



## Roll-to-Roll Printed Electronics for Standalone Smart Windows

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*Publication date:*  
2016

*Document Version*  
Publisher's PDF, also known as Version of record

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*Citation (APA):*  
Pastorelli, F. (2016). *Roll-to-Roll Printed Electronics for Standalone Smart Windows*. Abstract from 2016 Materials Research Society Fall Meeting & Exhibit, Boston, Massachusetts, United States.

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# Symposium PM5 : Hierarchical, Hybrid and Roll-to-Roll Manufacturing for Device Applications

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## Symposium Organizers

James Watkins, Univ of Massachusetts  
Karen Chong, Institute of Materials  
Research and Engineering (IMRE) / A-STAR  
Jukka Hast, VTT Printed Intelligence  
Mark D. Poliks, Binghamton University

## Symposium Support

State University of New York at  
Binghamton, University of Massachusetts  
Amherst (Center for Hierarchical  
Manufacturing)

## PM5.6: Lighting and Optical Applications

### Session Chairs

Jeff Morse  
Mark D. Poliks

Wednesday AM, November 30, 2016  
Hynes, Level 1, Room 109

### 9:00 AM - \*PM5.6.01

Towards High-Throughput Coating and Printing of Light-Emitting Electrochemical Cells

[Ludvig Edman](#)<sup>1</sup>

<sup>1</sup> The Organic Photonics and Electronics Group Umeå University Umea Sweden

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### 9:30 AM - PM5.6.02

Large Area Flexible Lighting Elements Manufactured by Roll-to-Roll Compatible Processes

[Kimmo Keranen](#)<sup>1</sup>, [Jyrki Ollila](#)<sup>1</sup>, [Sami Ihme](#)<sup>1</sup>, [Eveliina Juntunen](#)<sup>1</sup>, [Jukka-Tapani Makinen](#)<sup>1</sup>, [Kari Ronka](#)<sup>1</sup>

<sup>1</sup> VTT Technical Research Centre of Finland Oulu Finland

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**9:45 AM - PM5.6.03**

All-Printed Full-Color OPD Array with a Single Organic Active Layer

Igal Deckman<sup>1</sup>, Pierre Lechene<sup>1</sup>, Adrien Pierre<sup>1</sup>, Ana Claudia Arias<sup>1</sup>

<sup>1</sup> University of California, Berkeley Berkeley United States

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**10:00 AM - PM5.6.04**

Roll-to-Roll Printed Electronics for Standalone Smart Windows

Francesco Pastorelli<sup>1</sup>

<sup>1</sup> Technical University of Denmark Roskilde Denmark

 Hide Abstract

We implement a smart electrochromic plastic window using a flexible organic power transistors prepared with roll-to-roll compatible printing techniques. This innovative transistor is able to drive large currents while handling the thermal aspects in operation together with other organic printed electronics technologies such as large area organic photovoltaics(OPV) and large area electrochromic (EC) displays. We find especially that an elevated operational temperature is beneficial for the transistor characteristics.

The footprint of organic electronic technologies is important when united in complex circuitry. We present flexible organic power transistors prepared by fast (20 m min<sup>-1</sup>) roll-to-roll flexographic printing of the drain and source electrode structures, with an interspace below 50 μm, directly on polyester foil. The devices have top gate architecture and were completed by slot-die coating of the organic semiconductor poly-3-hexylthiophene and the dielectric material polyvinylphenol before the gate was applied by screen printing. We explore the footprint and the practically accessible geometry of such devices with a special view toward being able to drive large currents while handling the thermal aspects in operation together with other organic printed electronics technologies such as large area OPV and large area EC. We find especially that an elevated operational temperature is beneficial with respect to both transconductance and on/off ratio. We achieve high currents of up to 45 mA at a temperature of 80 °C with an on/off ratio of 100 which is sufficient to drive large area organic electronics such as an EC device powered by OPV devices that we also demonstrate. EC materials can change their transparency when an external voltage is applied. Such materials have interesting applications in windows. Thus, one can imagine a window in an office or a greenhouse which automatically pulls the shade by making itself darker, when the temperature gets too high.

Francesco Pastorelli, Thomas M. Schmidt, Markus Hösel, Roar R. Søndergaard, Mikkel Jørgensen and Frederik C. Krebs, " The Organic Power Transistor: Roll-to-Roll Manufacture, Thermal Behavior, and Power Handling When Driving Printed Electronics", Volume 18, Issue 1, pages 51–55, January 2016, doi: 10.1002/adem.201500348

**10:15 AM - PM5.6.05**

Development Process and Design Rules of Inkjet-Printed Silver Grid Electrodes for Use in Highly Efficient Solution-Processed ITO-Free OLEDs

Felix Hermerschmidt<sup>1</sup>, Ignasi Burgués-Ceballos<sup>2</sup>, Lukas Kinner<sup>3</sup>, Stefan Sax<sup>3</sup>, Gerburg Schider<sup>3</sup>, Christine Boeffel<sup>4</sup>, Stelios Choulis<sup>2</sup>, Emil List-Kratochvil<sup>1</sup>

<sup>1</sup> Humboldt-Universität zu Berlin Berlin Germany, <sup>2</sup> Cyprus University of Technology Limassol Cyprus, <sup>3</sup> NanoTecCenter Weiz Forschungsgesellschaft mbH Weiz Austria, <sup>4</sup> Fraunhofer Institute for Applied Polymer Research Potsdam-Golm Germany

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**10:30 AM - \***

Break

**11:00 AM - PM5.6.06**

High Volume Solution Based Roll-to-Roll Processing of OLEDs

Pim Groen<sup>1</sup>, Robert Abbel<sup>1</sup>, Joanne Wilson<sup>1</sup>, Ike De Vries<sup>1</sup>

<sup>1</sup> Holst Centre Eindhoven Netherlands

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**11:15 AM - PM5.6.07**

PDMS-Paraffin/Graphene Laminated Films with Electrothermally Switchable Haze

Jae Yeol Park<sup>1</sup>, Jeong Yong Lee<sup>1</sup>, Tae June Kang<sup>2</sup>

<sup>1</sup> Korea Advanced Institute of Science and Technology Daejeon Korea (the Republic of), <sup>2</sup> Inha university Incheon Korea (the Republic of)

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**11:30 AM - PM5.6.08**

Kirigami-Inspired Nanocomposite Manufacturing for Tunable Optical Gratings

Lizhi Xu<sup>1</sup>, Xinzhi Wang<sup>1</sup>, Nicholas Kotov<sup>1</sup>

<sup>1</sup> University of Michigan Ann Arbor United States

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**11:45 AM - PM5.6.09**

Low-Cost, Large-Area Patterning of Metasurfaces with Off-Axis Microsphere Photolithography

Chuang Qu<sup>1</sup>, Edward Kinzel<sup>1</sup>

<sup>1</sup> Missouri University of Science and Technology Rolla United States

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**PM5.7: Large Area and High Temperature Processing****Session Chairs**

Pavel Dutta

Mark D. Poliks

Wednesday PM, November 30, 2016

Hynes, Level 1, Room 109

**1:30 PM - \*PM5.7.01**

R2R CVD Architecture and Processes for Barrier Packaging of Next Generation Display Devices

F. Pieralisi<sup>1</sup>, Neil Morrison<sup>1</sup>, T. Stolley<sup>1</sup>, G. Steiniger<sup>1</sup>, M. Schaefer<sup>1</sup>, J. Degenhardt<sup>1</sup>

<sup>1</sup> Applied Materials WEB Coating GmbH Alzenau Germany

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**2:00 PM - PM5.7.02**

Integration of ALD and CVD Processes into One-Chamber—Depositing Inorganic-Organic Hybrid Layer with High-Throughput and Reliability

Hyejeong Seong<sup>1</sup>, Bong Jun Kim<sup>1</sup>, Hongkeun Park<sup>1</sup>, Sung Gap Im<sup>1</sup>

<sup>1</sup> Korea Advanced Institute of Science and Technology Daejeon Korea (the Republic of)

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**2:15 PM - PM5.7.03**

High Speed Roll-to-Roll Production of Atomically Thin (2D) Materials Using a Split Zone CVD Reactor

Piran Ravichandran Kidambi<sup>1</sup>, Dhanushkodi Mariappan<sup>1</sup>, Andrey Vyatskikh<sup>1</sup>, Martin Feldmann<sup>1</sup>, A. John Hart<sup>1</sup>

<sup>1</sup> Massachusetts Institute of Technology Cambridge United States

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**3:30 PM - PM5.7.04**

Roll-to-Roll Processing of Single-Crystalline-Like III-V, Si and Ge Thin Films on Flexible Metal Substrates for Low-Cost and High-Performance Opto-Electronic Device Applications

Pavel Dutta<sup>1</sup>, Monika Rathi<sup>1</sup>, Ying Gao<sup>1</sup>, Yongkuan Li<sup>1</sup>, Sicong Sun<sup>1</sup>, Yao Yao<sup>1</sup>, Devendra Khatiwada<sup>1</sup>, Ali Khadimallah<sup>1</sup>, Venkat Selvamanickam<sup>1</sup>

<sup>1</sup> University of Houston Houston United States

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**3:45 PM - PM5.7.05**

High Throughput, Room Temperature Synthesis of Cluster Assembled Nanostructured Nanocrystalline Silicon Films

Giorgio Nava<sup>1</sup>, Francesco Fumagalli<sup>1</sup>, Salvatore Gambino<sup>4</sup>, Davide Beretta<sup>1</sup>, Gabriella Cavallo<sup>2</sup>, Giancarlo Terraneo<sup>2</sup>, Giorgio Divitini<sup>3</sup>, Adriano Cola<sup>5</sup>, Fabio Di Fonzo<sup>1</sup>

<sup>1</sup> Center for Nanoscience and Technology Milano Italy, <sup>4</sup> Università del Salento Lecce Italy, <sup>2</sup> Politecnico di Milano Milano Italy, <sup>3</sup> Darwin College, Cambridge Cambridge United Kingdom, <sup>5</sup> CNR Lecce Italy

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**4:00 PM - PM5.7.06**

Large-Area Nanoparticle Film Deposition via Hypersonic Particle Deposition

Peter Firth<sup>1,2</sup>, Zachary Holman<sup>1,2</sup>

<sup>1</sup> Arizona State University Tempe United States, <sup>2</sup> Swift Coat Phoenix United States

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**4:15 PM -**

DISCUSSION TIME

**4:15 PM - PM5.7.07**

Printable Carbon Nanotube Microstructures for Ultra-Flexible Li-Ion Batteries

Shahab Ahmad<sup>1</sup>, Davor Copic<sup>1</sup>, Simon Engelke<sup>1</sup>, Chandramohan George<sup>1</sup>, Michael Volder<sup>1</sup>

<sup>1</sup> Department of Engineering University of Cambridge Cambridge United Kingdom

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**4:30 PM - PM5.7.08**

High-Performance Low-Voltage Complementary Differential Amplifiers on Foil via Solution-Processed Hybrid Organic/Metal-Oxide Integration

Vincenzo Pecunia<sup>1,2</sup>, Iyad Nasrallah<sup>2</sup>, Mark Nikolka<sup>2</sup>, Henning Sirringhaus<sup>2</sup>

<sup>1</sup> Institute of Functional Nano and Soft Materials Soochow University Suzhou China, <sup>2</sup> Cavendish Laboratory University of Cambridge Cambridge United Kingdom

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**4:45 PM - PM5.7.09**

Considerations and Methodology to Determine R2R Manufacturing and Scaling of Electronic Devices on Flexible Stainless Steel Foil Substrates

Aditi Chandra<sup>1</sup>, Mao Takashima<sup>1</sup>, Raghav Sreenivasan<sup>1</sup>, Patricia Beck<sup>1</sup>, Scott Bruner<sup>1</sup>, Arvind Kamath<sup>1</sup>

<sup>1</sup> Thinfilm Electronics San Jose United States

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