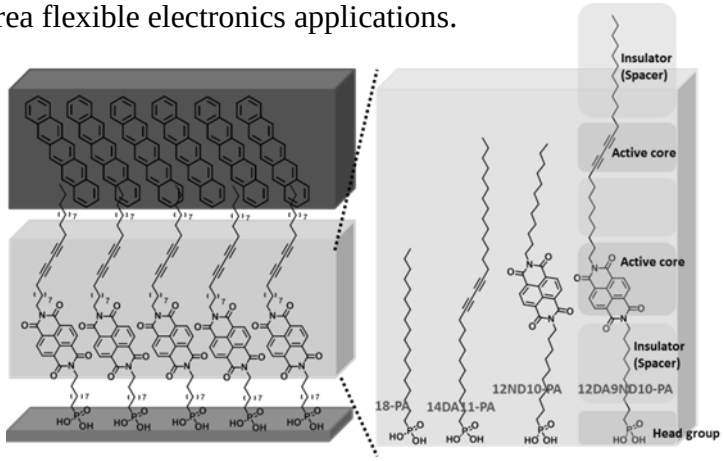
Keywords: Organic memory device, self-assembled monolayer, field-effect transistor, electric bistability**.**

Organic memory device constitutes an essential component for data processing, storage and communication in realizing all-organic electronic devices. Among various types of memory devices, transistor-based memory device is attractive for structural integration. The memory effect can be achieved in a transistor by inserting a charge-trapping floating gate between the semiconductor and the gate dielectric to give the electric bistability needed in the memory function.

We have assessed carrier traps based on metal nanoparticles, conjugate diacetylenic polymer, self-assembled monolayers for their role as floating gate in fabricating the transistor memory device.[1-4] The performance characteristics such as width of memory window, switching response time, memory retention time are dependent on the structure of the charge trapping moieties, which allow some room for rational design. In this presentation, a flexible, low-voltage and non-volatile memory device is designed by implanting a single molecular layer on aluminum oxide dielectric surface in a pentacene-based organic transistor. The monolayer-forming molecule contains different functional core groups flanked between two alkyl chain spacers. The memory characteristics strongly depend on the type of monolayer used due to localized charge trapping in different core groups, including diacetylenic unit (DA) as the donor, naphthalenediimides unit (ND) as the acceptor, and the ones with both DA and ND in the same molecule, respectively. The device with the molecule containing both donor DA and acceptor ND shows better device performance than others in terms of memory window and retention time. This hybrid organic monolayer/inorganic dielectric device also exhibited rather stable device characteristics upon bending of the substrate. The simple and low temperature processing procedures of the key elements (self-assembled monolayer) could be integrated with large area flexible electronics applications.



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Abstract of Posters

P-01

A-D-A Type Organic Dyes Employing Coplanar Heteroarene for Efficient Small Molecule Organic Solar Cells

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Keywords: fused π system, coplanar, rigid, heteroacene, organic solar cells

Organic solar cells (OSCs) have attracted great attention in recent years because of their potential advantages such as cost effective fabrication, mechanical flexibility, color-tunable feature, and low environmental impact production which make them as possible alternative to the conventional Si-based solar cells.[1] The molecular design strategies of efficient electron donors in OSCs generally involve the combination of electron-rich group and electron-deficient group to facilitate effective intramolecular charge transfer (ICT) which can reduce the bandgaps of molecules and extend the absorption spectrum towards longer wavelength. Among various molecular architectures, photovoltaic devices utilized the molecules adopting symmetrical acceptor-donor-acceptor (A-D-A) configuration have achieved promising performance. On the other hand, ladder-type π-conjugated molecules with fully-fused coplanar backbone are emerging as a new class of compounds for organic optoelectronics because of their diverse and interesting properties such as intense photoluminescence and high carrier mobility.[2] Accordingly, we used the fused pentacyclic and hexacyclic heteroacenes as donor moieties and dicyanovinylene as acceptor to synthesize new organic dyes DTPTDCV and DTPTtDCV (Fig. 1). The incorporation of rigid and coplanar features into the donor-acceptor system can enhance π-electron delocalization and elongate effective conjugation length, resulting in higher photocurrent due to a better spectral response. Moreover, the stiff molecular frameworks can suppress the conformational disorder and reduce the reorganization energy upon electron transfer, destined to enhance intrinsic charge mobility. As a result, the solar cells based on **DTPTtDCV** shows a power conversion efficiency (PCE) of 3.02% and the device based on **DTPTDCV** performing a PCE up to 5.64% was achieved. The results will be presented in this conference.

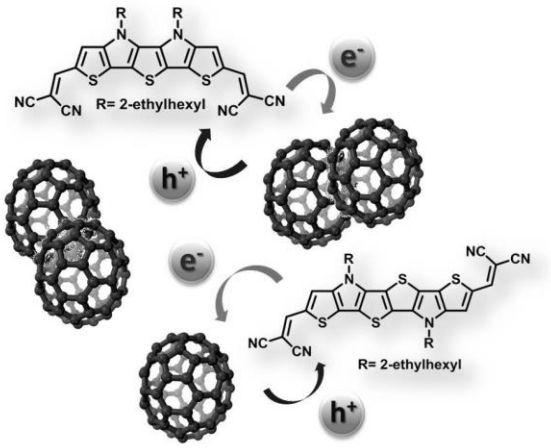

Fig. 1

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P-02

Highly flexible bending deformation in single crystalline diamond nanoneedles for biomedical applications

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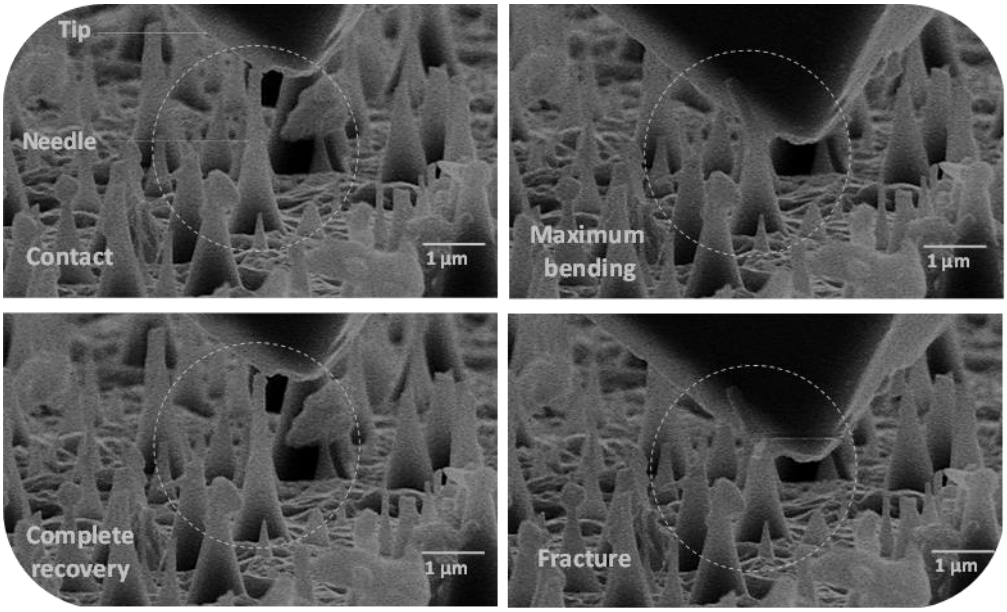
Keywords: Diamond structure, Nanoneedle, brittle failure, flexural deformation, Nanomechanics.

Through *in situ* investigations performed by a quantitative nanoindenter inside a scanning electron microscope (SEM), we report that single crystalline cone-shaped artificial diamond nanomaterial (nanoneedles), fabricated by plasma assisted deposition and etching, can undergo highly flexible and reversible bending deformation before experiencing brittle failure. The dimensions of the nanoneedles utilized during the present experiments belong to the following ranges, length: 0.5 – 3 μm, base diameter: 200 – 900 nm, and the tip diameter: 50 – 150 nm respectively. Through systematic mechanical characterizations conducted by indentation, compression, and flexural deformation modes, the mechanical properties of diamond nanoneedles are evaluated. The material is observed to retain its high hardness and Young's modulus, in addition the nanoneedles are observed to obtain as much as 13 – 19 % local flexural strain at failure. Due to the *in situ* nature of the experiments, the visuals of the bending deformation and the failure mechanism of the nanoneedles under loading and unloading cycles are revealed and correlated with classical beam theory. These nanoneedles have recently been shown to find promising applications in intracellular drug delivery by several groups.



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Efficient emitters based on neutral Ir(III) complexes with bis-tridentate chelates

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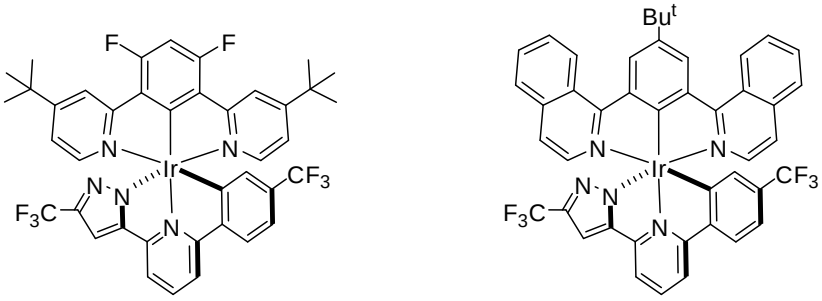
Keywords: Iridium complex, tridentate chelate, OLED**.**

Organic light emitting diodes (OLEDs) hold great promise for the emerging commercial market of both the flat panel displays and solid state luminaries. For continuous improving relevant technologies, it is essential to acquire various light emitting material, particularly the transition-metal based phosphors, with higher efficiencies and having all three elementary colors, namely: red, green and blue. Unlike the extensive studies of iridium complexes with bidentate ligands as OLED phosphors, there is no sufficient attention to those with terdentate ligands, even though they might be expected to offer advantages such as improved chemical stability, for example.

In this paper, a new series of iridium complexes (**1**-**2**) with bis-tridentate chelates were prepared and their device performances were discussed.



1 **2**

We preliminarily fabricated two multi-layer OLEDs devices with the configuration consisting of ITO / TAPC (40 nm) / mCP: （**1** or **2**） 8.0 wt % (30 nm) / TmPyPB (50 nm, device A for **1**) or BP4mPy (50 nm, device B for **2**) / LiF / Al. All the OLED performances are summarized in Table 1. The turn on voltage was 3.8 V for device A and 3.7 V for device B. The external quantum efficiency was evaluated to be 13.2 for **1** and 14.7 for **2**.

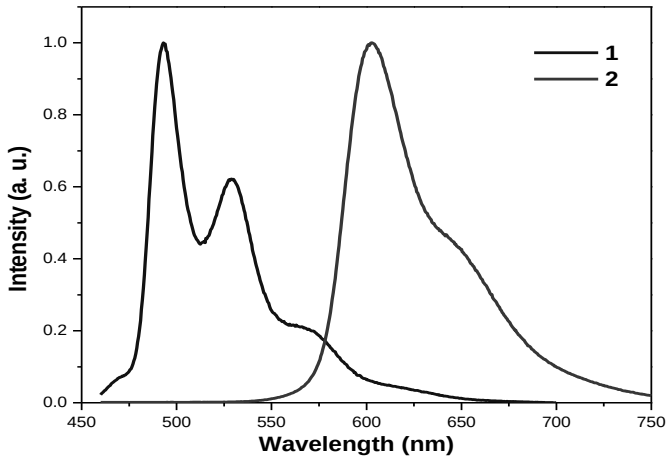


Figure 1. PL spectra of iridium complexes in CH_2Cl_2.

Table 1. Performances of the electrophosphorescnt devices.

Device		η_{xt}[%]	η_l[cd/ A]	η_p[lm /W]	V_{on} (@ 1 cd/m^2)	CIE [x, y] (@ 100 cd/m^2)	L_{max} [cd/m^2]
A	Peak	13.2	41.4	35.5	3.8 V	(0.305, 0.582)	15787 (11.0 V)
	100 cd/m^2	13.0	40.7	26.6			
B	Peak	14.7	21.8	21.9	3.7 V	(0.628, 0.368)	24416 (13.4 V)
	100 cd/m^2	13.6	20.1	11.2			

In summary, we have developed a new series iridium complexes and demonstrated that good OLED performance is possible using such complexes.

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Deep Blue Emission p-n Type Polyfluorenes with Steric Hindrance Effects, Exhibiting Excellent Thermal, Morphology and Spectra Stability

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Keywords: Fluorinated, steric hindrance effects, p-n type, polyfluorenes, stability.

P-n copolymerization serves as the most effective toolbox to tune the properties both inter and intra molecules in plastic semiconductor materials. Here, a serial of polyfluorenes containing tetrafluorobenzene were synthesized by facile palladium-based direct aromatization. The band gap of the poly (2,7-fluorene-co-alt-1,4-tetrafluorobenzene)s poly(PFs-alt-TFP) were broadened expectedly by incorporating electronic deficient tetrafluorobenzene, exhibiting a deep blue emission and low HOMO energy level, which enhanced the antioxidant capacity. The polymers with steric hindrance effects all showed excellent stability, including thermal, spectra and morphology, compared to 9,9-dioctylfluoene one. Therefore, p-n type polyfluorenes with steric hindrance effects prepared by direct aromatization is promising strategy for stable solution processing semiconductors for commercial applications.

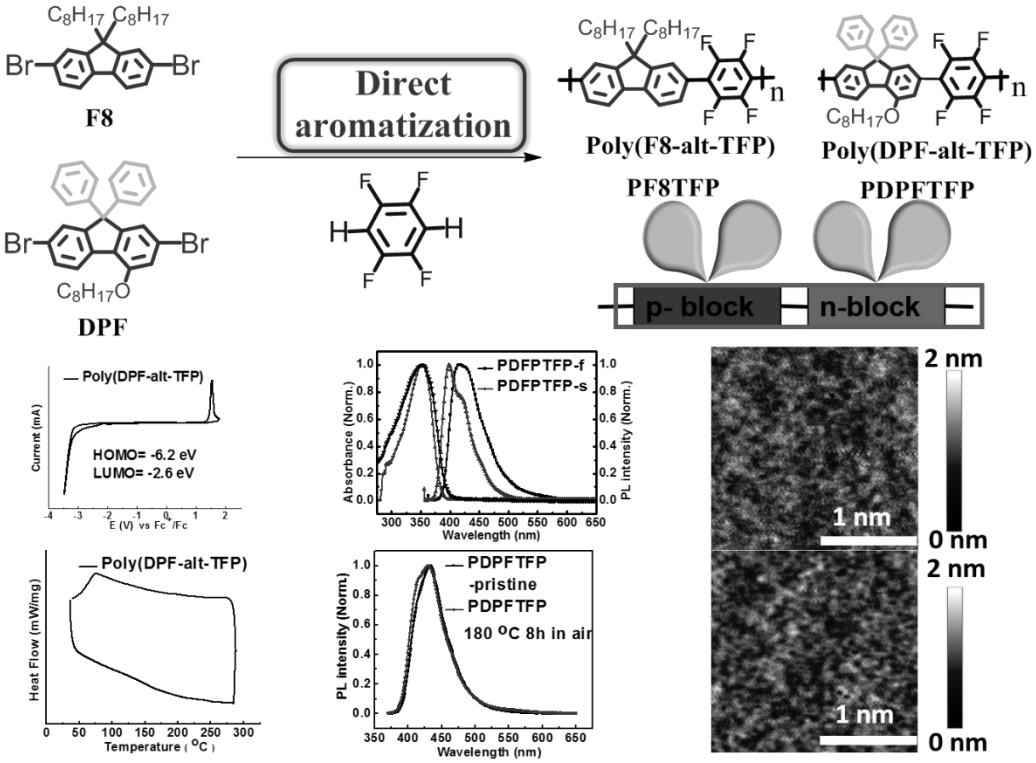

Figure 1. The UV and PL spectra was obtained from spin-coated film (f) and dilute solution (s), respectively; the annealing PL spectra was obtained from film after 180°C in air for 8 hours; the AFM images stand for pristine film (upper) and film under annealing for 180°C in air for 3 hours (down).

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P-05

Enhanced Self-Assembled Monolayer Treatment on Polymer Insulator for Organic Field-effect Transistor

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Poly-4-vinylphenol, poly(methyl methacrylate) and cross-linked PVP are employed as polymeric insulator and chemical vapor deposition is used to form self-assembled monolayer on polymeric insulators surface. An ordered molecular orientation is formed with larger grains resulting in improved carrier mobilities, and low threshold voltages (V_T) with self-assembled monolayer on polymeric dielectrics. Moreover, ultraviolet/ozone (UVO) treatment is ultized to enhance the alignment of HMDS monolayer on polymeric insulator surface and a time dependent effect is observed for UV/ozone treatment. For PVP and cross-linked PVP substrates, a short UVO exposure enhances the HMDS reaction on the polymer surface, and a long UVO exposure shows an adverse effect. On the other hand, PMMA is found to be more sensitive to UVO treatment and displayed performance degradation. These findings will be of value for solution processed insulators for printable electronic applications on flexible substrates.

The Open-circuit Voltage Dependence on Bulk Energy and Electrode Interfacial Potential in Perovskite Solar Cells

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Keywords: perovskite solar cells, electrode interfacial potential, bulk energy and open-circuit voltage

The open-circuit voltage (V_{OC}) dependence on bulk energy and electrode interfacial potential is investigated by using the capacitance-voltage and photoluminescence intensity measurements based on the planar heterojunction perovskite solar cells. We find that the V_{OC} would be reduced by increasing the annealed time for perovskite film (Figure 1). Our experimental results indicate that two major factors exist in reducing the V_{OC} with the increase of annealed time: the lower bulk energy and the higher electrode interfacial potential in the opposite direction with the built-in potential. The peak wavelength (λ_{peak}) in the photoluminescence spectrum would shift to the larger value with increasing the annealed time. It indicates that the perovskite film with longer annealed time has the lower bulk energy. While the light-intensity dependent capacitance-voltage measurements show that more free charges are accumulated at the interface in the devices with the longer annealed time, resulting in the higher electrode interfacial potential. Therefore, the bulk energy and the electrode interfacial potential play an important role in determining the V_{OC} in perovskite solar cells.

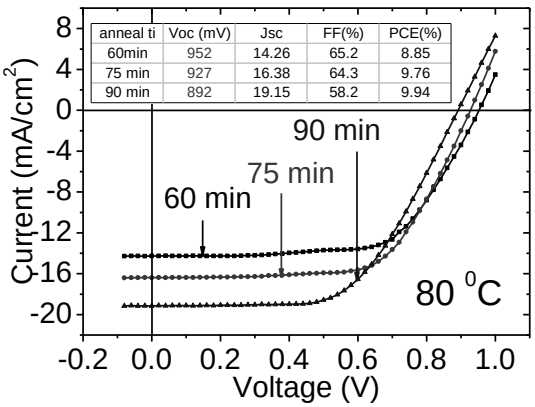

Figure 1 the current-voltage characteristics for perovskite solar cells with varied annealed time

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P-07

Bulky D-A-type (p-n) Organic Charge Trapping Elements of Cyano-Substituted Spirofluorenes for High-Performance Transistor Memory

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Keywords: spirofluorene, p-n type, organic charge trapping elements, transistor memory.

Organic memory devices have attracted extensive attentions on account of their unique advantages, such as good scalability, light weight, and low-cost fabrication process. Among the various types of organic memories, the non-volatile organic field-effect transistor (OFET) memory devices are the most striking devices since their direct smart behavior, multiple-bit storage, and nondestructive read-out property in a single transistor. As compared to the widely researched inorganic nano-floating gate, only a few attempts have been devoted to introducing the organic small molecule charge elements (OSMCEs) into FET memory. And such few small organic molecular trapping elements still do not sufficiently satisfy the criteria demanded in order to tune the electronic structure which can be matched with the energy level of the semiconductor layer to obtain smart control of charge trap and storage. Therefore, in this research, we have synthesized some cyano-substituted spirofluorenes, and successfully tuned their electronic band and dipole moments so that their bandgaps can be more matched with energy level of the semiconductor layer to obtain smart control of charge trap and storage. The FET memory characteristics of these trapping elements (Fig. 1.) showed that the negative shit of V_{th} was 39.3 and 31.4 V in the symmetric spirofluorenes, respectively. However, the $\triangle V_{th}$ is only 8.3 V when the situation is asymmetric system. We also have found that these cyano-substituted spirofluorenes can be erased only under the 365nm irradiation circumstance without any gate bias voltage. Such D-A-type (p-n) OCTMs provide a promising design strategy for organic charge trapping elements in transistor memory.

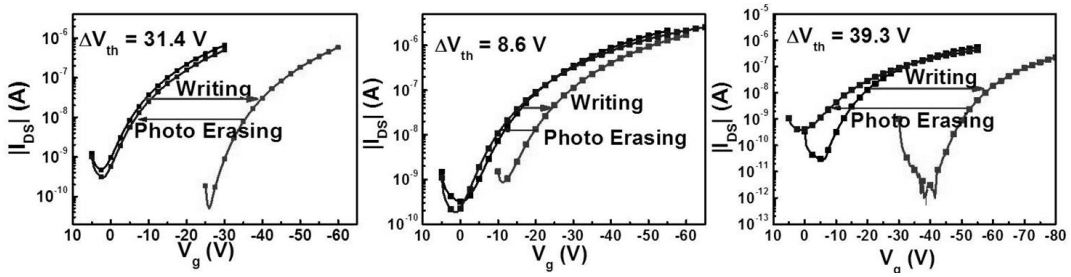

Fig. 1. Reversible shifts in V_{th} of photo-responsive transistor memory device with cyano-substituted spirofluorenes as trapping elements

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Interfacial dipole effects on charge accumulation and collection in planar heterojunction perovskite solar cells

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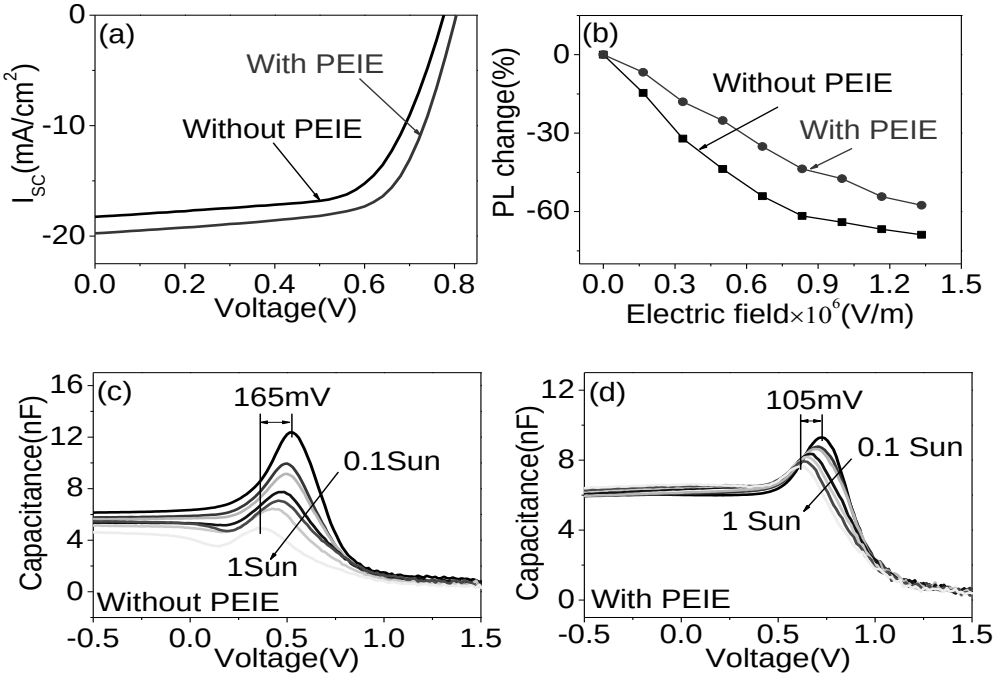
Keywords: Interfacial dipole, charge accumulation, collection, perovskite solar cells

This article reports experimental studies on the effects of interfacial dipole on surface-charge accumulation and collection by using electric field-dependent photoluminescence (electro-photoluminescence) and capacitance-voltage (C-V) measurements. The cost-effective and alcohol-soluble polyethylenimine ethoxylated (PEIE) thin layer is used as the cathode interlayer in planar heterojunction perovskite solar cells. In electro-photoluminescence measurements, we find that the device with PEIE layer shows a smaller photoluminescence quenching value at a certain applied electric field. This provides the direct evidence that the incorporation of PEIE interlayer forms interfacial dipoles at the PCBM/cathode interface, in the direction against the applied electric field. Our C-V measurements find that the Vpeak shows a smaller shift with light intensity when the PEIE thin film is used. This means that the interfacial dipole can decrease the surface-charge accumulation at the electrode interfaces. The experimental finding indicates that interfacial dipole plays an important role in the surface-charge accumulation and collection in the generation of photocurrent in perovskite solar cells. We demonstrate that the device performance can reach the power conversion efficiency of 10.5% when incorporating a thin layer of PEIE to enhance the charge transport and collection in perovskite solar cells. Clearly, this study provides a promising pathway for device process for high efficient perovskite solar cells.



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P-09

High-cycle fatigue testing of individual nanowires based on DMD

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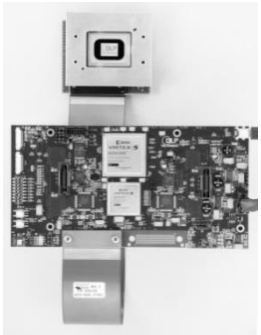
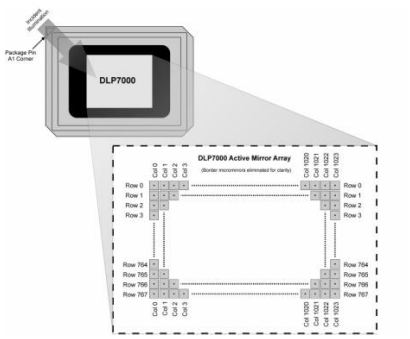
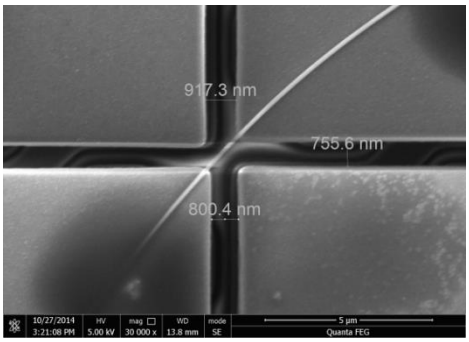
Keywords: fatigue, in situ mechanical testing, MEMS, nanowire, DMD**.**

Nanowires have been used in more and more applications, such as next generation bio-sensors and flexible electronics. However, the reliability and the lifetime of such devices undergoing repeated cyclic loading highly depend on the nanowires' fatigue performance. Despite extensive research into the mechanical properties of one-dimensional nanomaterials, such as metallic/semiconductor nanowires and carbon nanotubes, for the past two decades, experimental data on the fatigue behavior of these 1-D nanostructures have rarely been reported, especially for high cyclic fatigue. Recently, MEMS-based devices had been developed and adopted for testing low-dimensional nanostructures. Here, instead of designing a dedicated MEMS device, we propose to adopt a commercially available MEMS product ---DMD (Digital Micromirror Device, by Texas Instruments) for the development of a novel nano-fatigue testing platform. The ultimate goal of this research is establish an entirely new platform for high-cycle fatigue study of individual 1-D nanomaterials, and to offer some critical insights into the fatigue mechanisms and life prediction for nanowire/nanotube-based electronic device applications.







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Bipolar spin-filtering, rectifying and giant magnetoresistance effects in zigzag silicene nanoribbons with asymmetric edge hydrogenation

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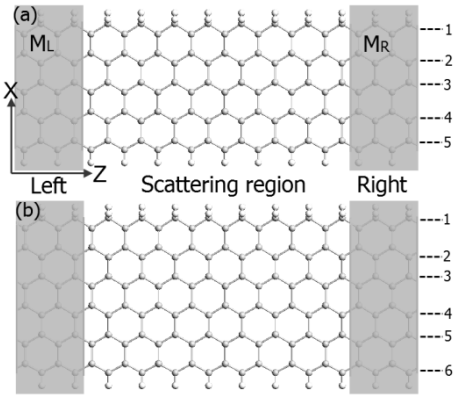
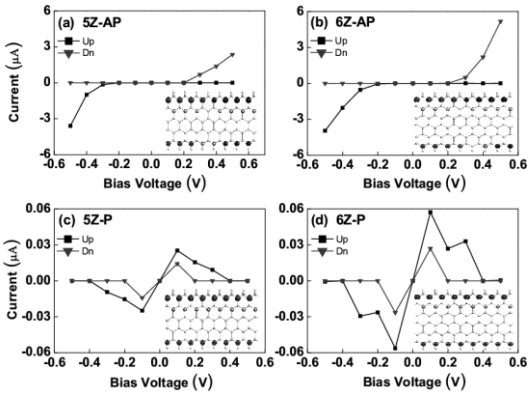
Keywords: zigzag silicene nanoribbons, asymmetric edge hydrogenation, bipolar spin-filtering, rectifying behavior, giant magnetoresistance

Graphene, one monolayer of sp^2-bonded carbon tightly packed into a two-dimensional honeycomb lattice, has drawn numerous attention as a hopeful candidate material for spintronic devices due to its high electronic mobility, gate tunability, magnetic zigzag edges and unique transport properties [1,2]. But there still exist many technical barriers in combining carbon based graphene with silicon based modern electronic industry. At this time, silicene--a material isostructural to graphene but with atomic bonds that are buckled rather than flat has been synthesized and attracts enormous research attention [3,4]. Former researches show that the silicene features a Dirac-like electron dispersion at the K points of the Brillouin zone and exhibits exciting properties beyond those present in graphene [5,6].

Usually, silicene are tailored into nanoribbons in practical applications. And it can mainly be classified into zigzag silicene nanoribbons (ZSiNRs) and armchair silicene nanoribbons (ASiNRs). ASiNRs are semiconductors, and the band gap oscillates with a period 3 dimers when ribbon width increases [7]. While the ZSiNRs have stable antiferromagnetic(AFM) states, and it can become half-metals under an external transverse electric fields [8]. When comes to the transport properties of ZSiNRs, they also posses the same symmetry-dependent properties although they have a buckled structure, and the giant magnetoresistance has been predicted in ZSiNRs connected to two semi-infinite silicene electrodes [9]. The amazing properties of ZSiNRs could give rise to many promising applications in silicon based spintronic technology. However, ZSiNRs display spin degeneracy in the AFM state, which limits their application in spintronic devices. Presently, there are many methods which can be used to break the spin degeneracy, such as an electric field, doping, defects, and edge modifying [10-12]. In particular, the asymmetric edge hydrogenation, which corresponds to the two edges with different hybridizations (i.e. sp^2 and sp^3 edges), could bring diverse magnetic properties in the silicene nanoribbons, and has attracted the research interest of many researchers recently [13]. Theoretical studies have demonstrated that ZSiNRs with asymmetric edge hydrogenation are more stable than symmetric single H saturation. Moreover, ZSiNRs with asymmetric edge hydrogenation are bipolar magnetic semiconductors and can be changed to half-metals by doping and strain [14]. The edge states can significantly affect the nanoribbons' electronic and magnetic properties, but how the asymmetric edge hydrogenation affects the transport properties of ZSiNRs remains completely unclear. Therefore we are mainly focusing on the spin-dependent transport properties of the asymmetric edge hydrogenated ZSiNRs with parallel (P) and antiparallel (AP) magnetic configurations.

Using the nonequilibrium Green's function method and the spin-polarized density functional theory, the spin-dependent electronic transport properties of ZSiNRs with asymmetric edge hydrogenation have been studied. The results show that there exists nearly 100% bipolar spin-filtering behavior in the ZSiNR-based devices with AP spin configuration. Moreover, spin rectifying behavior as high as 3400 and giant magnetoresistance with the order of 10^8 % are found in the devices. Our calculation suggests ZSiNRs with asymmetric edge hydrogenation as a promising candidate material for spintronics.





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Facile synthesis and optical characteristics of ZnSe and Mn:ZnSe quantum dots

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Keywords：ZnSe Quantum Dots Fluorescence

ZnSe quantum dots(QDs) having greater band gaps ranging from 2.8–3.4 eV (bulk ZnSe having a band gap of 2.7 eV) was especially interesting emitting materials over a region from UV to blue, which demonstrated a potential application of light-emitting diodes,[1] photovoltaic solar cells,[2] Zn-based doped quantum dots with strong dopant emission and high PL conversion efficiency(>40%) had the advantages of lower toxicity, larger stocks shift which enhanced thermal and environmental stability.[3]

In the present work, ZnSe and Mn:ZnSe quantum dots were successfully synthesized in aqueous media by a simple low-cost method using the thiol ligand as capping reagent. When the molar ratios of Zn:Se:TGA in the solution were 1:0.25:2.5, Zn:Mn:Se:MPA were 1:0.5:1.1:10, respectively, which yielded high optical performance quantum dots. The as-prepared ZnSe QDs showed emission at 411 nm with FWHM 25 nm under UV illumination for 4 hours. Mn:ZnSe QDs showed emission at 591 nm with FWHM 57 nm, the original bandgap emission was quenched almost completely, accompanied by the appearance of a new emission peak at 591 nm, which was ascribed to the $^4T_1$–$^6A_1$ transition of the Mn^{2+} doping centers. The obtained ZnSe QDs and Mn:ZnSe QDs had higher fluorescence performance properties.[4] The energy level structural models explained the process of the formation of fluorescence in photovoltaic devices to enhance the light-harvesting ability in the short-wavelength range.

In the next work, composite structures of organic/inorganic hybrid solar cell incorporation of ZnSe QDs and Mn:ZnSe QDs will be designed and studied their photophysical properties and photovoltaic performance.

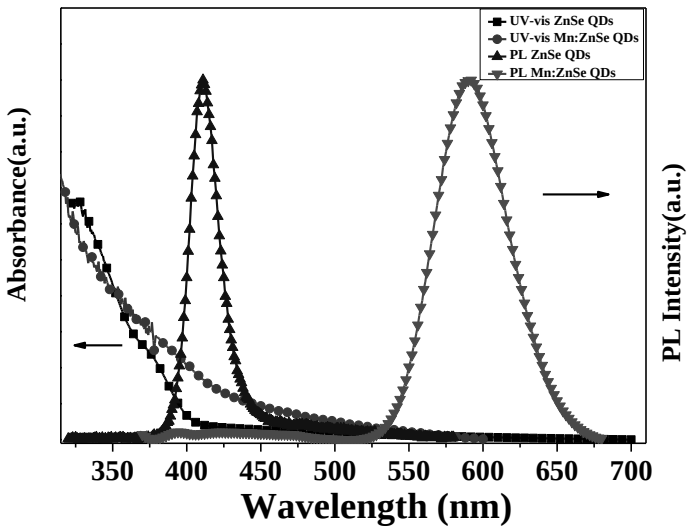

Fig. 1 UV-vis and PL emission spectra of the obtained ZnSe and Mn:ZnSe quantum dots.

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P-12

Long operation lifetime and colour stable hybrid tandem white organic light-emitting diodes for general lighting

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Keywords: electroluminescence, hybrid, organic, stack, tandem

A fluorescence blue emitting unit and a phosphorescence orange-green emitting unit were stacked to form a hybrid tandem white organic light-emitting diode (WOLED). Charge generating layers were inserted between the 2 emitting units. Firstly, the colour outputs of the devices were controlled by varying the concentration of the blue dopant in the device. With optimum blue dopant concentration, C.I.E. coordinates of (0.48, 0.44), (0.42, 0.40) and (0.38, 0.37) were obtained at 7 V, 10 V and 15 V respectively. To further improve the white coordinates and the colour stability, a layer of 2,2',2''-(1,3,5-benzinetriyl)-tris(1-phenyl-1-H-benzimidazole) (TPBi) was inserted between the electron injection layer and the electron transport layer in the blue emitting unit. With optimum interface engineering, C.I.E. coordinates of (0.39, 0.39), (0.35, 0.36), (0.33, 0.34) were obtained at 7 V, 10 V and 15 V respectively. In this paper, color stable hybrid tandem WOLED with maximum power efficiency of 60 lm/W and operation lifetime of 200,000 hours were reported.

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The influence of the thickness of electron transport layer on the properties of organic light-emitting diodes

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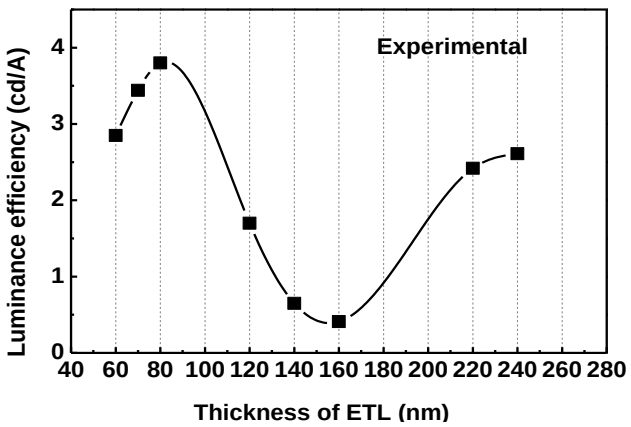
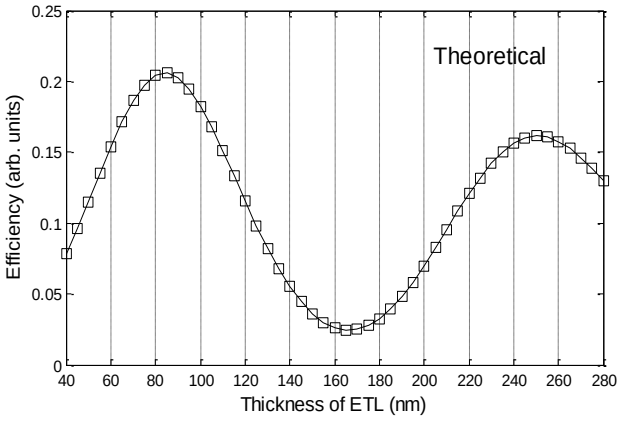
Keywords: Organic light-emitting diodes, electron transport layer, thickness,

In this study, we investigate experimentally and theoretically the influence of the thickness of electron transport layer (ETL) on the properties of the typical NPB/Alq_3 heterojunction based organic light-emitting diodes, where the the thickness of ETL is varied to adjust the distance between the emitting zone and the metal electrode. The devices show the maximum luminance efficiency of 3.8 cd/A when the ETL thickness is around 80 nm such that the emitting zone lies around at the first antinode of the metal electrode. While the devices show another lower peak luminance efficiency of 2.6 cd/A when the ETL thickness is around 240 nm such that the emitting zone lies around at the second antinode of the metal electrode. We adopt a rigorous electromagnetic approach that takes parameters such as dipole orientation, polarization, light emitting angle, exciton recombination zone and diffusion length into account to model the efficiency of devices as a function of varying thickness of ETL. It is shown that our simulation result is accurately consistent with the experimental results.





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P-14

Smart sensors for printable electronics

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Keywords: sensors, thin-films, nano-materials, flexible electronics

Thin film based smart sensors such as photo sensors, pressure sensors, gas sensors and temperature sensors are getting a lot of interest due to its high sensitivity, selectivity and simple device fabrication process. In this project, we demonstrate high performance electronic sensor based on solution processed materials. The objectives are to develop novel device structure and sensitive materials for building inexpensive wearable sensors. Various nano-materials and hybrid materials have been studied for the sensitive layer in the devices. Our efforts are focused on improving the sensitivity, selectivity, response time and recovery time of the sensors. Meanwhile, the stability and reproducibility of the sensing device are also characterized.

Nonvolatile Multilevel Organic Phototransistor Memory Using PVK Derivative as Polymer Electrets

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Keywords: OFET memory, photoresponsive, polymer electrets, charge transfer**.**

Functional organic field-effect transistors (OFETs) have attracted extensive attention due to their wide variety of potential applications, such as light detector, memory, emitting light and sensors. Actually, compared to the three terminal configutation (electrodes: gate, source and drain), organic phototransistors (OPTs) introduce light as a fourth electrode to control the channel conductance and realize multi-function. For the OPTs, the photogenerated excitons can diffuse and dissociate into free charge carriers if the illumination is removed, subsequently the different trapped charge carriers can result in bi-directional V_{th} shifts and ambipolar memory effect. And the charge transfer capacity of organic electrts in the OPTs significantly dominate the charge trapped property and device stability. In this regard, appropriate polymeric-gate electrets layers can stay the nonexponential relaxation of photoinduced conductance and enhance the memory retention time. In this work, we have fabricated the pentacene-based nonvolatile organic phototransistor memory device using novel poly(N-vinylcarbazole) (PVK) derivative as polymer electrets. It exhibits higher photosensitivity and I_{ph}/I_{dark} ratio than PVK-based device. The retention time of the ON and OFF states is maintained for 10^5 s with a high ON/OFF current ratio of around 10^4. This long retention time and stable ON/OFF current ratio indicates that this PVK derivative is a promising polymer electret for reliable, multilevel and stable nonvolatile organic phototransistor memory.

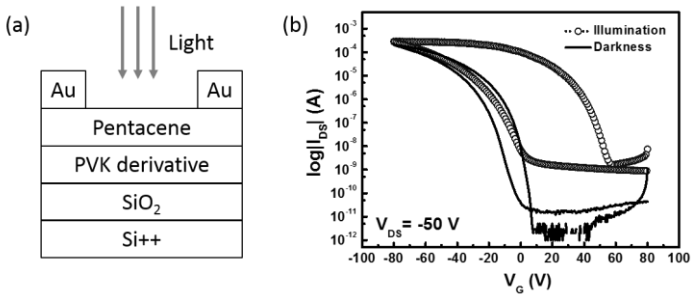

Fig. 1. (a) Schematic configuration of the OPT device , (b) The transfer characteristics of OFETs under dark conditions and under light illumination, respectively.

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P-16

Capacitance measurements to investigate exciton behaviors in organic photovoltaic materials

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Abstract:
The major obstacle to directly determine exciton behaviors in common organic photovoltaic materials (e.g. fullerene) is the absence of room-temperature luminescence. As to this issue, the capacitance dependences on incident light intensity and electric field are investigated for several typical organic photovoltaic materials. Distinctive correlations between capacitance and light intensity/electric field are observed for different samples, moreover, exciton dissociation rate of fullerene and charge density of pentacene are extracted from the C-V characteristics. All these results demonstrate a straight pathway to survey exciton behaviors in those materials with almost no luminescence at room temperature.

Synthesis and Electroluminescence Properties of Highly Efficient Dual Core Chromophores with Side Groups for Blue Emission

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Keywords: OLED, Blue emitting material, Dual core chromophores, Side group **.**

In this study highly efficient blue emitting materials consisting of dual core derivatives[1] with phenyl and/or naphthyl side groups and asymmetric or symmetric structures were designed and synthesized. The asymmetric structures 1-naphthalen-1-yl-6-(10-phenyl-anthracen-9-yl)-pyrene (Ph-AP-Na) and 1-(10-naphthalen-1-ylanthracen-9-yl)-6-phenyl-pyrene (Na-AP-Ph), and the symmetric structures 1-phenyl-6-(10-phenylanthracen-9-yl)-pyrene (Ph-AP-Ph) and 1-naphthalen-1-yl-6-(10-naphthalen-1-yl-anthracen-9-yl)-pyrene (Na-AP-Na) were synthesized.

The AP-core device has an efficiency of 3.34 cd/A but the luminance efficiencies of the devices containing the four compounds with side groups are higher, between 5.11 and 5.46 cd/A. This increase in efficiency can be explained in terms of the higher PL efficiency of the four compounds and the lower energy transfer loss that arises because of the decreased molecular packing with respect to that of the AP-core due to their side groups. Especially Na-AP-Na exhibits a high luminance efficiency, 5.46 cd/A, in a non-doped device and good color coordinate of (0.143, 0.131) that are applicable to displays requiring a blue emitter. Thus an orthogonally connected dual core can be used to produce a blue emission spectrum and prepare blue emitting materials.

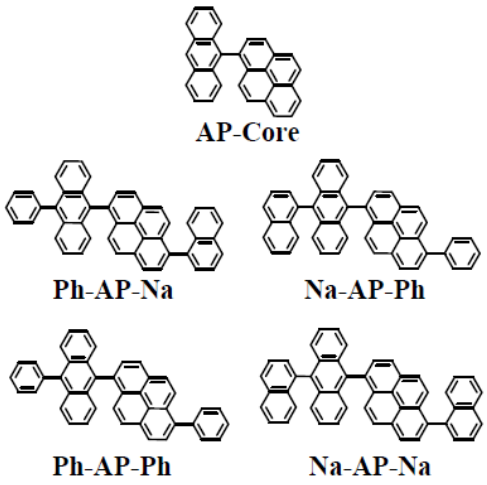

Fig.1 Chemical structures of the new blue emitting materials.

[1] B. Kim, Y. Park, J. Lee, D. Yokoyama, J. H. Lee, J. Kido, and J. Park, J. Mater. Chem. C, 1, 432 (2013)

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P-18

Study of Charge-transfer Complexes and the Application to Organic Optoelectronics

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Keywords: multi-layer, conductivity, charge-transfer complexes

Charge transfer and interactions at organic heterojunctions (OHJs) are known to have influences on various properties of organic electronic devices. First of all, recent studies of near infrared (NIR) organic photovoltaic devices (OPVs) by using charge-transfer complexes (CTCs) are summarized. Devices with photovoltaic respond from 900 nm to 1500 nm are demonstrated. The new IR absorption band is attributed to the charge-transfer complex formed by electron transfer between the donor and acceptor upon intimate contact.

In addition, high electric conductivity is observed in multilayer stack of m-MTDATA / F16CuPc. Impedance data shows that the circuit resistance is significantly dropped by three orders of magnitude from around 0.2 MΩ to around 0.4 kΩ when the number of alternating units is increased from one to six, keeping a total thickness of 300 nm. Impedance results show that as the number of alternating units increases, the organic stack shows an increasing capacitance and a decreasing resistance. This result suggests the increasing charges accumulate at the heterojunctions, leading to reduction in overall film resistance. The application of the high conductive units in OLED device results in stability enhancement.

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Alkoxyphenyl-Substituted Indacenodithiophenyl/Isomer Donor Unit for Efficient Bulk Heterojunction Solar Cells

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Keywords: solar cells, bulk heterojunction, low band gap, D-A copolymers, indacenodithiophene

Bulk heterojunction (BHJ) polymer solar cells (PSCs) have attracted much attention over the past two decades owing to their unique advantages, such as low manufacturing cost, easy fabrication, light weight characteristics, and device structural flexibility. So far, single-junction PSCs have exceeded 9% PCE. Through prolonged effort, many low-band-gap conjugated polymers have been designed and synthesized with the aim of improving charge transporting properties, narrowing the band gap to harvest more sunlight and deepening the highest occupied molecular orbital (HOMO) energy level in order to increase the open circuit voltage (Voc). Among them, indacenodithiophene (IDT) based D-A copolymers have been developed and exhibit promising photovoltaic performance due to that rigid and extended conjugated structure of IDT can effectively enhance interchain interaction of the polymers and improve charge carrier mobility higher hole mobility.

In this work, two new D-A copolymers containing IDT/isomer donor unit and DTBT acceptor unit PIDT2DTBT and PIDT3DTBT, were synthesized to study their structure-property relationships for the application in PSCs. The two copolymers show narrow bandgap and broad absorption in the visible region. Under the illumination of AM 1.5G, 100 mW/cm^2, the PSC based on PIDT2DTBT/PC71BM demonstrated a power conversion efficiency of 5.38%, which is significantly improved in comparison with that 2.29% of the device based on PIDT3DTBT /PC71BM under the same experimental conditions.

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P-20

Flexible and low-voltage organic field-effect transistors on biodegradable cellulose paper

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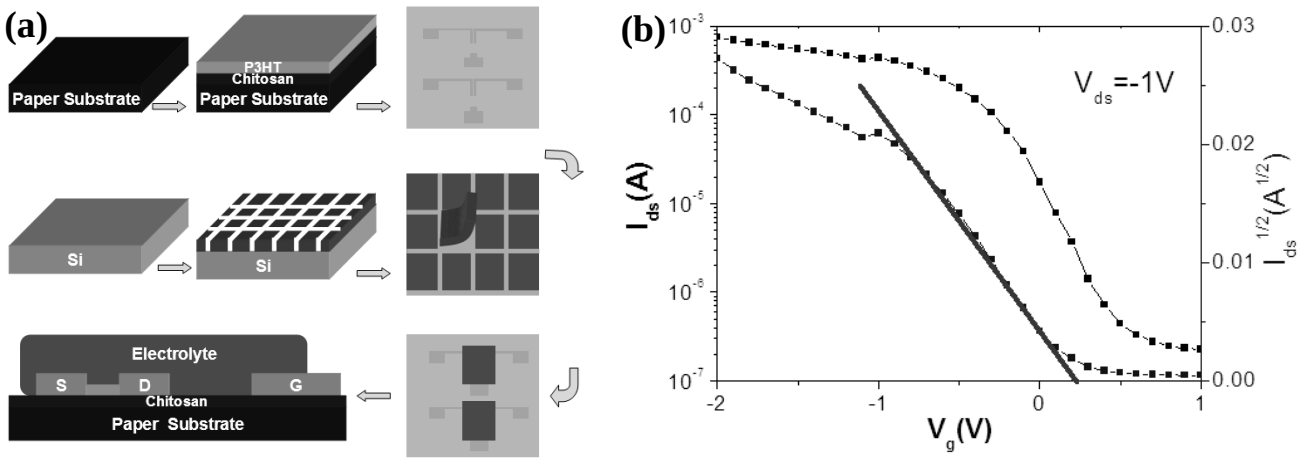
Keywords: use-and-recycle electronics, biodegradable paper, flexible organic transistors**.**

By virtue of the abundance, renewable and biodegradable properties of cellulose, paper is an excellent alternative with exceptional technological attributes and commercial perspectives for many substrates available. However, most of organic electronic devices usually require smooth interfaces, and the large surface roughness and porous structure of paper are intrinsic barriers to hosting electronic devices on this material. Here, we demonstrated the fabrication of flexible and low-voltage organic field-effect transistors (OFETs) on biodegradable paper substrates. A biopolymer chitosan was used as the smoothing layer and a free-standing ion gel laminated on in-plane-gate P3HT FETs was used as gate medium. The OFETs on paper substrates showed excellent operating characteristics with a low operating voltage of less than 2 V, a high on-current of ~0.75mA , and a current on/off ratio of larger than 10^3. Owing to the unique device structure and the simple device fabrication procedure, the ion gels were efficient recycled and reused in other OFETs without obvious device performance degeneration. These results make a step towards environmentally safe devices in low-cost, recyclable or throwaway electronic applications.



(a) A schematic diagram of the fabrication processes of the OFETs on cellulose paper. (b) Transfer characteristic curves (I_{ds} vs V_g) of an OFET on paper with V_{ds}=-1 V.

Acknowledgement

This project was supported in part by the National Natural Science Foundation of China (61306085, 11334014, 51173205), the China Postdoctoral Science Foundation (2013M530357), the Hunan Postdoctoral Scientific Program (2013RS4045), and The Postdoctoral Science Foundation of Central South University. YLG also acknowledges the support from NSF DMR-1303742.

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Surface Mechanical Attrition Treatment (SMAT)-Facilitated Fabrication of Porous Cu for Superior 3D Monolithic Supercapacitor Electrodes

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Keywords: SMAT, chemical dealloying, Cu alloys, porous metals, supercapacitors

Abstract:

A facile approach is developed to mass produce porous 3-D bulk metallic nanostructure with high purity, fine nanostructures of high specific surface area, and improved mechanical performance, at a low cost and high production rate. This approach is based on an effective mechanical pretreatment method (surface mechanical attrition techniques, SMAT) and the convenient dealloying technique. It was found that this novel approach is able to effectively remove the reactive metal at an accelerated rate, and greatly improve the morphology of the porous metallic framework, leading to 3-D bulk nanoporous structures. The porous Cu-based nanostructures obtained using this method showed superior performance for supercapacitor electrodes.

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P-22

Carries mobility in 2D Phosphorous sheets

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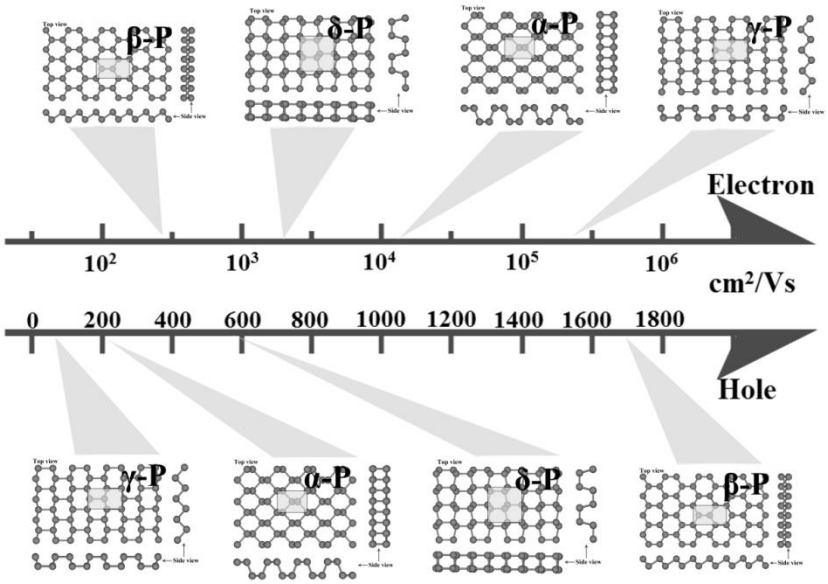
Keywords: Phosphorous sheets; Density functional theory; Electronic structure; carries mobility

There are four stable type phosphorous monolayer sheet (α-P, β-P, γ-P and δ-P) predicted by theory study [***Phys. Rev. Lett.* 112, 176802 (2014)** and ***Phys. Rev. Lett.* 113, 046804 (2014)**]. We have investigated the electronic structure and carrier mobility of four type phosphorous monolayer sheet using density functional theory combined with Boltzmann transport method with relaxation time approximation. It is shown that α-P, β-P and γ-P are indirection gap semiconductors and δ-P has direction gap. And all of four type sheets present anisotropic and have significant enough mobility which surpass MoS_2 monolayer. In α-P, β-P and δ-P sheet, charge carriers move faster along armchair direction than zigzag direction. But in γ-P sheet, the higher mobility is along zigzag direction. The electron mobility of α-P, β-P, γ-P and δ-P sheets is about 1.1×10^4, 4.7×10^2, 2.9×10^5 and 3.0×10^3 $cm^2V^{-1}s^{-1}$, respectively. The hole mobility of α-P, β-P, γ-P and δ-P sheets is about 2.0×10^2, 1.7×10^3, 7.3×10^1 and 5.9×10^2 $cm^2V^{-1}s^{-1}$, respectively. The highest mobility value (electron mobility in γ-P sheet) is even up to ~2.9×10^5 $cm^2V^{-1}s^{-1}$ which is comparable with graphene. Because of the huge difference mobility in hole and electron, α-P, γ-P and δ-P sheets can be considered as *n*-type semiconductors, and β-P sheet can be considered as *p*-type semiconductors. Our results indicate that phosphorous monolayer sheets can be considered as a new two dimensional material for applications in optoelectronics, nanoelectronic devices due to intrinsic band gap and high charge mobility.



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A Supramolecular π-Stacked Conjugated Polymer: Preventing Interchain π-π Stacking toward Deep Blue Polymer Light-emitting Diode and Laser

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Keywords: Supramolecular π-Stacked Conjugated Polymer, Single-chain Behavior, Supramolecular Conjugated Polymer Nanowires, Excellent Spectral Stability, Optoelectronic Device

For the large packing density and short inter-chain distance in conjugated polymer films, interchain π-π interactions of backbone chain can result into a wide variety of rather complex inter- or intrachain photo-physical processes, such as energy transfer, self-absorption, and excimer formation.[1] For the light-emitting conjugated polymer (LCP), interchain aggregation may lead to reduce photoluminescence quantum yield (PLQY) and energy gap, lower color purity and spectral stability.[2] These are undesirable, especially for fabrication of deep polymer blue-emitting devices (PLEDs). For the pervasive conformational and energetic disorder, an effective strategy for attaining stable deep blue emissive polymer films is to isolate the backbone chain, inhibit inter-chain interactions and further suppress aggregation.[3] Herein, we first proposed that the supramolecular π-stacked conjugated polymer (SSCPs) was an effective candidate to prevent interchain π-π stacking interaction, that the stacked units in the side chain can play as a block layer to suppress molecular aggregate and improve their spectral stability. Therefore, we introduced the carbazole (Cz) group as a pendent stacked unit into polydiarylfluorenes to fabricate a novel SSCPs, PCzODPF, as a model to investigate the effect of Cz stacked interaction on the molecular aggregation and opto-electrical property. PCzODPF exhibited intrachain absorption and emission behavior (single chain photo-physical processing) in solution, gel and film states. Moreover, PCzODPF films showed excellent spectral stability without the notorious green emission under thermal annealing at 200 °C or aging 21 days in the ambient atmosphere, indicating that the stacked Cz groups may act as a blocking layer to effective inhibit inter-chain aggregation (Figure 1). Weaker inter-chain interaction enabled single layer PLEDs with stable single chain deep blue emission, and higher current efficiency (C. E.) and lower turn on voltages than in control polymers (2.54 cd A^{-1} and 3.9 V respectively). PCzODPF also exhibits notable properties as active gain medium for polymer lasers (468 nm), leading to low lasing threshold values.

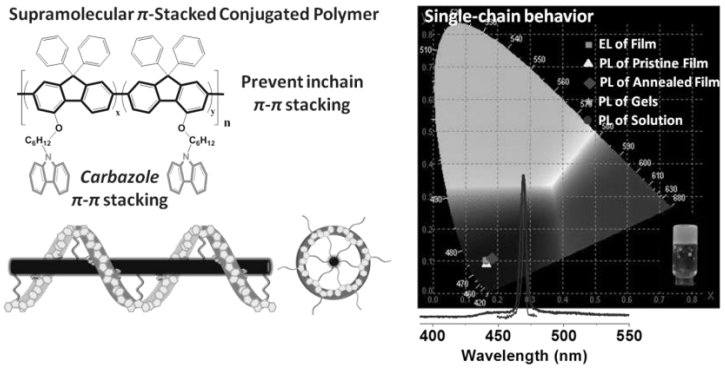

Figure 1. Schematic diagram illustrating the molecular packing model of PCzODPF and their spectra

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P-24

GO Based Quaternary States Memory

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Keywords: memory, GO, quaternary states, oxygen-migration

Increasing the number of state in each elemental cell is an effective method to increasing the data storage, and it paves a new way for the development of memory devices. We report a resistive switching device with four intrinsic states in ITO/GO/Al planar structure with GO synthesized by a modified Hummer's method characterized by oxidation twice combined with highly effective centrifugation. The GO film is prepared on an ITO glass substrate by spin-coating the homogenous solution followed by evaporating Al electrode. Electrical characterizations demonstrate it a quaternary WORM device with fine retention performance. During the first sweep, we can observe three states. Moreover, we obtain an additional stable state during the second sweeping cycle. Although the ratios are not large, the four states in GO memory device distinctly exist. We attributed them to different degrees of oxygen-migration, and variable content of oxygen in the GO layer closely dependent on the cycle number.

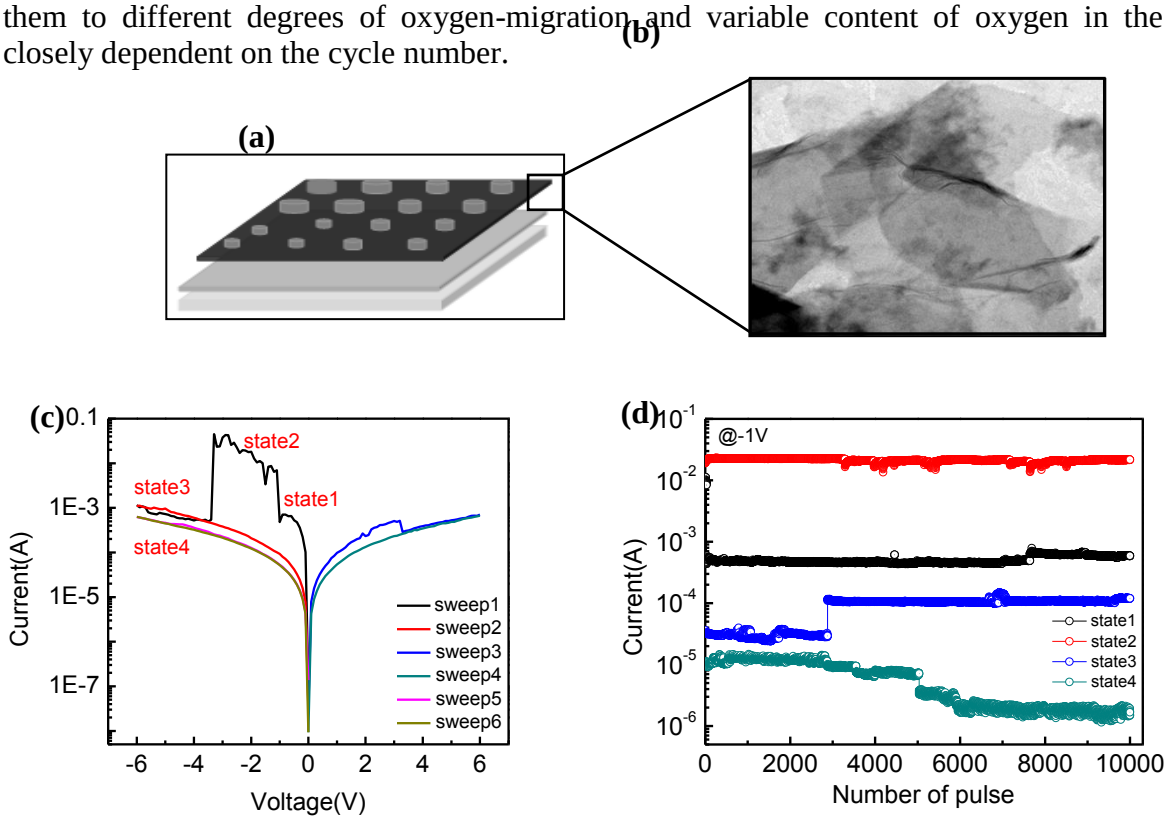

Fig. 1. Schematic illustration of ITO/GO/Al memory device (a) and TEM images (b) of GO film. I-V curves of six sweeps during -6V~6V (c) and retention characteristic (d) of each state read at -1V, corresponding to (c).

Microstructured fluorescent biosensor based on energy migration for selective sensing of metalloprotein

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Keywords: organic nanoparticles; pH-sensitive; **.**

Fluorescent microspheres consisting of a conjugated phenylenevinylene 3B2B doped with a fluorenone derivative DSFO were prepared by a reprecipitation method. The DSFO-doped 3B2B microspheres (DMPs) exhibited significantly reduced fluorescence from 3B2B (donor) and strongly enhanced emission from DSFO (acceptor), which is highly sensitive to the concentration of metalloprotein (Fig. 1). In the presence of metalloprotein, highly quenched emissions of the DMPs were observed with increasing concentrations of metalloprotein, whereas slightly increased emissions were observed with non-metalloprotein. The mechanism of quenching for metalloprotein ferritin is likely to be based on electron transfer, since there is no chromophore that could accept the excited-state energy from the DMPs. The quenching effects for cyt c and myoglobin are a result of energy and/or electron transfer processes between porphyrin cofactor and the fluorescent mcirospheres. The increased in fluorescence by non-metalloprotein is due to the induced decrease in π-π stacking of the microspheres.

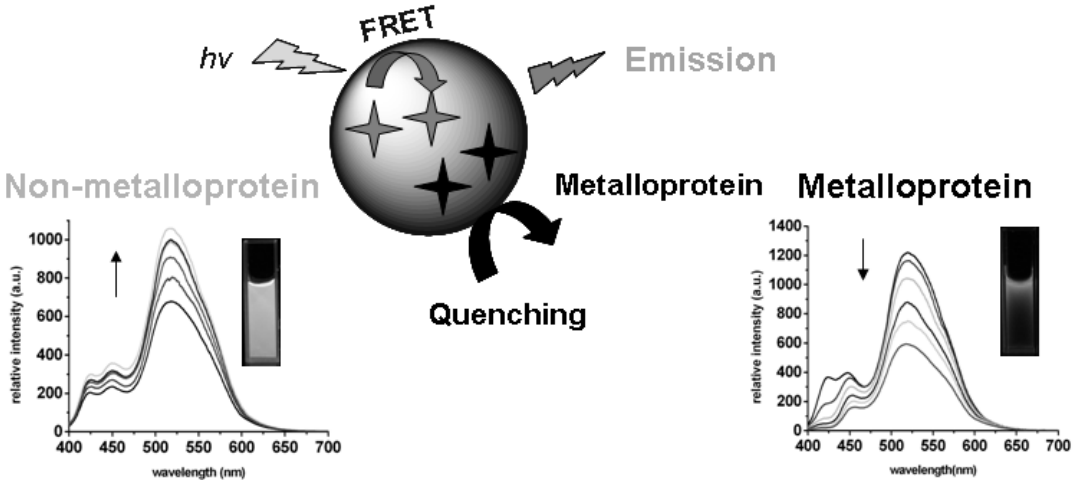

Fig. 1 Protein detection properties of DMPs

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P-26

Efficient Photo flux Manipulation for Organic Light-emitting diodes Using Bio-inspired Moth's Eye Nanostructures

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Keywords: Organic light-emitting devices, moth eye, light out-coupling, photo flux

Organic light-emitting devices (OLEDs) have been attractive in the last two decades as next-generation lighting source and full-color display panels. However, in conventional OLEDs constructed in a standard substrate emitting architecture, the out-coupling efficiency is approximately 20%, and the majority of the photo flux generated in the organic layers is confined in the devices. Here we propose a universal method of efficient photo flux manipulation by introducing bio-inspired moth's eye nanostructure into OLEDs both on ITO-glass substrates and plastic with embedded Ag networks (PEANs). For OLEDs based on ITO-glass substrate, light out-coupling efficiency of OLEDs with stacked triple emission units is over 2 times that of a conventional device, resulting in drastic increase in external quantum efficiency and current efficiency to 119.7% and 366 cd A^{-1} at a luminance of 1,000 cd m^{-2} without introducing spectral distortion and directionality. Furthermore, an efficient white OLED device structure is demonstrated, yielding an efficiency exceeding 123 lm W^{-1} through the combination of optimum light out-coupling and energy-efficient photon generation. Similarly, the flexible white OLEDs exhibit a maximum external quantum efficiency (EQE) of 49% and a record PE of 106 lm W^{-1} at 1,000 cd m^{-2} with angular color stability. These amazing results represent an exciting step towards the realization of high-efficiency OLEDs for use in a wide variety of high-performance displays and general lighting applications.

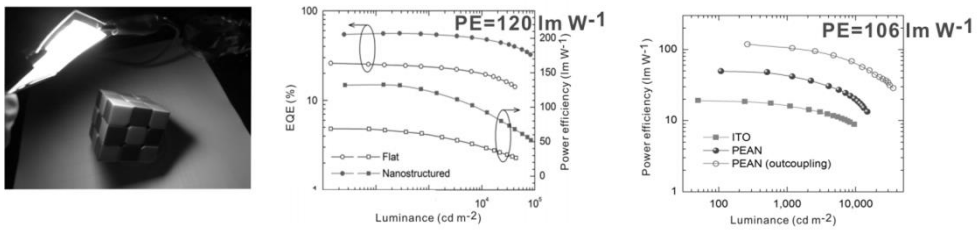

Fig. 1 Photography of flexible WOLEDs and performance characteristics of WOLEDs based on ITO-glass and PEANs substrates.

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Enhanced outcoupling efficiency of white organic light emitting device by microlens array and internal scattering layer

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Keywords: Light outcoupling, microlens, scattering layer, white OLED**.**

Current approaches on the light extraction technology of OLEDs are usually limited to single-color emission or rely on complicated, expensive equipment and process such as vacuum evaporation or lithographic procedures. Considering practical applications, it is essential that fabrication techniques must be applicable to a large area, multicolor (in case of white lighting), and cost effective. Hence, it is desirable to develop a simple fabrication technique for these out-coupling structures and study its effectiveness in terms of different colors.

In this study, solution-processed internal and external out-coupling structures for white organic light emitting devices (WOLED) were investigated [1]. Suitable size and thickness of inside scattering layer with nanoscale titanium dioxide (TiO_2) particles were selected in combination with metal grid-polymer composite printable anode system. Transmittance and haze, as a function of particle size and thickness of scattering layer, were characterized. Structure of WOLED with scattering layer used in this study is Glass/SL(3μm)/ PEDOT: PSS(60nm)/Ag grid/DNTPD(50nm)/TAPC(20nm)/mCP:Firpic-10wt%(20nm)/CBP:Ir(piq)$_2$acac-8wt%(10nm) /Bphen(30nm)/LiF(2nm)/Al(100nm); see Fig 1. The matrix of scattering layer was negative photoresist polymer (Ormocomp®). For the external out-coupling structure, microlens formed by convective self-assembly patterns was employed; polystyrene latex beads (Alfa Aesar) and polymethylmethacrylate powder (LDX30C, Sunjin chemical) were used for regular and irregular microbeads.

For WOLED internal without inside scattering layer, maximum luminous efficiency of reference device, irregular lens device and regular lens device are 7.24cd/A, 7.85cd/A, and 8.77cd/A, while the quantum efficiency of them are 6.56%, 7.11%, and 7.96%. For scattering layer (350nm TiO_2)-containing WOLED, maximum luminous efficiency of reference device, irregular lens device and regular lens device are 11.98cd/A, 12.00cd/A and 13.38cd/A. Corresponding quantum efficiency of them are 9.88%, 9.92%, and 10.95%, respectively. It is probed that combination of internal scattering layer and external microlens were more effective for enhancement of light outcoupling, while the overall factors of increase is not great. Usually, microlens plays a role as extracting waveguide mode emission at interface between substrate and air, however, internal scattering layer can extract light from transparent electrode to glass. Due to the broadband light emitting spectrum behavior of WOLED in this study, expectation for degree of light extraction at each specific mode (glass-air, near anode, and surface plasmon effects) is complicated. Analysis on the experimental results with proper optical simulation methods are performed and will be presented.

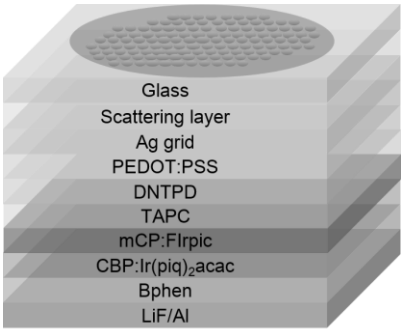

Fig.1 Structure of WOLED

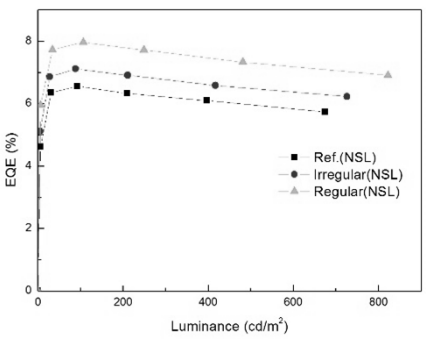

Fig.2 EQE of WOLED without scattering layer

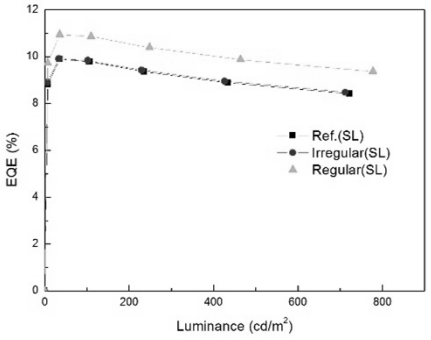

Fig.3 EQE of WOLED with scattering layer

Reference

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P-28

High-frequency oscillator based on a graphene resonant tunnelling transistor

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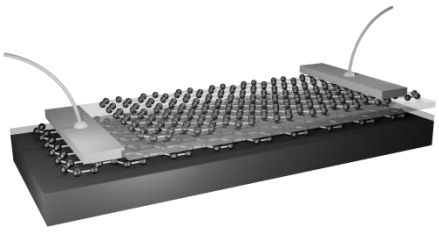
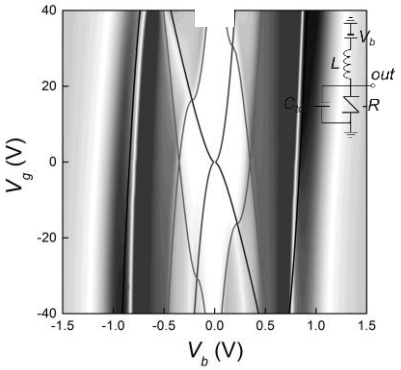
Keywords: graphene, resonant tunnelling, negative differential conductance, oscillator, THz

The use of graphene as electrodes and utilizing insulating or semiconducting materials as the tunnelling barrier led to the creation of tunnelling transistors and tunnelling photovoltaic devices. The combination of a hexagonal boron nitride (hBN) barrier sandwiched between two graphene electrodes is particularly attractive, because of the exceptional crystalline quality and the small lattice mismatch (1.8%) of two materials. An unprecedented degree of controlling the electronic properties of graphene-based heterostructure is not only available by means of the selection of materials in the stack, but also through the additional relative orientation of the component layers.

Here we report a new series of tunnelling transistor in which the crystal lattice of two graphene layers are intentionally aligned to a high degree of precision ($<2^{o}$) during the fabrication procedure[1]. Our measurement and theoretical modelling of the device characteristics reveal that the current flow is dominated by tunnel transitions in which both energy and in-plane momentum are conserved. The resonant conditions exist in a narrow range of bias voltages, and result in a resonant peak in the current-voltage characteristics, which leads to a strong negative differential conductance (NDC) that can persist up to room temperature. The bias position of the resonance can be controlled by relative orientation the two graphene crystalline lattices and the external magnetic field. In the NDC region, our devices generate radiofrequency oscillations when connected to a simple inductor-capacitor circuit. The frequency range is mainly limited by the parasitic capacitance between the contact pads of our devices and the underlying silicon gate. Much higher frequencies could be reached by reducing those parasitic capacitors. Even higher frequencies could also be achieved by fabricating a device in a slot antenna configuration, in which the slot acts as a resonator with the resonance frequency determined by the geometry of the slot. Moreover, our tunnelling devices are free of the fundamental limitation intrinsic to conventional double-barrier resonant tunnelling devices, namely the relatively long carrier dwell time (picoseconds) in the quantum well as compared with the time to transit the single barrier (femtoseconds), which suggest that potentially our tunnelling devices can be used to operate in the THz range.

a **b** **c**





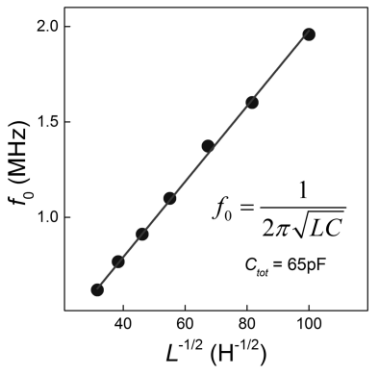


Figure 1. a, Schematic of our resonant tunnelling device. **b,** Contour map of dI/dV measured as function of bias and gate voltage. **c,** Performance of graphene-based oscillator.

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P-29

Electronic structures and photoconversion mechanism in perovskite/fullerene heterojunctions

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Keywords: Perovskite, organic heterojunction, photoemission study, fullerene

It has been generally believed and assumed that organometal halide perovskites would form type II P-N junctions with fullerene derivatives (C_{60} or PCBM), and the P-N junctions would provide driving force for exciton dissociation in perovskite-based solar cell. To the best of our knowledge, there is so far no experiment proof on this assumption. On the other hand, whether photo-generated excitons can intrinsically dissociate into free carrier in the perovskite without any assistance from a P-N junction is still controversial. To address these, we directly measure the interfacial electronic structures of a vacuum deposited perovskite/C_{60} and a solution processed perovskite/PCBM junctions by ultraviolet photoelectron spectroscopy (UPS). Contrary to the common believes, both junctions are found to be type I N-N junctions with bandgap of the perovskites embedded by that of the fullerenes. Meanwhile, device with such a charge inert junction can still effectively functions as a solar cell. These results give direct experimental evidence that excitons are dissociated to free carriers in the perovskite film even without any assistance from a P-N junction.

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Highly efficient fullerene/perovskite planar heterojunction solar cells via cathode modification with an amino-functionalized polymer interlayer

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Keywords: perovskite solar cells, interfacial engineering, amino-functionalized polymer interlayer

A new amino-functionalized polymer, PN4N, was developed and applied as an efficient interlayer to improve the cathode interface of fullerene/perovskite ($CH_3NH_3PbI_xCl_{3-x}$) planar heterojunction solar cells. The PN_4N polymer is soluble in IPA and n-BuOH, which are orthogonal solvents to the metallohalide perovskite films, and therefore they can be spuncast on the heterojunction layer before the deposition of the metal cathode. This simple modification of the cathode interface showed a remarkable enhancement of power conversion efficiency (PCE) from 12.4% to 15.0% and also reduced the hysteresis of photocurrent (See fig. 1). We also found that conventional water–methanol-soluble polymer interlayer, such as PFN, was incompatible with the perovskite films because of the small molecular size of aprotic solvent such as MeOH, which could decompose the perovskite films to PbI_2, resulting in considerably lower solar cell performance. This study provides new design guidelines for efficient interfacial materials and also demonstrates that interface engineering could be a key strategy to improve perovskite solar cells.

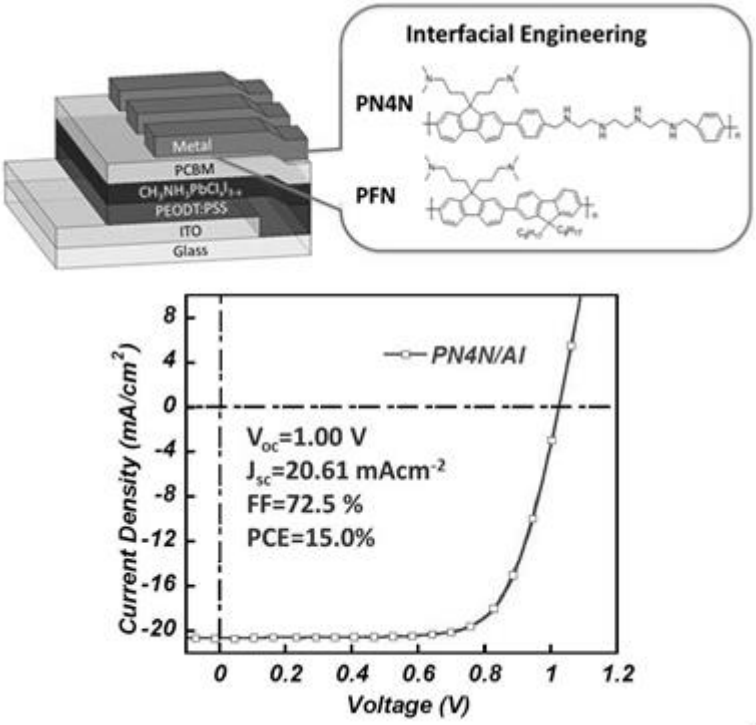

Fig. 1 Device structure of the hybrid planar heterojunction solar cell and the molecular structure of PN_4N and PFN as well as the cell performance.

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P-31

Effects of Graphene Defect on Electronic structures of Its Interface with Organic Semiconductor

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Keywords: Graphene, Electronic Structure, UPS, Defect**.**

Since the first reported in 2004,[1] graphene has attracted significant attention due to its unique properties, including outstanding electron mobility, [2-5] high mechanical strength, [6,7] and extremely high thermal conductivity,[8] etc. These fascinating properties make graphene an ideal candidate for many applications in organic electronic devices. The quality and surface chemistry of graphene crucially determine its performance in device applications. Various plasma treatments have been employed to modify the physical, chemical, and electronic properties of graphene.

It is worth noting that during the plasma treatment, defects would be inevitably introduced in the graphene. However, up till now, there are few reports on the implications of defect density in graphene on its applications in organic electronic devices.

Electronic structures of copper hexadecafluorophthalocyanine (F_{16}CuPc)/graphene with different defect density were studied with ultra-violet photoelectron spectroscopy (UPS). We showed that the charge transfer interaction and charge flow direction can be interestingly tuned by controlling the defect density of graphene through time-controlled H_2 plasma treatment. By increasing the treatment time of H_2 plasma from 30 second to 5 minutes, both the interface surface dipole and the electron transporting barrier at F_{16}CuPc/graphene interface are significantly reduced from 0.86 to 0.56 eV and 0.71 to 0.29 eV, respectively. These results suggested that graphene's defect control is a simple approach for tuning electronic properties of organic/graphene interfaces.

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Funtional materials for organic flash memories

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Keywords: printed electronics, flash memory, floating gate, organic semiconductor, transistors

The next-generation electronic systems are expected to be light, flexible and portable for applications in large area displays, integrated circuits (ICs), organic light emitting diodes (OLEDs), radio frequency identification (RFID) tags, solar cells and so on. Memory is an essential part of advanced electronic systems for data processing, storage and communication. Among many types of memories such as ferroelectric, electret, resistive and floating gate, nano-floating gate flash memory devices have gained a great deal of attention due to the simple device structure, non-destructive read-out and controlled trap capacity. In this presentation, we will demonstrate recent works based on solution processable or printable materials for organic flash memories.

P-33

Limiting factors of thermally activated delayed fluorescent materials

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Keywords: exciplex, thermally activated delayed fluorescence, reverse intersystem crossing

Thermally activated delayed fluorescent (TADF) materials have received considerable attention in recent years because of its unit maximum theoretical efficiency. In the framework of TADF mechanism, a small singlet-triplet energy difference ($\Delta E_{(S-T)}$) are needed to thermally activated the triplet states to the singlet state via reverse intersystem crossing (RISC) process. While as a matter of fact, a lot of materials with small $\Delta E_{(S-T)}$, including intra molecular materials and exciplexes, give low external efficiencies than its theoretical maximum of 20%. Here we report our relative work on the limiting factors of the efficiency of exciplex. The first topic we studied is temperature dependence of the PL decay characters of mCBP:PO-T2T mixed film, an exciplex with TADF property. As shown in figure 1a, as temperature increased from 16K to RT, the long component of the PL lifetime decreased drastically, indicating an equilibration between the thermally activated RISC process and the phonon exciplex quenching effect. Similar results also determined in other exciplexes.[1-2] This phenomenon is in contradiction with theoretical prediction of the TADF mechanism, suggesting the bimolecular exciplex is a very loosely bonded state and can be dramatically influenced by the phonon at high temperature than 200K. Another dominant effect of lower efficiency is the effect of substituent group on the PL character of exciplex which is also beyond the definition of TADF mechanism. We compare the PL characters of two exciplexes with the same donor component, i.e., mCBP:PO-T2T and mCBP:3PT2T. As displayed in figure 1b, the RT PL lifetime of mCBP:3PT2T is only about 20 ns which is far short than that of the mCBP:PO-T2T exciplex with a lifetime of about 2.3 μs. This result indicating that the substituent group could influence the PL decay character and the PL efficiency significantly. We postulate that the substituent group can influence the rate of RISC and the amount of transient dipole between donor and acceptor.

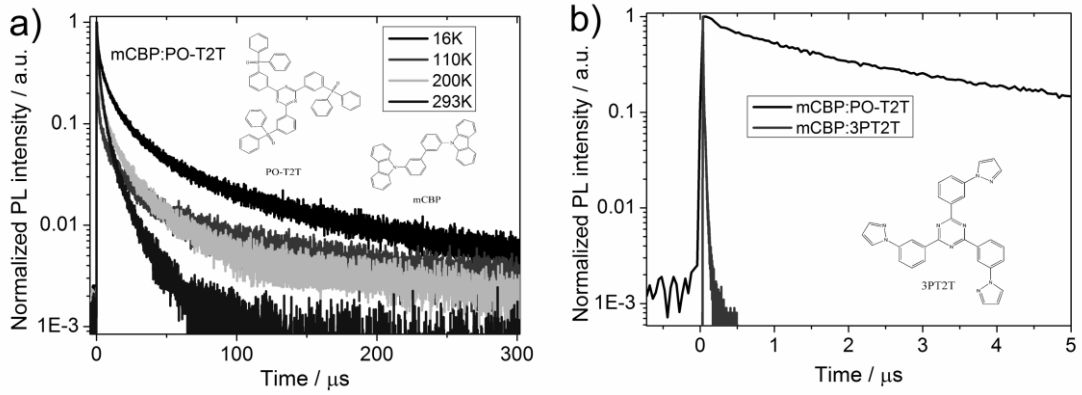

Figure 1. a) PL decay characters of mCBP:PO-T2T exciplex at different temperatures, monitored at 473 nm and excited at 266nm. b) PL decay characters of mCBP:PO-T2T and mCBP:3PT2T exciplexes at room temperature, monitored at 460 nm and excited at 266nm.

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Formation chemistry of perovskite with mixed iodide/chloride and its implications to charge transport properties

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Keywords: Interface energetics, XPS, formation chemistry, methylammonium iodide, lead chloride

Although Cl doping is common technique for high photovoltaic (PV) performance of perovskite solar cells, its content is negligibly small and can be hardly tuned. We herein therefore study the formation chemistry of Cl-doped perovskites by examining the chemical interactions between thermally evaporated methylammonium iodide (MAI) and lead chloride ($PbCl_2$) through X-ray photoemission spectroscopy (XPS). We show that $PbCl_2$ is not stable at the MAI/ $PbCl_2$ contact due to the difference in ionic radii of Cl^- and I^- ions. The Cl atom readily detaches from the $PbCl_2$, which subsequently initiates electron transition from Pb to MAI. As a result, negligible amount of Cl could be observed close to the MAI/$PbCl_2$ contact. Via thermal-evaporation, perovskite with high $PbCl_2$ content can be prepared and examined. We found that metallic Pb associated with increased Cl content can quench the photogenerated exciton in PV devices. By optimizing the ratio of MAI:$PbCl_2$, a perovskite solar cell with ~6% efficiency is obtained. Our result shed light on the formation chemistry of the perovskite and its implication to charge transport properties.

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P-35

Broadband Light Absorption Enhancement in Nano-structured Organic Solar Cells

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Keywords: Organic photovoltaics, inverted organic solar cells, light trapping,

The broadband light absorption in nano-structured OSCs is dependent on the photonic structures. The use of different metal nanoparticles or nanostructures, formed by cross-beam lithography and nanoimprint techniques, has been demonstrated. Enhanced electrical losses attenuated optical absorption was found when studying the electro-photonic optimization of OSCs with simple optical grating structures. Here, a comprehensive study of inverted organic solar cells (OSCs) with moth's eye nanostructure (MEN) pattern in the active layer was carried out. The performance of MEN-based OSCs and flat control cells, fabricated using the blend of poly[4,8-bis[(2-ethylhexyl)oxy] benzo [1,2-b:4,5-bA] dithiophene-2,6-diyl] [3-fluoro-2-[(2-ethylhexyl) carbonyl] thieno [3,4-b] -thiophenediyl] (PTB7):[6,6]-phenyl-C_{70}-butyric-acid-methyl-ester ($PC_{70}BM$) was analyzed by experimental optimization and FDTD simulation. The results reveal that nano-structured OSCs possess a 6.15 % increase in power conversion efficiencies (PCE) and a 7.24 % increase in short circuit current density (J_{SC}) compared to a flat control OSC. The theoretical simulation reveals that the absorption enhancement that occurs in the nanostructured active layer contributes mainly to the improvement in cell performance.

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Organic Semiconductor Heterostructures as Memory Elements: a New Strategy to Achieve Nonvolatile Organic Field-Effect Transistor Memory Devices

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Keywords: heterostructures, organic field-effect transistors, memory, multilevel, flexible**.**

Although great progress has been made in organic field-effect transistor (OFET) memory which can be mainly classified into three types: floating-gate OFET memory, polymer electret OFET memory and ferroelectric OFET memory,[1-4] the approaches to realizing the memory function of the above three typical types of OFET memory devices mainly depend on the regulation of gate dielectric layer of OFETs rather than organic semiconductor layer, which restricts the deeper-level development of the organic semiconductor materials to some extent. Therefore, it is necessary to develop new approaches to realize high performance OFET memory.

Herein we provided a new design strategy of memories to realize high-performance organic field-effect transistor (OFET) memory devices using the organic semiconductor of pentacene (*p*-type)/ *N*,*N′*-Ditridecylperylene-3,4,9,10-tetracarboxylic diimide (P13) (*n*-type)/pentacene (*p*-type) to form trilayer organic semiconductor heterostructure as the active layers as well as memory elements. The heterostructure OFET memory devices showed excellent nonvolatile memory properties with a large memory window of about 80 V, a high ON/OFF current ratio of about 10^4, a short switching time of about 1μs, stable data endurance cycles of more than 10^3 cycles and a long data retention time of more than 10^4 s. A series of control experiments were also carried out to confirm that the pentacene/P13/pentacene heterostructure brought about the memory properties of the heterostructure OFET memory devices. The nonvolatile memory properties were believed to originate from the interface dipoles generated by the pentacene/P13/pentacene heterojunction effect, which resulted in the reversible shift of the transfer curve by manipulating the concentration of induced holes in the conductive channel of OFETs under the application of programming and erasing voltage. In addition, organic semiconductor heterostructure pentacene/P13/pentacene has also been successfully applied in multilevel and flexible nonvolatile memory devices, showing that the heterostructure OFET memory devices could be considered as promising candidates for future high-density data storage and flexible memory devices.

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P-37

Staggered Face-to-Face Molecular Stacking as a Strategy for Designing Deep-Blue Electroluminescent Materials with High Carrier Mobility

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Keywords: phenanthroimidazole; high carrier mobility; staggered stacking; deep-blue electroluminescence

Compared with red and green emitters in organic light-emitting devices (OLEDs), it is much more difficult to develop blue emitters with matching performances due to the opposing requirements for optical and electrical properties. Deep-blue emission requires emitters with wide energy gaps, which often implies low carrier mobility and higher carrier-injection barrier and thus inferior electrical performance.

In this research, we present a successful example of achieving synergy between optical and electrical properties, namely, deep-blue emitting and high carrier mobility were demonstrated by a novel planar linear molecule, 4,4"-bis(1-(4-(*tert*-butyl)phenyl)-1*H*-phenanthro[9,10-*d*]imidazol-2-yl)-1,1':4',1"-terphenyl (BBTPI), for effective deep-blue electroluminescence (Fig. 1a). To the best of our knowledge, the planar linear molecule BBTPI is the first report on exploiting staggered π-π molecular stacking (Fig. 1b) for avoiding impairment of color purity (Fig. 1c) and simultaneously enabling high charge mobilities (greater than 10^{-3} cm^2 V^{-1} s^{-1} for hole and 10^{-5} cm^2 V^{-1} s^{-1} for electron, Fig. 1d). Using BBTPI as the non-doped emitter, we demonstrate a high-performance (5.48 cd A^{-1}) OLED with deep-blue (CIE coordinates: (0.15, 0.10)) electroluminescence.[1]

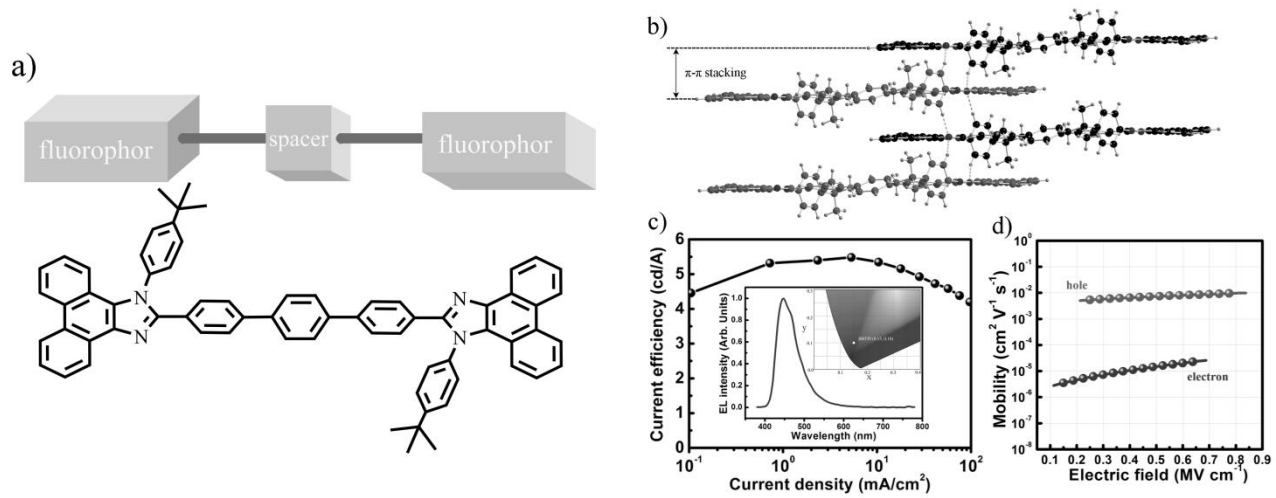

Fig. 1 a) Molecular design strategy, b) single-crystal packing mode, c) non-doped device performances d) hole and electron mobilities of the new emitter BBTPI.

Reference:
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Phosphorescence switch and logic gate of iridium(III) complexes containing triarylboron moiety triggered by fluoride and electric field

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Keywords: Iridium(III) complex, Logic gate, Phosphorescence switch**.**

Phosphorescent iridium(III) complexes have attracted wide attention as a result of their advantageous photophysical properties, such as high sensitivity of emission properties to changes in the local environment, evident Stokes shifts for easy separation of excitation and emission, highly efficient phosphorescent emission and relatively long emission lifetimes.[1] The excited-state properties of phosphorescent iridium(III) complexes are complicated and depend on the chemical structures and energy levels of the ligands, which will be suitable for designing stimuli-responsive materials. In this work, a dimesitylboryl moiety, which has bulky mesityl group to protect the boron center from nonspecific nucleophilic attack, is connected to the cyclometalating C^N ligand of two iridium(III) complexes **1** and **2** (Fig. 1a and 1e). Both complexes display phosphorescence quenching upon addition of fluoride ion. Interestingly, the phosphorescence can be recovered due to the rupture of the B-F bond under an electric field. As shown in Fig. 1b and 1c, complex **1** in the cuvette exhibits orange-red luminescence color under a UV lamp and the phosphorescence is completely quenched after the addition of approximate two equiv. of F^-. Then two Sn foil electrodes are placed on the left and right of the cuvette, respectively. Interestingly, the orange-red emission reappears around the anode electrode after applying a voltage of about 10 V on the electrodes. Subsequently, the orange-red emission near the anode electrode extends to the cathode direction and reaches the equilibrium in the middle of the anode and cathode (Fig. 1d). Moreover, the luminescence can also be quenched again via turning off the electrical source and agitating the solution around the anode. For complex **2**, the emission intensity decreases upon addition of two equiv. of F^- (Fig. 1f and 1g). After applying a voltage of 10 V on the electrodes, the luminescence intensity resumes near the anode and remains unchanged around the cathode (Fig. 1h), which is similar to what was observed for complex **1** under the electric field. Thus, a phosphorescence switch and INH logic operation has been realized via using fluoride ion and electric field as two stimulus inputs. We believe that the phosphorescence switch and logic gate induced by fluoride and electric field will have potential applications in molecular optoelectronic devices.

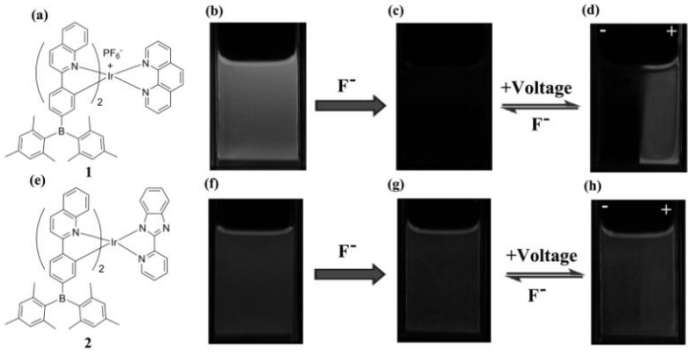

Fig. 1 Chemical structures of (a) **1** and (e) **2**. Photographs of **1** and **2** in CH_3CN (10^{-4} M) without (b,f) and with (c,g) F^- under a UV lamp, respectively. Photographs of (d) **1** and (h) **2** with F^- after electrical stimuli under a UV lamp.

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P-39

Electro-Mechanical Characterization of Liquid Metal and its Application on Ionic Liquid Based Sensors

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Keywords: Galinstan, flexible electronics, electro-mechanical coupling, micro-channel, sensor**.**

Galinstan, a eutectic metal that is composed of 68.5% Ga, 21.5% In and 10% Sn, has attracted a lot of interests for its potential applications on flexible electronics[1], liquid-state sensors[2] or batteries[3]. This liquid-state metal exhibits high electrical conductivity, low vapor pressure, easy phase control properties in wide range of temperatures and is non-toxic. However, whether the rheological behavior [4] of the fluid liquid metal will influences the electrical conductivity when injected into microchannel remains unclear. So, electrical and mechanical characterizations were carried out to examine whether the fluid metal eutectic will retain its metallic conductivity in stretchable conductive wires. In both PET and high deformable silicone tube, the resistivity of the liquid metal increases gradually when the tube is elongated more than 300%. Detail analysis reveals that this resistance increase because of the geometric change of the tube - the tube elongates and the cross sectional area narrows. So further application on sensors reveals that the liquid metal can withstand outstanding connecting functions, while another liquid, ionic liquid, can be used as the sensing component. Specially designed micro-channel guarantees a stable heterojunction structure form at the interface between liquid metal and ionic liquid. This kind of sensor device is highly deformable due to the liquid-state components and the flexible PDMS substrate.

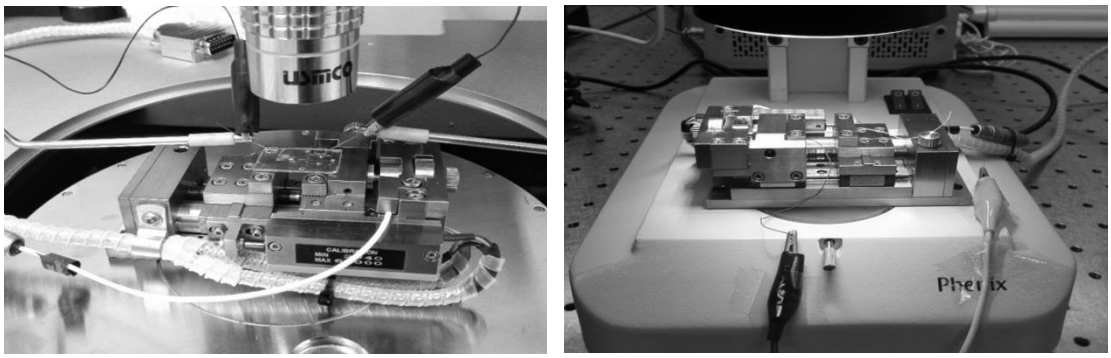

Fig. 1. Set-up for in situ electro-mechanical characterization

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Lifetime improvement of TADF device by using dibenzothiophene based host materials

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Keywords: OLED, TADF, Lifetime, 4CZIPN, dibenzothiophene **.**

We have succeed in improving the lifetime of green thermally activated delayed fluorescence(TADF) organic light emitting device by using DBT1 and DBT2 as hosts, derived from dibenzothiophene, and 2,4,5,6-tetra(9H-carbazol-9-yl)isophthalonitrile(4CZIPN) as a green dopant. Quantum efficiency of device with DBT1 was 17.4% at 1000cd/A, and a maximum quantum efficiency of 18.3% was obtained. Quantum efficiency of device with DBT2 is 17.2% at 1000cd/ m^2, and a maximum quantum efficiency of 17.5% was obtained. Two devices did not show a significant difference, but showed better efficiency than the device using 4,4'-di(9H-carbazol-9-yl)-1,1'-biphenyl(CBP) as host. In particular, the lifetime of the 4CZIPN device was more them doubled by using the DBT1 and DBT2 as a host instead of common CBP. Therefore, the dibenzothiophene derived DBT1 and DBT2 are promising as host materials to improve the efficiency and lifetime of the 4CZIPN devices.

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in situ controllable formation of nano-gaps for local enhancement of the electromagnetic field

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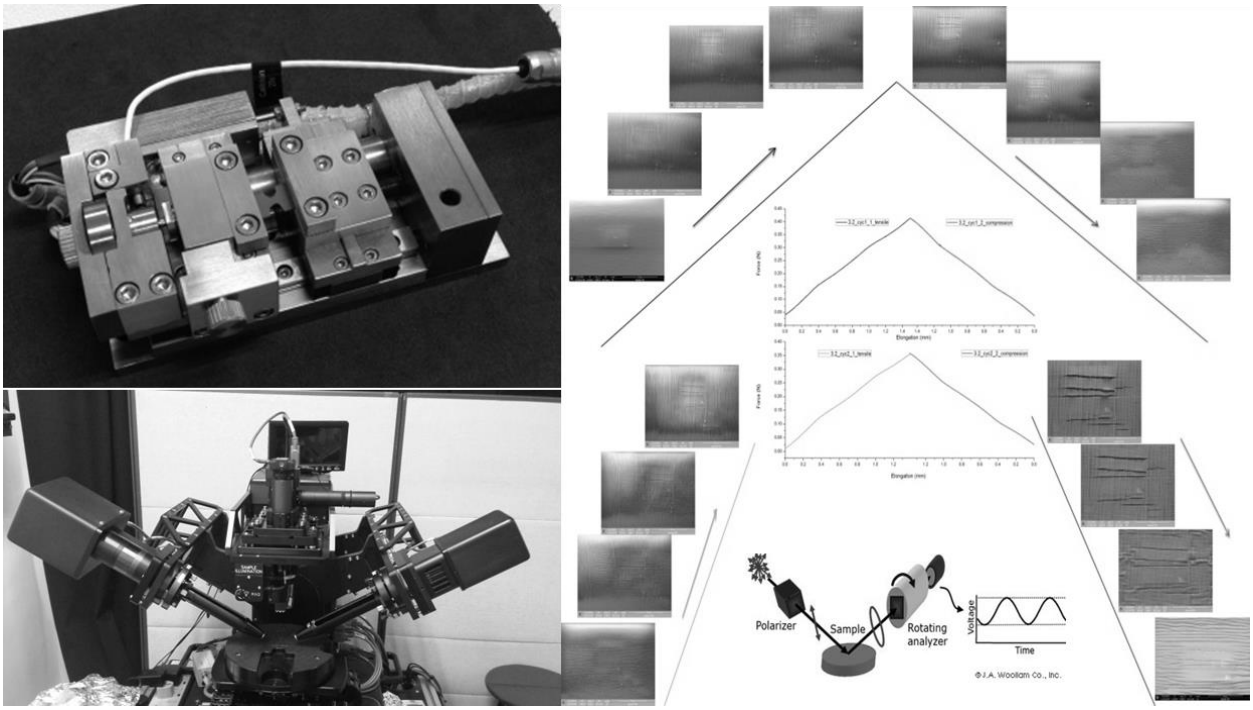
Recent research indicated that nano-sized cracks can enhance the fluorescence and Raman signal for great potential in biosensor applications. By mostly utilizing a thin layer of metal with grating structure, we can considerably increase the electromagnetic field on the film surface once nano-gap formed. Nanosized gaps (tens to a few hundreds of nanometers) on such metal (such as Au) thin films have been proven to greatly increase the sensitivity, compared with just a thin layer of metal. However, previous works usually relied on random crack formation. Here, our work mainly focuses on the controllable, uniform gap formation on gold thin film with PDMS as the substrate. *In situ* ellipsometer and Raman measurement can be used to investigate the signal enhancement from nano-naps with specific widths, to quantify the improvement of the single molecular detection sensitivity.



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Near-Infrared Lasing from Self-Assembled Organic Hemispheres

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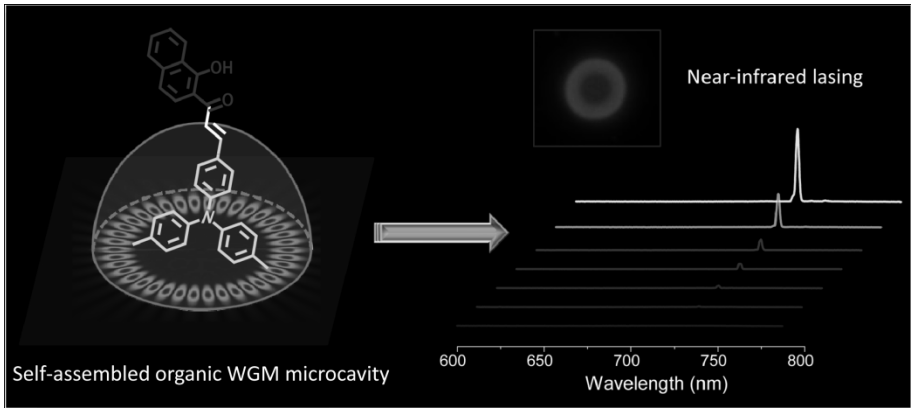
Keywords: Organic photonics, Solid-state laser, Self-assembly, Microlaser, Whispering-gallery mode

Near-infrared (NIR) lasers are key components for applications, such as telecommunication, spectroscopy, display, and biomedical tissue imaging. Inorganic III-V semiconductor (GaAs) NIR lasers have achieved great successes,[1] but require expensive and sophisticated device fabrication techniques. Organic semiconductors exhibit chemically tunable optoelectronic properties together with self-assembling features that are well suitable for low-temperature solution processing.[2,3] Major blocks in realizing NIR organic lasing include low stimulated emission of narrow-bandgap molecules due to fast nonradiative decay, and exciton–exciton annihilation which is considered as a main loss channel of population inversion for organic lasers under high carrier densities.[4] Here, we designed and synthesized the small organic molecule 3-[(4-(N,N-di(*p*-tolyl)amino)phenyl)-1-(2-hydroxynaphthyl)prop-2-en-1-one (DPHP) with amphiphilic nature, which elaborately self-assembles into micrometer-sized hemispheres that simultaneously serves as the NIR emission medium with a moderate quantum-efficiency of ~15.2%, and the high-*Q* (~1.4×10^3) whispering-gallery-mode (WGM) optical microcavity. Moreover, the radiative rate of DPHP hemispheres is enhanced up to ~1.98 ns^{-1} on account of the exciton-vibrational coupling in the aggregated state, and meanwhile the exciton–exciton annihilation process is eliminated under the high optical excitation for population inversion. As a result, NIR lasing with a low threshold of ~610 nJ/cm^2 is achieved in the single DPHP hemisphere at room temperature. Our demonstration is a major step towards incorporating the organic coherent light sources into the compact optoelectronic devices,[5] which have been applied as a lab-on-a-chip for high-sensitivity explosive detection.



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Simultaneous Harvesting of Triplet Excitons in OLEDs by both Guest and Host Materials with Intramolecular Charge-transfer Feature *via* triplet-triplet annihilation

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Keywords: triplet-triplet annihilation, intramolecular charge transfer, guest, triplet fusion delayed fluorescence, OLED**.**

Recently, OLEDs based on triplet fusion delayed fluorescence have attracted much attention, because their IQE_{max} could reach 62.5% if triplet excitons could be converted efficiently into singlet ones through TTA process.[1] However, most of the research works related to TFDF-OLEDs are focused on the elucidation of the role TTA process plays in the enhancement of EL efficiency; while the TFDF compounds used are generally limited to those with $\pi\pi^*$ character.[1] Our recent study has revealed that the ICT compound CzPhONI (**Fig. 1**) is a promising TFDF host material for high performance OLED if they possess a lowest triplet excited state with $^3\pi\pi^*$ character.[2] Inspired by this discoveries, and fluorophores with good structural similarity could form efficient energy transfer (ET) pair,[3] a ICT-featured red D-π-A fluorophore **NA-TNA** was designed and synthesized (**Fig. 1**). As both CzPhONI and **NA-TNA** are naphthalimide derivatives, they could form an efficient host/guest ET pair; while the presence of a bulky diphenylamine segment could endow **NA-TNA** with suppressed molecular interaction. In addition, similar to CzPhONI, **NA-TNA** also has TFDF property. Using **NA-TNA** and CzPahONI as guest and host materials, a 6 wt% **NA-TNA** doped OLED with LE_{max} of 7.73 cd/A, L_{max} of 31940 cd/m^2, and EQE_{max} of 5.83% has been achieved, which is much higher than its theoretical limited 25% singlet production (3.03%). On the contrary, although the PLQY of the 1.4 wt% doped **NA-TNA** film is higher than that of the 6 wt% doped one (0.778 *vs* 0.606), the 1.4 wt% doped reference device shows much inferior device performance, with LE_{max}, L_{max}, and EQE_{max} of 2.38 cd/A, 24900 cd/m^2 and 1.78%, respectively. Detailed to MEL characterization and transient EL indicates that the high performance of the 6 wt% device was attributed to the concurrent harvesting of triplet excitons by both the host and guest materials through triplet fusion.

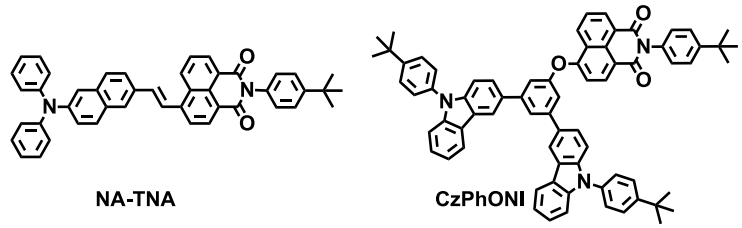

Fig. 1. Structures of **NA-TNA** and CzPhONI.

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Bulk Crystal Growth of organic-inorganic Perovskites $CH_3NH_3PbX_3$ (X=Br, I)

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Keywords: crystal growth, hybrid perovskite, $CH_3NH_3PbX_3$, crystal orientations

The hybrid perovskite materials have generated significant interests due to their potential applications in the optoelectronic fields. However, some of the fundamental properties of perovskite materials are still disputable, because of most of them resulted from thin-film state. To better understand the intrinsic characteristics in single crystal, here we report, for the first time, the bulk crystal growth of $CH_3NH_3PbX_3$ ($MAPbX_3$, X=Br, I). The single crystals of cubic $MAPbBr_3$ with dimensions of 8 mm×8 mm×8 mm and tetragonal $MAPbI_3$ with dimensions of 10 mm×10 mm×8 mm were grown by temperature-lowering method in HX (X=Br, I) solution, respectively. The orientations of $MAPbX_3$ (X=Br, I) single crystals are conducted based on the high quality crystals. The exhibited natural facets of $MAPbBr_3$ were determined to be square {100} and rectangle {110}, while the exhibited natural facets of $MAPbI_3$ were hexagon {100} and parallelogram {112} using X-ray diffraction.

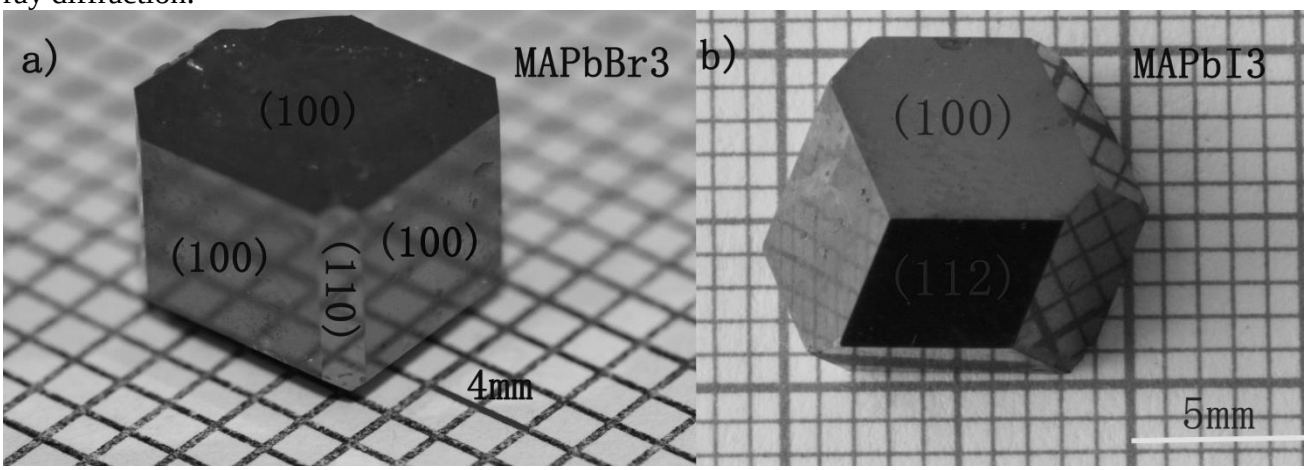

Fig. 1 The photographs of $MAPbBr_3$ and $MAPbI_3$ with the natural facets

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Roughened Cu-foam coated with octahedral Cu_2O for better photocatalysts

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Keywords: electrodeposition, dealloying, specific surface area, foams, photocatalysts

With good thermal and electrical conductivities and good corrosion resistance, metal foams have been widely used for electrode materials, catalysts and electromagnetic shielding materials. However, the low surface area of commercial metal foams has largely limited their performance. Here we report a facile electrochemical method for increasing the surface area of metal foams. Taking Cu foams as an example, high surface area Cu foams were fabricated using this convenient method in a one-pot one-step manner. Moreover, the treated Cu foam demonstrated significantly improved performance for different applications, e.g., as hosts for octahedral Cu_2O nanoparticles exhibiting greatly enhanced photocatalytic performance.

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Highly Efficient Green TADF OLED Based on Co-Host and Tandem Architectures with External Quantum Efficiency Above 30 %

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Keywords: Tandem, TADF, Green OLED

Thermally activated delayed fluorescence (TADF) based OLEDs have been attracting much attention recently because of its high external quantum efficiency (EQE) and little efficiency roll-off. In this work, we report the first TADF-based tandem OLED with the highest EQE achieved so far using 4CzIPN as a green TADF emitter, mCP:TPBI as a co-host structure, and BPhen:Li/HAT-CN as a connecting unit. With the device structure of ITO/HAT-CN (10 nm)/TAPC (40 nm)/TCTA (10nm)/mCP:TPBi:4CzIPN (1:1:0.15, 20nm)/TmPyPB (40 nm)/Bphen:Li (1.2%, 15 nm)/HAT-CN (10 nm)/TAPC (40 nm)/TCTA (10nm)/mCP:TPBi:4CzIPN (1:1:0.15, 20nm)/TmPyPB (40 nm)/Liq (2 nm)/Al (120 nm), we successfully fabricated green-emitting OLED with a CIE (x,y) of (0.285,0.610) and a maximum current efficiency and EQE of 117.5 cd/A and 32.5%, respectively. The efficiency obtained in our TADF OLED is comparable to that of phosphorescent green OLED. It was found that the co-host system has a deeper highest-occupied-molecular-orbital (HOMO) and higher singlet and triplet energies, which eliminate exciton quenching and provide efficient energy-transfer between the co-host and 4CzIPN.

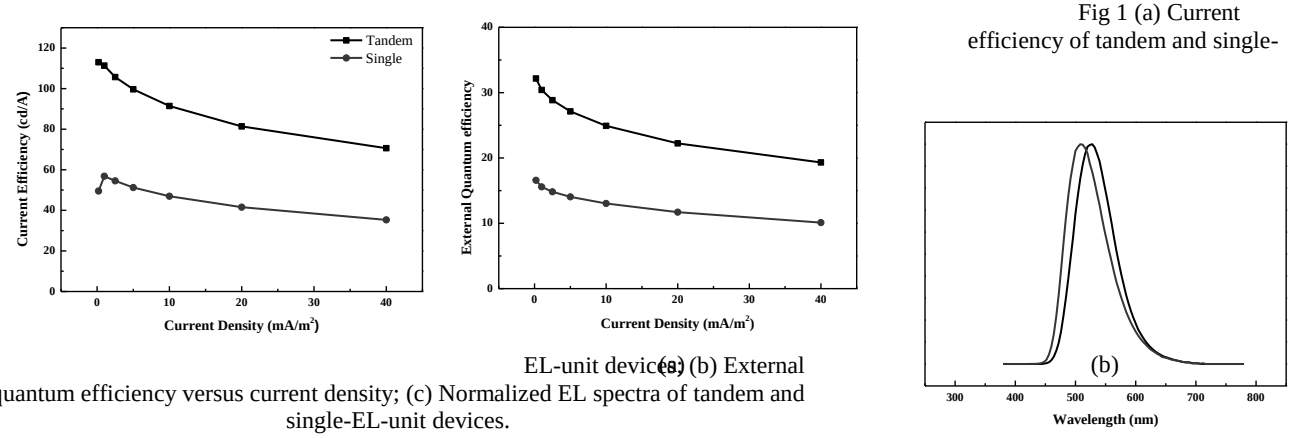

Fig 1 (a) Current efficiency of tandem and single-EL-unit devices; (b) External quantum efficiency versus current density; (c) Normalized EL spectra of tandem and single-EL-unit devices.

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Towards highly efficient dope-free electrofluorescent materials: A fine modulation on the components of hybridized local and charge-transfer (HLCT) state

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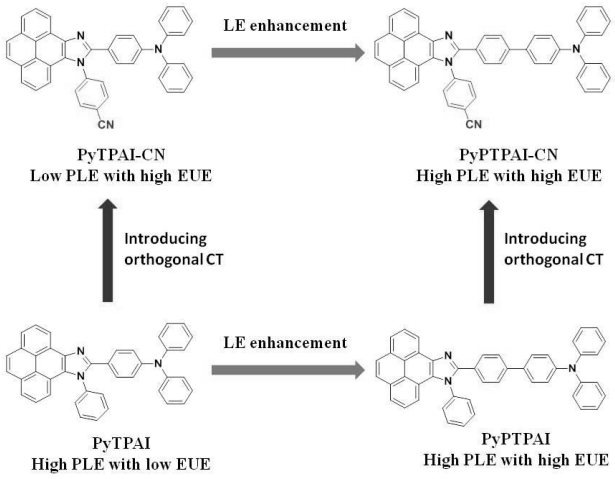
Keywords: Optoelectronics, PL efficiency, OLED, exciton utilization, HLCT state.

Since the first OLED was illuminated in 1987, scientists have been struggling for over two decades for stable highly efficient organic electro-luminance, especially for the fully exciton utilization that was once limited to 25% in terms of the spin statics. The electro-phosphorescence showed such feasibility by directly utilizing the lowest triplet excitons for phosphorescent emission. The recently promoted thermally activated delayed fluorescence (TADF) materials further lowered the cost of precious metal in electrophosphorescence. However, the triplet excitons always possess long lifetimes, which may cause serious efficiency rolling-off by triplet-triplet annihilation (TTA) and concentrate quenching, so that the emissive layer must be doped one to avoid the problems in OLEDs. What's more , the response time of triplet utilizing luminance is still much longer than the fluorescence. Herein, we introduce a new concept, the hybridized local and charge-transfer (HLCT) materials that both benefit from the high efficiency local-emissive (LE) and the small binding charge-transfer (CT) state components, and can receive considerably stable, high efficiencies in the electrofluorescent non-doped device by careful optimization on the molecular structure of HLCT materials.

We designed a series of HLCT materials by an original orthogonal connection method, and carried out systematically researches on the state species of the orthogonal HLCT molecular system. The LE dominant material PyTPAI is high in photo luminance (PL) efficiency but is low in singlet utilization (~12%) while the CT dominant material PyTPA-CN is low in photo luminance (PL) efficiency but is high in singlet utilization (~80%). By carefully state modulation, the LE-enhanced material PyPTPAI and PyPTPAI-CN relatively showed excellent electrofluorescent properties as a maximum current efficiency of 2.69 cd/A and 3.47 cd/A, a maximum power efficiency of 2.8 lm/W and 2.1 lm/W, and a maximum EQE of 2.9%(at 33 cd m^{-2}) and 2.5% (at 1786 cd m^{-2}) in non-doped EL device. It is an ideal strategy to design the next-generation organic EL materials with the combined high PL efficiency and high exciton utilization by means of HLCT state.



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An insight on oxide interlayer in organic solar cells: From light absorption and charge collection perspectives

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Keywords: organic solar cells, ZnO interlayer, absorption enhancement charge collection

A comprehensive study of the effect of zinc oxide (ZnO) interlayer on the performance of bulk-heterojunction organic solar cells (OSCs), based on poly[[4,8-bis[(2-ethylhexyl)oxy] benzo [1,2-b:4,5-b'] dithiophene-2,6- diyl] [3-fluoro-2-[(2-ethylhexyl)carbonyl] thieno [3,4-b] thiophenediyl]] (PTB7):3'H-Cyclopropa[8,25] [5,6]fullerene-C70-D5h(6)-3'- butanoicacid, 3'-phenyl-, methyl ester ($PC_{70}BM$) blend system, is carried out by theoretical simulation and experimental optimization. It is found that a PTB7:$PC_{70}BM$ blend layer thickness optimized for maximum light absorption in OSCs does not generally give rise to the highest power conversion efficiency (PCE). The presence of a ~15 nm thick ZnO interlayer layer between a thinner photoactive layer and the cathode is favorable for efficient OSCs. The ZnO interlayer serves a dual purpose to overcome the Optical-Electrical Mismatch Effect as well as to reduce bimolecular charge recombination. The following three techniques were applied to study the physical mechanisms behind the optical and electrical effects of ZnO spacer: optical admittance analysis, measurement of light intensity dependent current-voltage (I- V) characteristics and transient photocurrent measurements.

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Directly observe the relaxation process of charge transfer states in organic photovoltaics

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Keywords: Organic photovoltaic, charge transfer states, relaxation process, charge modulated electroabsorption spectroscopy

Charge transfer (CT) states formed at donor/acceptor interface determine the photocurrent generation in organic photovoltaic (OPV) device. General models describe a competition mechanism between the charge dissociation and energy relaxation in high-energy CT states. However, the relaxation process is not easy to be measured due to the ultrafast charge transfer below 100 fs. In addition, how relaxation process influences CT dissociation is still under debate.

Recently, a new technique named charge modulated electroabsorption spectroscopy (CMEAS) was used to judge the effective bandgap of OPV. In this work, we used CMEAS to detect CT states by sub-bandgap exciting in four polymer: fullerene OPVs, including P3HT: $PC_{61}BM$, PTB7: $PC_{71}BM$, PCDTBT: $PC_{71}BM$ and PDTS-TPD: $PC_{71}BM$. The CT signals present different response with different modulated frequency. The signals from higher energy CT show a stable trend with increasing frequency, just same as excitonic CMEAS signals. However, CT signals with lower energy decrease dramatically when the frequency increases, indicating a transfer from delocalized states to localized states. These experimental results provide the evidence for the relaxation process from delocalized CT to localized CT. Our research suggests that with CMEAS we can directly observe the relaxation process in CT states of OPV and by analyzing the tendency of CMEAS vs. frequency, delocalized degree of CT states with different energy can be determined.

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Influence of thermal annealing on graphene oxide memory devices

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Keywords: graphene oxide, annealing temperature, memory devices, the ON/OFF current ratio, the atomic force microscopy images

We study the effects of annealing temperature on graphene oxide (GO) memory devices [e.g., nonvolatile write-once-read-many-time memory cells based on GO] by analyzing the atomic force microscopy images of active layer surfaces before and after being annealed at a series of temperatures. When the annealing temperature is in the range of 40-140℃, the ON/OFF current ratio varies between 60000 and 2000. However, as the annealing temperature exceeds 160℃, the ON/OFF current ratio drops to 1, suggesting that the sample has lost its resistive switching characteristics. Thermogravimetric analysis of GO revealed the significance of water in the GO memory devices.

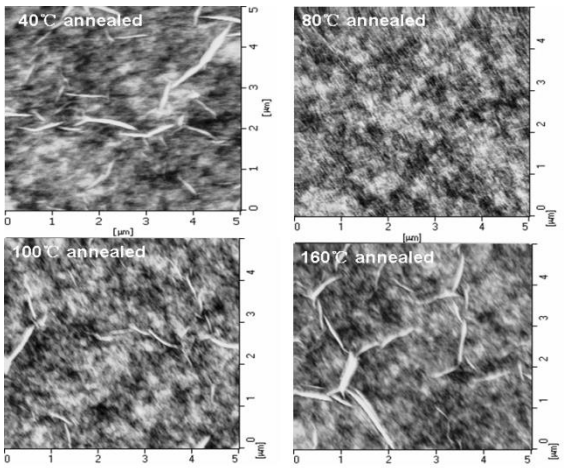

Fig.1. Atomic force microscopy low magnification images of the GO films annealed temperature

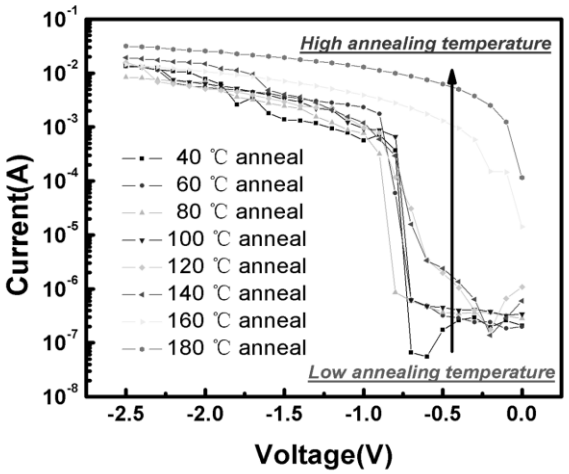

Fig.2. OFF-state I-V curves of memory devices annealed at different temperatures

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Highly efficient green organic light-emitting devices based on intermolecular exciplex

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Keywords: OLED, exciplex

A blended bimolecular exciplex formation was demonstrated between two individual donor and acceptor molecules, which are Tris(4-carbazoyl-9-ylphenyl)amine(TCTA) and 2,4,6-Tris(3'-(pyridin-3-yl)biphenyl-3-yl)-1,3,5-triazine(Tm3PyBPZ). The photoluminescence of the thin film showed a strong green exciplex emission with a peak around 514 nm, energetically identical with the energy difference between the donor and acceptor. The photophysics study showed that this intermolecular exciplex has a relatively high photoluminescence quantum yield, which was believed from the triplet exciton reharvesting through the delayed fluorescence channel. By applying this exciplex as an emitting layer, a highly efficient fluorescent organic lighting emitting diode with maximum efficiencies of 13.1% and 53.4 lm/W can be realized with an extremely low turn-on voltage of only 2.4V.

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A red-emissive sextuple hydrogen-bonding self-assembly molecular duplex bearing perylene diimide fluorophores, and a white organic light-emitting diode based on it

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Keywords: Hydrogen-Bonding Self-Assembly Duplex, Perylene Diimide, Incomplete Energy Transfer, White Organic Light-emitting Diode

Solution-processed white organic light-emitting devices (WOLEDs) have attracted much attention owing to their potential applications for low-cost large-area display and lighting panels, and devices based on polymeric light-emitting materials have dominated the solution-processed WOLEDs currently. However, polymer materials often suffer from batch-to-batch variations on molecular structures and low purity, which are adverse to the performance and reproducibility of the devices. Compared with polymer materials, hydrogen-bonding (HB) self-assembly supramolecules should be more promising because of their well-defined structures, however, the electroluminescent performance of WOLEDs based on them is still unsatisfactory.[1,2]

In our previous work, we have demonstrated that the introduction of sextuple HB self-assembly oligoamide strands into small molecular fluorophores is a quite effective approach for spatial isolation of fluorophores. Encouraged by these discoveries, herein, by incorporating red perylene diimide (PDI) fluorophores into a sextuple HB sites, a red-emitting self-assembly supramolecular duplex **PDIHB** (vide Fig 1.) has been constructed successfully. Photophysical results indicate that the presence of bulky HB self-assembly segments is beneficial to not only the suppression of concentration quenching of PDI luminogens, but also the spatial isolation of the luminogens, hence could promote incomplete energy transfer between **PDIHB** and its corresponding host material **2TPhNIHB** (vide Fig. 1) reported by us before.[3] Consequently, using the doping system of **PDIHB** and **2TPhNIHB** as the emitting layer, combined with the elctroplex formed at the interfaces,[3] a simple solution-processed two-layer WOLED with CIE coordinates of (0.42, 0.33) has been fabricated readily. The maximum brightness and current efficiency of this WOLED are 260 cd/m^2 and 0.49 cd/A, respectively; and It is worth mentioning that the chromaticity of the device is bias-independent. All these preliminary results indicate that the HB self-assembly compounds should be promising materials in WOLED applications. We believe that these findings are of particular interest for the development of high performance OLEDs based on supramolecular materials.

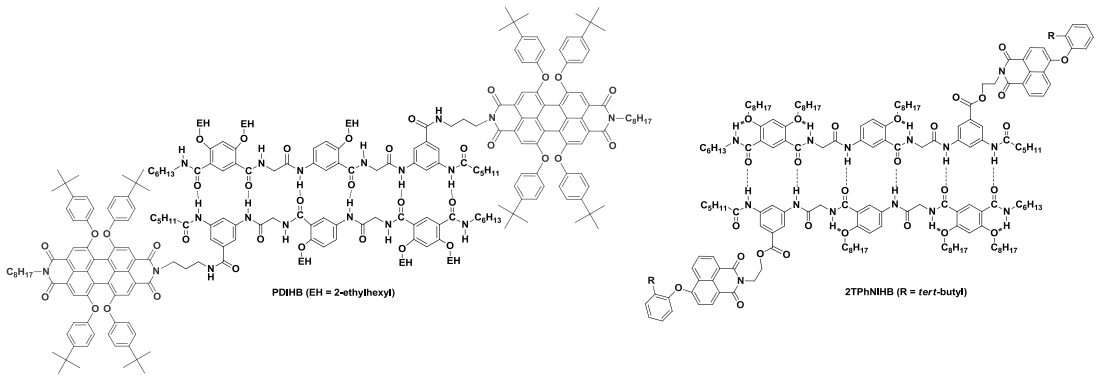

Fig. 1. Structures of **PDIHB** and **2TPhNIHB**

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Novel Exciplexes for Highly Efficient OLEDs Enabled by Thermally Activated Delayed Fluorescence (TADF)

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Keywords: exciplex, organic light-emitting diodes, delayed fluorescence, charge-transfer (CT)**.**

Fluorescent OLEDs based on pure TADF emitters have been reported with external quantum efficiencies (EQE) approaching the best results of phosphorescent OLEDs. Similar to the pure TADF emitters with intramolecular charge-transfer (CT) states, the exciplex emitters having intermolecular CT states exhibit intrinsically small singlet-triplet energy splitting (ΔE_{ST}, ca. 0 ~ 50 meV) and allow TADF emission via reverse intersystem crossing (RISC) from the non-radiative triplet excited state (T_1) to the radiative singlet excited state (S_1). Hence, the fluorescent OLEDs based on exciplex emitters also have theoretically 100% internal quantum efficiencies, corresponding to maximum EQEs of 20% (assuming a typical light out-coupling efficiency of 20%). However, the EQEs of the reported exciplex OLEDs are far lower than the theoretical limit due to the lack of exciplex emitters with high fluorescence quantum yields (Φ_f). Herein, we designed three exciplexes TAPC:DPTPCz, TCTA:DPTPCz and NPB:DPTPCz by half-and-half mixing three hole-transporting arylamines with a high-T_1 bipolar host. The three exciplexes show broad and notably red-shifted emissions relative to those of the constituting molecules. TAPC:DPTPCz and TCTA:DPTPCz have strong TADF emissions due to the effective energy confinement by their constituting molecules. Specially, TAPC:DPTPCz shows high Φ_f of 0.68 and small ΔE_{ST} of 47 meV, affording intrinsically efficient fluorescence radiation and high RISC efficiency. The TAPC:DPTPCz based device achieves a high EQE of 15.4%, which is the highest performance exciplex OLED up to date. After all, high-T_1 constituting molecules are shown to be preferable for designing exciplex emitters with high Φ_f, because the high T_1 of the constituting molecules prevent energy leakages and enable efficient RISC.

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Interface Engineering for high-performance, low-voltage n-channel organic thin film transistors (OTFTs) based on C_{60}

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Keywords: Interface engineering, work function, electron injection, high-performance, C_{60}

Exploring suitable electrode materials with sufficiently low work function, ambient stability and low-cost is of great technological importance to the development of n-channel OTFTs. Here, we show that the work function of Cu can be effectively reduced from 4.65 eV to 4.28 eV through surface modification via simply spin-coating a thin layer of branched polyethylenimine (PEI). By exploiting a high-capacitance density gate dielectric (200 nF/cm^2), low-voltage (3 V) C_{60} TFTs with electron mobility (μ_e) of 3.2 cm^2/Vs are demonstrated with PEI modified Cu as source-drain (S/D) electrodes. In contrast, the device with Cu S/D electrodes possesses μ_e of only 1.0 cm^2/Vs. The improvement in electrical performance of the PEI modified device is attributed to the efficient electron injection at the Cu/C_{60} interface which resulted from the reduction in work function of Cu. Moreover, upon PEI modification, the bias stability of the device can be obviously enhanced as compared to the unmodified one, and the resultant device exhibits an excellent thermal stability up to 200 ^{o}C without appreciable degradation in mobility. The facile modification of low-cost Cu as S/D electrodes for high-performance n-channel OTFTs as well as the low-voltage operation will pave the way for large scale manufacturing of organic electronics.

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Enhanced Light Harvesting in Organic Solar Cells Featuring a Bio-inspired Moth's Eye Nanostructures

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Keywords: organic solar cells, light manipulation, moth's eye nanostructures.

Organic solar cells (OSCs) hold great promise as low-cost and large-area devices and renewable energy sources. But the devices power conversion efficiency (PCE) is limited by the restricted absorption of solar radiation due to the optimized thickness of active layers in conventional devices. Here, we demonstrate enhanced light harvesting single-junction OSCs with a series of active layers using the moth's eye nanostructures for broadband light harvesting.

Nanoimprint lithography technique is used for introducing the nanostructures on the perfluoropolyethers (PFPE) mold into the devices. All films deposited on the moth's eye structured ZnO layer follow the ZnO surface feature with a slightly decreased nanostructure depth. By combining the experimental photocurrent measurements with optical modeling, structured active layer induced self-enhanced absorption, structured metal electrode induced surface plasmonic resonance, anti-reflection and light scattering effects are considered as the mainly contribution to the enhancement of incident light harvesting in nanostructured OSCs. Using moth's eye nanostructures, more than 20% increase in photocurrent is realized without sacrificing dark electrical properties, yielding a 22.2% enhancement in power conversion efficiency for OSCs with a poly(3-hexylthiophene-2,5-diyl):indene-C60 bis-adduct (P3HT:ICBA) active layer. Furthermore, with a nanostructured ZnO film surface smooth treatment for minimizing the charge recombination probability, a substantial increase in PCE to 10.1% is realized in the nanostructured single-junction PSCs with a poly[4,8-bis(5-(2-ethylhexyl)thiophen-2-yl)benzo[1,2-b:4,5-b']dithiophene-co-3-fluorothieno[3,4-b]thiophene-2-carboxylate]:[6,6]-phenyl-C71-butyric acid methyl ester (PTB7-Th:$PC_{71}BM$) active layer.

Accordingly, this method is straightforward represents an accessible and attainable way for the development of high-efficiency PSCs towards the future photovoltaic applications.

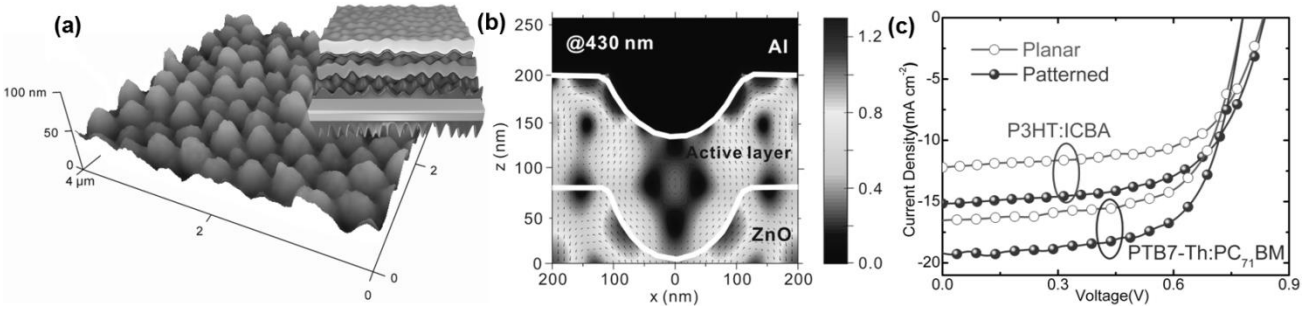

Fig. 1 a) AFM image of nanostructured ZnO film and schematic of nanostructured device. b) The normalized photon flux distribution diagrams in nanostructured device at a wavelength of 430 nm. c) The J-V characteristics of OSCs with different active layers.

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Highly efficiency electron transfer layer based on Ag, Al co-doped ZnS in organic lighting emission diodes

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Keywords: electron transfer layer, ZnS:Ag,Al, Electroluminescence, Impurity.

The possibility of the ZnS:Ag, Al film as highly efficiency electron transfer layer (ETL) has been analyzed and the Bohr radius of impurity atoms has been calculated by using quantum theory. The best efficient thickness of theoretical reference value was given for the Ag-Al co-doped ZnS as ETL. The organic light-emitting diodes (OLEDs) which use the Ag, Al co-doped ZnS film as ETL have been fabricated with the structure of ITO/NPB/Alq3/ZnS:Ag,Al(x)/PBD/Al. The effect of Ag, Al co-doped ZnS ETL thickness to the characters of OLEDs were investigated in experiments. It is shown that the relative external quantum efficiency (REQE) and electroluminescence (EL) intensity of device with co-doped ZnS ETL (8nm) increases by 430 times and 130 times respectively as compared to device without ETL. Besides the turn-on voltage is reduced about 4V. Comparing with OLED with un-doped ZnS ETL, the REQE of Ag-Al co-doped ZnS ETL devices was enhanced by 3 times. Comparing with the device owning 40nm TPBi ETL shows that the using of co-doped ZnS can reduce the thickness of ETL from 40nm to 8nm and performs comparable REQE and higher EL intensity. Results of PL spectrum studies and current density-voltage characters reveal that the improved electron transmission is attributed to the introduction of impurity energy level and the increased concentration of electron. The studied results reveal that Ag, Al co-doped ZnS behave ideal proprieties of electrons transporting and hole blocking properties. Thus it can be expected that Ag-Al co-doped ZnS could be used as other organic photo-electronic devices.

$$|E_i| = \frac{m_e^* e^4}{8\varepsilon_0^2 \varepsilon_s^2 h^2} = \frac{m_e^*}{m}\frac{1}{\varepsilon_s^2}\cdot 13.6\,\text{eV} << 13.6\text{eV} \qquad a = \varepsilon_s\left(\frac{m}{m_e^*}\right)\frac{\varepsilon_0 h^2}{\pi e^2 m} = \varepsilon_s\left(\frac{m}{m_e^*}\right)a_0 \approx 2.2\text{nm}$$

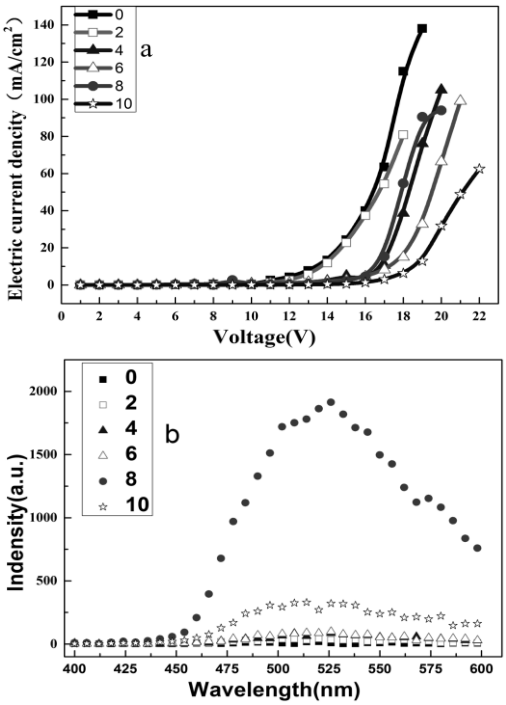

Fig.1 Emission performance of devices with various thicknesses of Ag-Al co-doped ZnS ETL. (a) Current density-voltage, (b) EL spectrum.

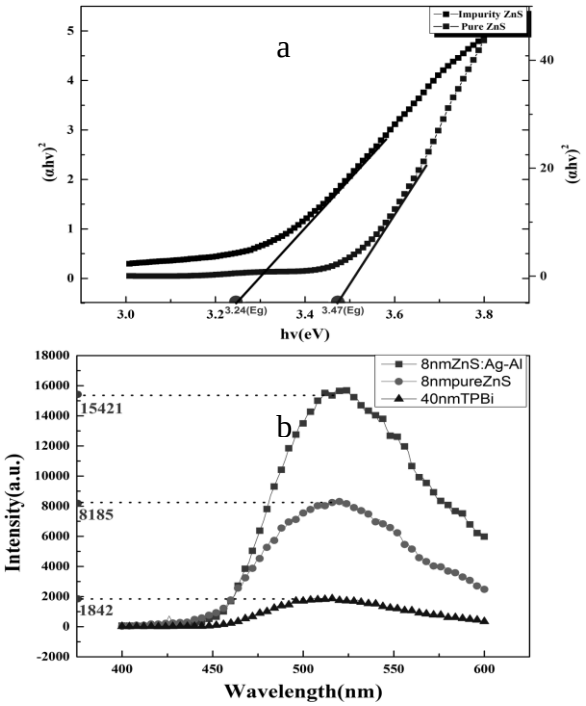

Fig.2 the energy gap of ZnS and ZnS:Ag,Al (a) and EL spectrum of diodes with different ETL (b)

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The simulation study of fluid physical properties on drop formation of drop-on-demand inkjet printing

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Keywords: drop-on-demand; inkjet; volume of fluid; pressure waveform

Motivated by the desire to improve the theoretical understanding of drop-on-demand inkjet printing, a simulation analysis is carried out to study the effect of pressure waveform on the droplet formation. However, the physical phenomenon in inkjet printing process is very complicated with the coupling of piezoelectricity, elasticity, and free surface fluid dynamics. In order to simplify the problem and focus on the process of droplet ejection, the sine curve pressure waveform at the nozzle inlet is proposed by the propagation theory of acoustic waves, and a 2D rotational symmetric model with symmetry on the nozzle axis is built to reduce the CPU time. The volume of fluid (VOF) method is implemented in the commercial code FLUENT(R) to model the details of the drop formation process. The three primary factors, negative, positive pressure amplitude and dwell time of the pressure waveform that influence the droplet formation process are investigated. The results indicated that the velocity and length of liquid thread play important roles for the jet formation process. The jet stability can be achieved through optimizing the pressure waveform factors

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Crystal-Domain Orientation and Boundary of Organic Semiconductor Thin Film Investigated by *in-situ* Kelvin Probe Force Microscopy

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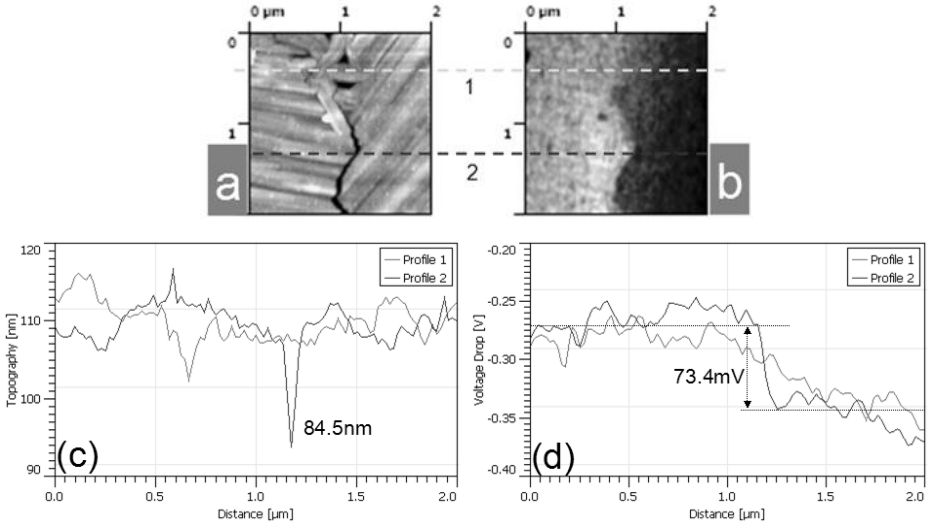
Keywords: domain orientation; domain boundary; organic semiconductor thin film; kelvin probe force microscopy; weak epitaxial growth**.**

The electrical properties of highly oriented phthalocyanine copper (CuPc) thin film field-effect transistors (FETs) fabricated by weak epitaxial growth (WEG) on *para*-sexiphenyl (*p*-6P) are strongly dependent on the microstructure of organic semiconductor thin film. They are demonstrated based on the analysis of film morphology, electrical measurement, and kelvin probe force microscopy (KPFM). The thin film topography and electrical potential distribution of CuPc FETs under operating condition were investigated by KPFM. We disclose how the microstructure of organic semiconductor thin films, *e.g*., intra-domains and nanoscale boundaries, influence the performance of organic electronic and optoelectronic devices. The potential wells and steep voltage drop were observed at domain boundaries under bias between the source and drain electrodes, indicating the formation of the potential barrier at the domain boundaries (DBs) which limits the charge transport. The field-effect mobility of CuPc devices increased with the domain sizes, resulting from the reduction of the mismatched orientation degree and the number of DBs. Domain boundary model was proposed to explain the relationship between field-effect property and microstructure of CuPc/*p*-6P thin films, providing a guide for rational optimization of film morphology for high performance FETs.



(a) Topographic image of CuPc by KPFM. Line 1 crosses the domain boundary; line 2 crosses the amorphous region between two domains. (b) Corresponding voltage drop image by KPFM. The scan area is 2 µm×2 µm. (c) Line sections in (a). (d) Line sections in (b).

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Investigation on the roles of weight ratio between precursors in the CVD growth of bilayered MoS_2 crystals

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Keywords: Molybdenum disulfide; Chemical vapor deposition; Raman spectra; AFM; XPS

Atomically thin molybdenum disulfide (MoS_2) with a ~1.8 eV direct band gap is a promising two-dimensional (2D) materials that goes beyond graphene for the next generation of nanoelectronics devices. Here, we investigate the dependence of the chemical vapor deposition growth of MoS_2 on the weight ratio between sulfur and molybdenum trioxide (MoO_3) in details by optical microscopy, scanning electron microscopy, X-Ray photoemission spectra, Raman spectra and high-resolution atomic force microscopy. By tuning the corresponding weight ratio, the concentration ratio between sulfur and MoO_3 vapor can be well controlled, resulting in well-controlled MoS_2 single crystal microflakes in different thicknesses and shapes on the SiO_2/Si substrates. The results reported here provide a beneficial insight to synthesize not merely high crystalline MoS_2, but also other layered 2D chalcogenide semiconductors and their related heterstructures.

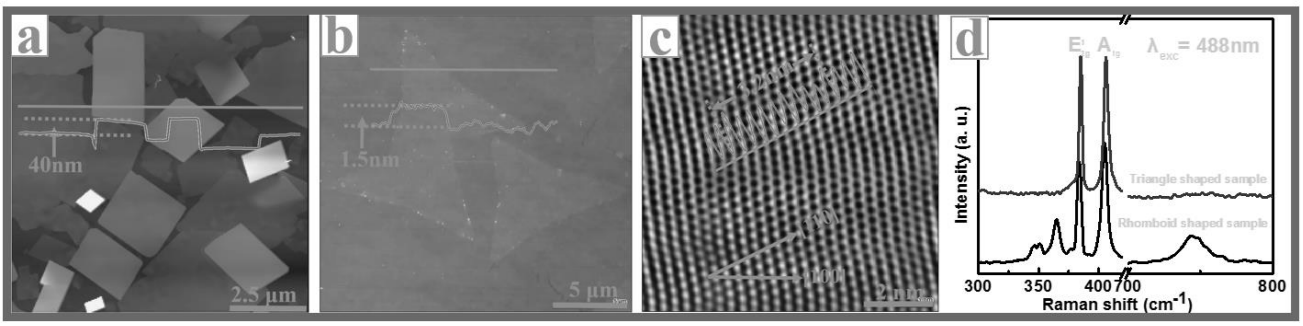

Figure: (a) The rhomboid shaped MoS_2 microflakes and corresponding height profile scan by blue solid line. (b) The triangle shaped molybdenum disulfide microflakes and corresponding height profile scan by blue solid line. (c) The atomic resolution AFM friction image and corresponding lattice constant profile scan by the crystal orientation [110] (Inset), indicating the lattice constant is ~0.32 nm. (d) The Raman spectra of two samples with different morphologies, which including two characteristic peaks of MoS_2 crystals, indicating the success synthesized of MoS_2 crystals.

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Electronic structures at the interface between Au and $CH_3NH_3PbI_3$

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Keywords: Au/$CH_3NH_3PbI_3$ interface, Interfacial electronic structure, UPS, XPS, IPES

The electronic properties of interfaces formed between Au and organometal triiodide perovskite ($CH_3NH_3PbI_3$) are investigated using ultraviolet photoemission spectroscopy (UPS), inverse photoemission spectroscopy (IPES) and X-ray photoemission spectroscopy (XPS) [1]. It is found that the $CH_3NH_3PbI_3$ film coated onto the substrate of PEDOT:PSS/ITO by two-step method [2] presents n-type semiconductor behavior, with a band gap of 1.7 eV and a valence band (VB) edge of 1.0 eV below the Fermi energy (E_F). An interface dipole of 0.1 eV is observed at $CH_3NH_3PbI_3$/Au interface. The energy levels of $CH_3NH_3PbI_3$ shift upward by ca.0.4 eV with Au coverage of 64 Å upon it, resulting in band bending, hence a built-in field in $CH_3NH_3PbI_3$ that encourages hole transportto the interface. Hole accumulation occurs at the vicinity of the interface, facilitating the hole transfer from $CH_3NH_3PbI_3$ to Au. Furthermore, the shift of VB maximum of $CH_3NH_3PbI_3$ toward the E_F indicates a decrease of energy loss as extracting holes from the $CH_3NH_3PbI_3$ film to the Au coverage.

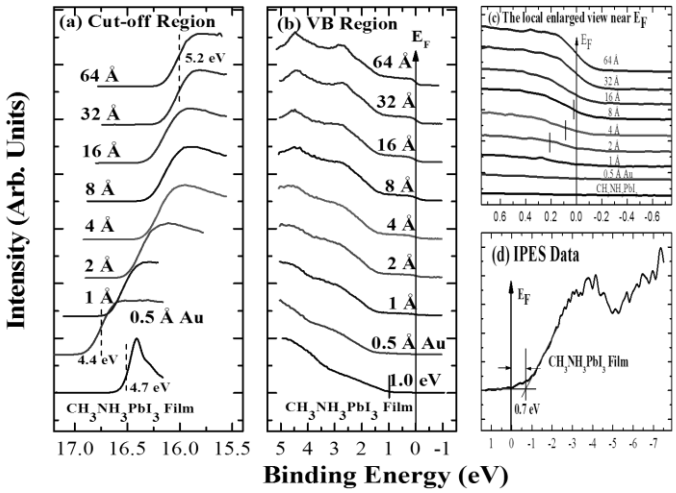

Fig. 1 Thickness dependent UPS spectra of Au on $CH_3NH_3PbI_3$ coated on PEDOT:PSS/ITO substrate showing (a) the cut-off region, (b) the VB edge region, (c) the local enlarged view of the VB edge region near E_F. (d) presents IPES spectra of the density of states close to the bandgap of the $CH_3NH_3PbI_3$. Positions of the VB edge, the CB edge and the Fermi edge are marked.

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P-61

Fast and simplified fabrication of well-crystallized perovskite methylammonium lead iodides films with a CVD method

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Keywords: Perovskite solar cells, fast fabrication, CVD & thin film

Methylammonium lead iodides ($MAPbI_3$) are generally synthesized from lead iodides (PbI_2) with solution methods. Here, we report a simple and fast chemical vapor deposition method for fabricating highly crystallized perovskite $MAPbI_3$ films. We converted PbI_2 thin films into $MAPbI_3$ films with semi-opened low-pressure hot-wall chemical vapor deposition apparatus. We recorded the evolution of X-ray diffraction patterns (Fig. 1). The left figure in figure 1 shows that all PbI_2 has been converted into $MAPbI_3$ within 10 minutes. SEM results suggest that $MAPbI_3$ films exhibit the same coverage with their precursor PbI_2 films, indicating that MAI reacts with PbI_2 in situ. One advantage of this method is that neither carrier gases nor high vacuum is needed during the fabrication. Therefore, this method is expected to find applications in the large-scale fabrication of perovskite solar cells in the future.

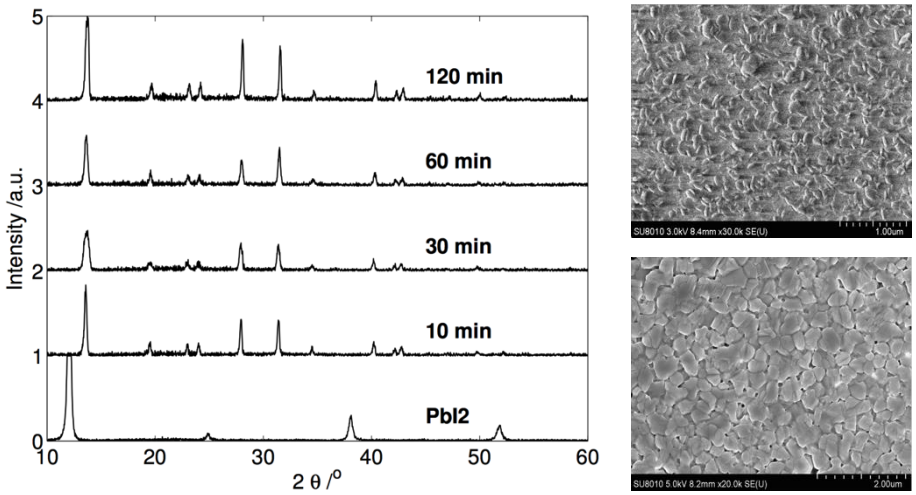

Figure 1 Left: evolution of XRD patterns of $MAPbI_3$ films synthesized in different times. Right: SEM images of precursor PbI_2 (top) and synthesized $MAPbI_3$ (bottom).

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Platinum-based Luminescent Metallomesogens: Synthesis, Photophysical Properties and Application for OLEDs

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Keywords: Metallomesogens; Platinum complex; Luminescence; WOLEDs

Organic light-emitting diodes (OLEDs) containing luminescent liquid crystal (LC) materials have been recognized as a promising light source for the backlight of LC displays (LCDs) due to their active emission and high efficiency displays. To this end, luminescent metallomesogens hold promise for organic semiconductor due to the combination of the optoelectronic characteristics of luminescent materials with the unique properties of anisotropic fluids. In this contribution, we reported both novel platinum-based luminescent metallomesogens (**Pt1** and **Pt2**) featuring D-A-D framework. Their liquid crystals and the luminescent properties were investigated, as described in **Figure 1**. In addition, the OLEDs were fabricated with the configuration of ITO/PEDOT:PSS(30 nm)/PVK(30 nm)/PFO:**Pt2** (80:20, 70 nm)/B3YMPM(50 nm)/Ca(100 nm)/Al(100 nm). The white emission with a highest dichromatic ratio of 1.32 was achieved (**Figure 2**). This study may pave the way for luminescent LC materials application for the backlight of LCDs.

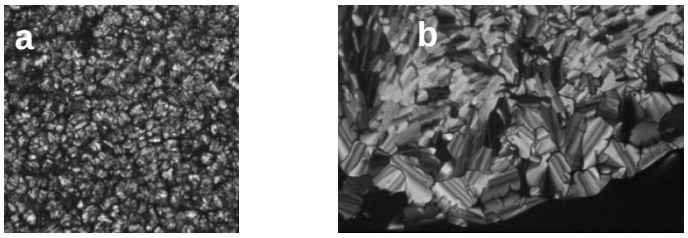

Figure 1. The POM images of **Pt1** (a: Pt4, 144^{o}C) and **Pt2** (b: 121^{o}C)

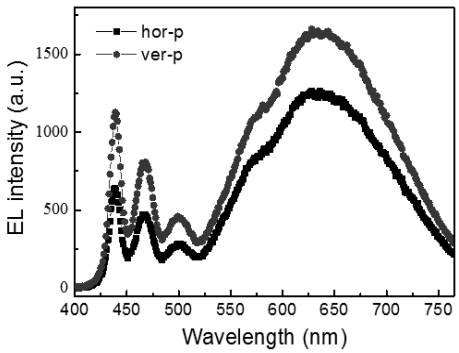

Figure 2. **EL** of **Pt 1 (**hor: horizontal, ver: vertical**)**

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P-63

Thickness Dependent Air-Exposure Induced Phase Transition of CuPc Ultra-Thin Films to Well-Ordered One-Dimensional Nanocrystals on Layered-Substrates

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Keywords: CuPc, layered substrates, nanocrystals, air exposure, phase transition

Highly ordered organic crystals are important building blocks for future high-performance organic nanodevices. Here we report a feasible way to produce arrays of well-ordered one-dimensional (1D) CuPc nanocrystals by using MoS_2 or HOPG as templates. The growth behaviors of CuPc on MoS_2 as well as on HOPG and corresponding effects of air-exposure were systematically investigated by means of *in situ* photoemission spectroscopy (PES) and low-energy electron diffraction (LEED), combined with *ex situ* atomic force microscope (AFM), grazing incidence X-ray diffraction (GIXRD) and Raman. *In situ* PES and LEED results show that CuPc molecules adopt an face-on configuration at the thickness up to 4.8nm, consistent with previous reports [1,2], while *ex situ* AFM and GIXRD results show 1D nanocrystals with molecules in an edge-on configuration for 4.8 nm-thick CuPc. Detailed analyses show that the formation of these 1D nanocrystals is closely related to the air exposure, CuPc thicknesses and growth temperature. Such 1D CuPc nanocrystals can be further optimized by changing growth conditions and may have great potential for use in high-performance organic devices.

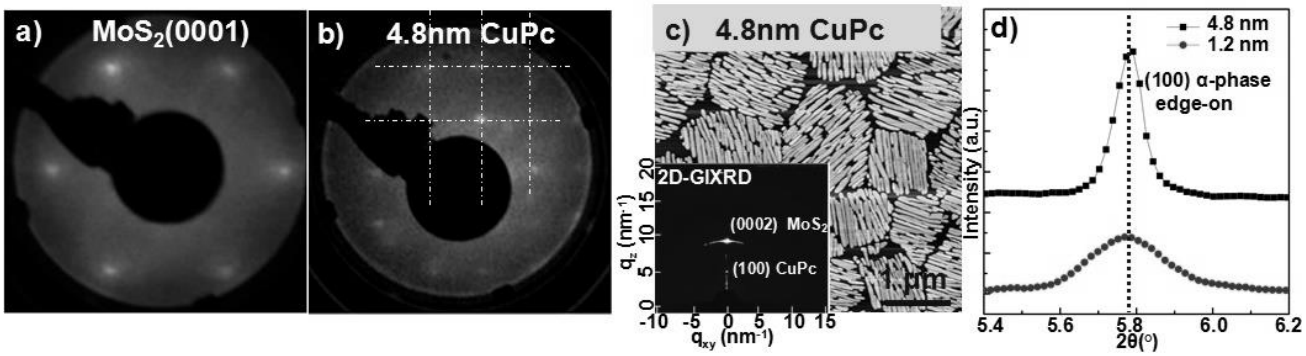

Fig. *LEED patterns of (a) MoS_2(0001) and (b) 4.8nm-thick CuPc on it. (c) AFM image of 4.8 nm-thick CuPc and corresponding 2D-GIXRD. (d) Out-of-plane GIXRD spectra of 1.2 and 4.8 nm-thick CuPc films around the α-phase (100) peak.*

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Elimination of the herringbone reconstruction of Au(111) surface by self-assemblied HBB

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Key Words: Au(111); dereconstruction; HBB; STM

Au(111) reconstructs at room temperature into the well-known (22×√3) superstructure due to a unidirectional compression along the <110> directions of the top gold layer, leading to 23 top layer gold atoms in 22 bulk lattice atomic spaces. Utilization and manipulation of these reconstructions are active fields in surface science. The effect of the self-assembly monolayer HBB film on the Au(111) surface reconstruction has been studied by high-resolved Scanning Tunneling Microscopy (STM). Under UHV condition, the herringbone reconstruction pattern on clean Au(111) surface is clearly observed. Upon deposition of sub-monolayer HBB molecules, part of herringbone reconstruction on Au(111) surface disappear. Molecular-resolved STM observation indicates that, HBB molecules are in a square arrangement in the islands without herringbone reconstruction but surrounded by closed soliton. In contrast, HBB molecules are in a hexagonal arrangement in the islands with visible herringbone reconstruction and the corresponding reconstructed patterns were consecutive cross the border of the molecule layer. The sub molecularly resolved STM images show that in the former case HBB molecules lift some Au atoms from their equilibrium positions resulting in surface atom density reducing and thus relieve Au(111) surface reconstruction, indicating stronger interaction with substrate, On the contrary, a strong interaction is observed among HBB molecules with hexagonal lattice, which barely influence the substrate. Giving geometric analysis, we put forward two possible arrangements of HBB molecules.

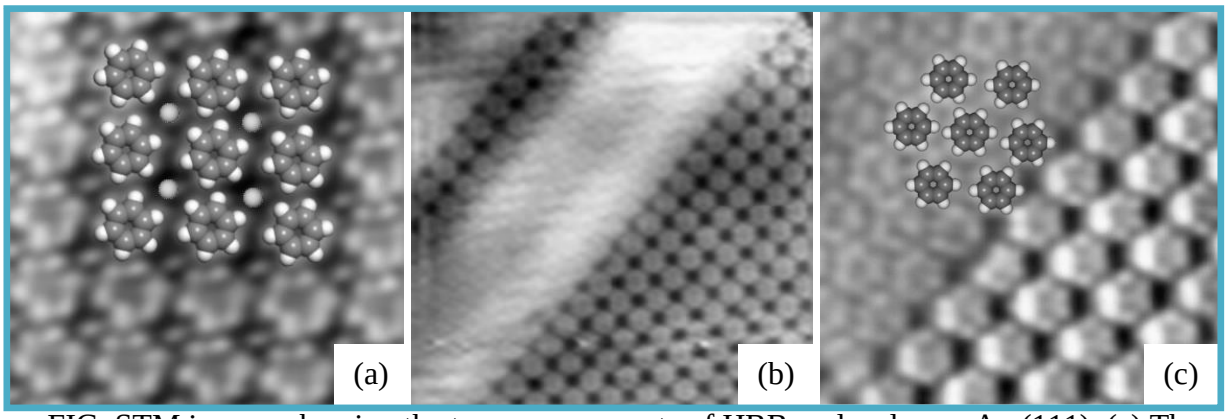

FIG. STM images showing the two arrangements of HBB molecules on Au (111). (a) The tetragonal lattice. (b) The concurrence of the tetragonal lattice and the hexagonal lattice. (c) the hexagonal lattice.

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P-65

Interfacial Energy level alignment at $MoOx/CH_3NH_3PbI_3$ Interface

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Keywords: photoemission spectroscopy, $MoOx/CH_3NH_3PbI_3$ interface, interfacial energy level alignment

Interfacial electronic properties of the $MoOx/CH_3NH_3PbI_3$ interface are investigated using UPS and XPS. It is found that the pristine $CH_3NH_3PbI_3$ film coated onto the substrate of PEDOT:PSS/ITO by two-step method [1] behaves as an n-type semiconductor, with a band gap of ~1.7 eV [2] and a valence band (VB) edge of 1.43 eV below the Fermi energy (E_F). With the MoOx deposition of 64 Å upon $CH_3NH_3PbI_3$, its energy levels shift toward higher binding energy by 0.6 eV due to electron transfer from $CH_3NH_3PbI_3$ to MoOx, and its conduction band (CB) edge is observed to penetrate the E_F to reach to the position of 0.33 eV below the E_F at the very interface of $MoOx/CH_3NH_3PbI_3$ due to an interface reaction. A transition from semiconductor to quasi-metal occurs at the interface of $MoOx/CH_3NH_3PbI_3$, indicating a significant enhancement of conductivity. Meanwhile, an interface dipole of 2.97 eV is observed at the interface of $MoOx/CH_3NH_3PbI_3$. Most importantly, a potential barrier of 0.8 eV is observed for hole extraction from $CH_3NH_3PbI_3$ to MoOx, indicating that the interface of $MoOx/CH_3NH_3PbI_3$ is not an ideal choice for hole extraction in OPV devices.

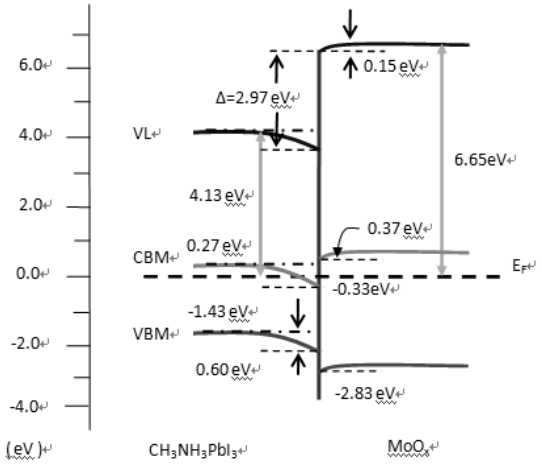

Fig. 1 The energy levels alignment diagram for the $MoOx/CH_3NH_3PbI_3$ interface

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Effects of precursor ratios on electronic structure and surface composition of perovskite films

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Keywords: $CH_3NH_3PbI_3$, UPS, XPS, precursor ratio, annealing

The characteristics of high absorption coefficient, appropriate direct bandgap, excellent carrier transport, low cost, and solution-based fabrication process make the organometallic halide perovskites have attracted intensive interest in recent years. [1-2] We have investigated the electronic structure of the $CH_3NH_3PbI_3$ films fabricated by one-step method with different precursor ratios (PbI_2/CH_3NH_3I) using ultraviolet photoemission spectroscopy (UPS) and X-ray photoemission spectroscopy (XPS). It is found that the *n* to *p* type transition can be adjusted by changing precursor ratios, [3] as shown in Fig. 1. The perovskite film shows heavily n-doped behavior with the precursor ratio of 1.7, and the Fermi level is pushed down closer to valance band top as reducing the precursor ratio, then the film is observed to be weak p-type with the precursor ratio of 0.3. The XPS results show that the lead content for the perovskite film with 0.3 precursor ratio reaches the minimum, indicating the existence of Pb vacancies to lead to the formation of p-type film. Furthermore, we have investigated the effects of annealing on the electronic structure and surface composition of perovskite films. We find that the perovskite film with 0.3 precursor ratio can be changed from p-type to *n*-type after annealing due to the reduction of iodine content.

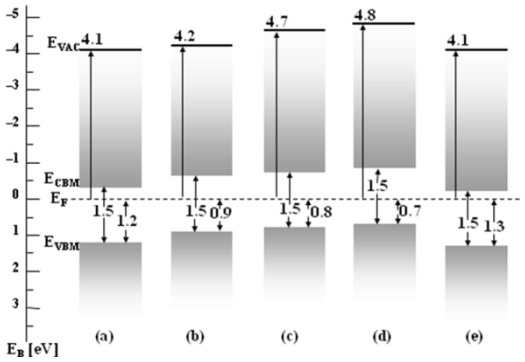

Fig. 1 The energy levels of perovskite films with different precursor ratios. (a) 1.7 precursor ratio, (b) 1.0 precursor ratio, (c) 0.65 precursor ratio, (d) 0.3 precursor ratio, (e) 0.3 precursor ratio film after annealing.

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P-67

The Study of Spectroscopic Properties of Colloidal Solutions of Superparamagnetic Nanoparticles (Fe_3O_4/SiO_2)

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Keywords: Magnetite Nanoparticles, Fe_3O_4/SiO_2 Composite Nanoparticles, UV-Vis spectroscopy, Biomolecular Electronics, G. Mie Theory.

The development of novel methods of medical diagnostics such as magnetic resonance imaging (MRI), positron emission tomography, X-ray computed tomography has required further research in the field of agents for contrast-enhanced imaging [1]. Composite superparamagnetic Fe_3O_4 nanoparticles could be considered as negative contrast agents reducing spin-spin relaxation time. Furthermore, due to their biocompatibility magnetic nanoparticles may be also used as magnetic drug-targeting agents [2] and as a potential medium for magnetic hyperthermia in high-frequency AC magnetic field [3]. Optical properties of thin magnetite films are of great interest: such films demonstrate UV absorption and decent transmission in visible region allowing to consider nano-sized magnetite as a promising optoelectronic material [4].

The research presented in this thesis has two distinct objectives. The first objective is identification of parameters of the optical absorption spectra of colloidal solutions of magnetic nanoparticles. The second objective is to create a structure model of a single composite Fe_3O_4/SiO_2 nanoparticle. Specord® 40 Analytik Jena was used to fulfill measurements of optical absorption spectra of the samples at the temperature of 300K.

According to P. Levy [5], the shape of the absorption bands is considered to be Gaussian [Eq. (1); where K_0 corresponds to absorbance at the wavelength of an absorption band maximum, U is the half-width of an absorption band (cm^{-1}) and ν_0 is the position of an absorption band maximum (cm^{-1})] .

$$K(\nu) = K_0 \exp\left[-\frac{4\ln 2}{U^2}(\nu - \nu_0)^2\right] \quad (1)$$

The appearance of absorption spectra of colloidal solutions indicates the identity of the chemical composition. Alternation in the concentration of Fe_3O_4 nanoparticles deposited on the SiO_2 gel matrix during the Massart reaction was obvious and the largest concentration of Fe_3O_4 nanoparticles is detected while using a solution of tetraethoxysylane (TEOS) in isopropanol with the concentration of TEOS 60 vol. %.

As a result of mathematical treatment of absorption spectra using Origin© 8.1 six distinctive absorption bands in UV region corresponding to the following maxima were discovered: 25130 cm^{-1}, 26220 cm^{-1}, 27300 cm^{-1}, 28480 cm^{-1}, 29530 cm^{-1} and 30480 cm^{-1} with intrinsic half-width remaining constant. The presence of these bands is suggested to be due to the formation of Fe_3O_4 clusters on the surface of the gel matrix with six characteristic dimensions. Absorption maxima observed at a concentration of TEOS 60 vol. % and associated with clusters of all sizes are caused by the interaction of clusters. Cluster size was estimated using G. Mie Theory [6].

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Highly Efficient Planar Heterojunction Perovskite Solar Cells Fabricated by Solvent Engineering

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Keywords: perovskite solar cell; planar heterojunction; $CH_3NH_3PbI_3$; organic Semiconductor**.**

Organic-inorganic hybrid perovskite solar cells are attracting considerable attention owing to their advantages such as large absorption coefficient, direct bandgap and high carrier mobility. All kinds of preparation methods have been developed to fabricate highly efficient perovskite solar cells, including vacuum deposition [1], two-step sequential solution deposition [2], vapor-assisted two-step reaction method [3], and so on. The solution-processed technique is popularly attractive due to its facile preparation and low cost. But it is still greatly challenging to prepare pin-hole free and continuous perovskite film through solution deposition. Herein, we successfully fabricate pin-hole free and continuous perovskite films using controllable solvent treatment, which are further used to fabricate planar heterojunction perovskite solar cells with a structure ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/$PC_{61}BM$/Al. It shows an average power conversion efficiency (PCE) of 9.26%, which is one of the highest efficiencies for low-temperature, solution-processed planar heterojuction perovskite solar cells based on the structure ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/$PC_{61}BM$/Al. More importantly, perovskite solar cells fabricate using this method show well repeatability and no obvious hysteresis with different scan directions and scan speeds.

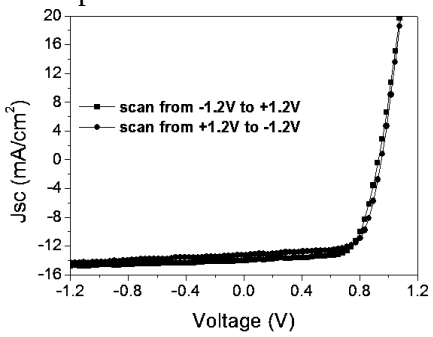

Fig. 1. J-V curves for a devices scan with different scan direction.

A**cknowledgement**

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Boosting the Power Conversion Efficiency of Organic Solar Cells Using Weakly Luminescent Gold(III) Corrole with Long-Lived Exciton State

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Keywords: organic solar cell, photo-conversion, triplet state, gold-corrole, and electron-donor**.**

Transition metal complexes have been widely used as light-emitting and photon-absorbing materials in optoelectronic devices with diverse applications. While these complexes have been intensively studied in the field of organic light-emitting devices (OLEDs) due to their ***inherently high phosphorescence quantum yields*** (Φ), they are rarely employed in the fabrication of organic solar cells (OSCs) ***with reported examples showing poor photovoltaic responses*** with unexpectedly low power conversion efficiency (PCE) of ≤ 2.9% for most of the vacuum-deposited devices or ≤ 5.0% for solution-processed devices in the literature. Here, we successfully employed ***weakly luminescent gold(III) corrole***, namely **HKU-AuC**, as photon-absorber which can ***effectively boost up the PCE of OSCs to 6%*** under 1 sun AM1.5G simulated light illumination with high short-circuit current density of 14.2 mA cm^{-2} and fill factor of 0.57, which is the highest value among the reported PCE for OSCs incorporating metal-organic complexes. The superior device performance may be ascribed to the ***weakly emissive nature with low Φ of 0.04% and long excited state lifetime of 63 μs*** of **HKU-AuC**, which can minimize recombination loss and favor exciton-dissociation. A broad absorption covering the entire visible spectral region has also been observed, which is originated from mixing excited states of triplet ligand-to-metal charge-transfer and singlet ligand-centered $\pi \rightarrow \pi^*$ transitions. These distinct features of **HKU-AuC** may account for the significant increase in the photocurrent and PCE of OSCs. More importantly, the Φ is suggested to play an important role affecting the PCE and can be used to rationalize the inferior OSC performance based on other phosphorescent organometallic complexes. ***This work demonstrates for the first time to employ gold(III) complex as donor*** and opens up a new avenue to fully utilize transition metals for the fabrication of OSCs.

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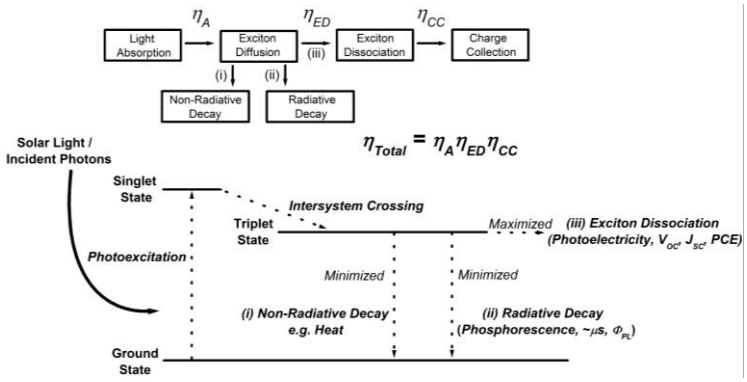

FIG 1. Mechanisms of the photoconversion in OSCs with triplet photoactive materials. η_{TOTAL}, η_A, η_{ED}, and η_{CC} are the total, light-absorption, exciton-dissociation and charge-collection efficiencies, respectively.

RELEVANT PUBLICATION

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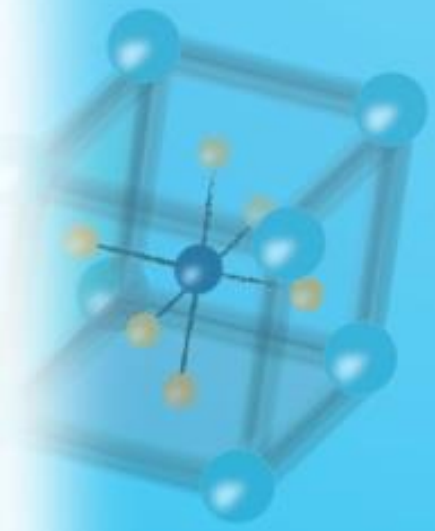

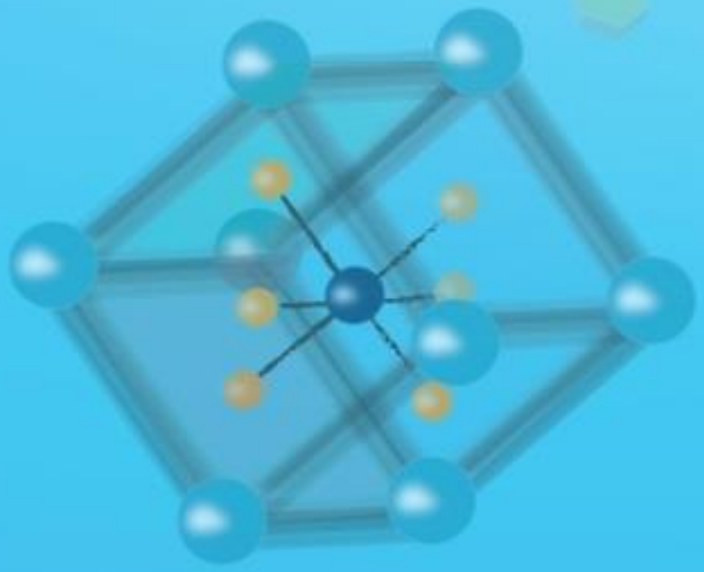

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