Innovations in Large-Area Electronics Conference (innoLAE) 2015

The latest results from the UK research community; developments & applications from manufacturers, integrators and users

SPEAKER PROGRAMME

February 2015
3-4

Downing College, Cambridge
www.largeareaelectronics.org

Day 1	
09:30 – 10:15	**Keynote 1** Professor Tsuyoshi Sekitani, Osaka University *Large-area, ultraflexible organic electronics for biomedical applications*
10:35 – 12:30	**Session 1: New materials and process technologies** 1.1 Professor Thomas Anthopoulos, Imperial College London *New materials and patterning methodologies for large-area electronics* 1.2 Dr Barbara Stadlober, Joanneum Research *Advanced micro- and nano-manufacturing for high performance organic electronics* 1.3 Dr Trystan Watson, SPECIFIC, Swansea University *A 16% organolead halide perovskite solar cell incorporating an ITO free flexible transparent self-adhesive top electrode* 1.4 Moritz Graf zu Eulenburg, InovisCoat GmbH *New continuous production method of large-area EL-systems* 1.5 Dr Dimitris Karnakis, Oxford Lasers Ltd *High resolution digital fabrication of OTFT with laser-assisted inkjet printing and LIFT*
14:00 – 16:00	**Session 2: Smart systems components, integration technologies and future challenges** 2.1 Professor Henning Sirringhaus, University of Cambridge *Integrated sensor systems – the iPESS flagship project* 2.2 Dr Metin Koyuncu, Robert Bosch GmbH *Heterogeneous integration technologies for conformable electronics* 2.3 Lee Skrypchuk, Jaguar Land Rover Ltd *The future vehicle interface challenge* 2.4 Professor Martin Taylor, Bangor University *Vacuum evaporation route to organic large-area electronics* 2.5 Dr Zari Tehrani, Swansea University *Printable flexible energy storage devices*
16:30 – 18:10	**Session 3: Design, testing and validation methods** 3.1 Dr Richard Price, PragmatIC Printing Ltd *Integrated circuits for a flexible world* 3.2 Dr Ahmed Nejim, Silvaco Europe Ltd *Physical modelling of large area semiconductor devices* 3.3 Dr Ravinder Dahiya, University of Glasgow *Large area skin for robots* 3.4 Dr Antony Sou, University of Cambridge *Design flow for organic integrated circuit design*

Day 2	
09:15 – 09:45	**Keynote 2** Dr Christian Brox-Nilsen, Thin Film Electronics ASA *R2R production of printed electronics at Thin Film Electronics*
09:45 – 10:15	**Invited plenary** Dr Simon Ogier, Centre for Process Innovation *High mobility organic semiconductor materials and low temperature fabrication processes for flexible electronics applications*
10:35 – 12:30	**Session 4: Applications and scale-up manufacturing of LAE** 4.1 Simon Jones, Plastic Logic Ltd *Requirements and applications for truly flexible electronics* 4.2 Dr Himadri Majumdar, VTT Technical Research Centre of Finland *Latest Innovation technology and projects in large-area, printed electronics* 4.3 Pit Teunissen, Holst Centre *Towards roll-to-roll solution processing of OLED devices on an industrial scale* 4.4 Dr Aurelie Meneau, Merck Chemicals Ltd *Organic materials for printed electronics* 4.5 Professor Don Lupo, University of Tampere *Towards a printed internet of everything – printed energy harvesting and storage and high- speed flexible circuitry*
14:00 – 15:45	**Session 5: Future perspectives of organic electronics in neuroscience applications; standardization of printed electronics; support to SMEs/access to funding** 5.1 Professor George Malliaras, Ecole des Mines *Interfacing with the brain using organic electronics* 5.2 Matteo Donegà, University of Cambridge *Organic electronics for the treatment of the injured spinal cord* 5.3 Dr Alan Hodgson, 3M/TC119 Printed Electronics *International standards for printed electronics* 5.4 Dr Andy Sellars, innovateUK *A strategy to promote innovation and growth in high-value manufacturing*

Keynote 1 Large-Area, Ultraflexible Organic Electronics for Bio-Medical Applications

Tsuyoshi Sekitani, Ph. D., Professor
The Institute of Scientific and Industrial Research, Osaka University, 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan

We present the development of large-area, ultraflexible, thin, and stretchable organic electronics suitable for use in next-generation wearable electronics, biomedical sensors, and intelligent welfare [1-5].

Large-area, ultraflexible, and stretchable electronics are a recent technical trend in the field of electronics mainly driven by researches on thin-film transistors (TFTs), light-emitting diodes (LEDs), and photodetectors (PDs) built on flexible polymeric plastic substrates utilizing the latest advancements in technologies related to organic materials, device physics, process engineering, and circuit design. On the basis of our initial works on manufacturing flexible organic circuits including TFTs, LEDs, and PDs, we have developed organic electronic systems that use large-area sensors and actuators [6-12]. For example, by taking advantage of an ultraflexible and microcompliant amplifier that can amplify biological signals 500 times, we have developed 64-channel active matrix electrocardiogram and electromyogram monitoring systems.

In this paper, we will review functional soft-materials, device physics, process engineering, and circuit design for realizing large-area, ultraflexible electronics. We will also present new applications for large-area flexible biomedical sensors. In addition to these bioapplications, we will review a wide range of new applications including infrastructure monitoring and smart agriculture that can benefit by using large-area, flexible electronic and photonic sensors.

References

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Biography

Tsuyoshi Sekitani received his M.S. and Ph.D. degrees from the Department of Applied Physics, School of Engineering, the University of Tokyo, Japan, in 2001 and 2003, respectively. From 2003 to 2010, he worked as an Assistant Professor in the Department of Applied Physics at the University of Tokyo. In 2011, he was appointed as an Associate Professor in the School of Engineering at the University of Tokyo. In 2014, he became a Professor at the Institute of Scientific and Industrial Research, Osaka University.

Sekitani's current research interests include organic transistors, flexible electronics, plastic integrated circuits, large-area sensors, and plastic actuators. He is the recipient of the Paul Rappaport Award for the best papers published in IEEE Transactions on Electron Devices in 2009 and 2010. He is among the Highly Cited Researchers 2014 (Thomson Reuters).

S1.1 New materials and patterning methodologies for large-area electronics

Prof. Thomas D. Anthopoulos
Department of Physics & The Centre for Plastic Electronics, Imperial College London, Blackett Laboratory, London, SW7 2BW (United Kingdom)

Soluble semiconducting materials that can be processed using a wide range of solution-based methods represent an emerging class of electronic materials that could potentially be used to manufacture a wide range of large-area optoelectronics. Due the relatively modest performance characteristics, however, their use to date has been limited to conventional thin-film devices and relatively simple integrated systems. In the first part of my talk I will discuss the development of solution-processable inorganic semiconductors and devices while in the second part I will describe the development and application of a novel patterning method that enables manufacturing of large-area nano-scale devices onto arbitrary substrate materials. These new materials concepts combined with our novel processing methods could potentially enable the development of plastic electronics with performance characteristics beyond the current state-of-the-art devices based on conventional inorganic semiconductors.

Biography

Thomas Anthopoulos is a Professor of Experimental Physics in the Department of Physics, Imperial College London. He has spent several years in industry (Philips Research Laboratories, The Netherlands) before joining Imperial College as an Engineering & Physical Sciences Research Council Advanced Fellow and later as Research Council UK Fellow. He is a recipient of a European Research Council (ERC) Starting Grant Award (2011), the Ben Sturgeon Award, The Alfred Woodhead Best Paper Award and the Imperial College London Research Excellence Award. He has co-/authored over 160 scientific publications, filed over 10 patents & patent applications and sits on the Advisory Board of Advanced Functional Materials (Wiley) and on the Editorial Board of Advanced Science (Wiley). He is a co-founder of C-Change UK LLP., and The Centre for Plastic Electronics (CPE).

S1.2 Advanced micro- and nanomanufacturing for high performance organic electronics

Dr. Barbara Stadlober
JOANNEUM RESEARCH Forschungsgesellschaft mbH, Institut für Oberflächentechnologien und Photonik, Franz-Pichlerstrasse 30, A-8160 Weiz

The structure resolution of mass printing processes such as flexographic printing, gravure printing, screen printing or offset printing is typically found in the range of 100µm. Contrary, R2R-UV-Nanoimprint Lithography (R2R-UV-NIL) is capable of patterning down to the sub-µm and even nanoscale regime with production-fit throughput thus paving the way for high-resolution patterning on large-area flexible substrates.

This talk will raise your awareness that substantial effort is needed to realize the vision of producing square-meters of complex nanostructures utilizable for organic electronic devices and components such as the development of an appropriate imprint resist system, the fabrication of flexible polymer stamps as well as the surface treatment of the imprint tools. Applications ranging from biomimetic surfaces, over metallic nano-patterns to microfluidics - all realized on m2-areas - will be presented. Finally, micro- and nanomanufacturing aspects relevant for organic circuitry and organic sensors will be discussed.

Biography

Dr. Barbara Stadlober is Head of the Research Group “Micro- & Nanostructuring” at the Institute of Surface Technologies and Photonics of the JOANNEUM RESEARCH Forschungsgesellschaft mbH (JR) located in Weiz, Austria. She has a background in low temperature and solid state physics, was part of the technology development team at Infineon Technologies Austria in Villach and joined JR in 2003 for building up the group “Organic Field Effect Transistors”. Her current interests range from organic and printed electronics over R2R-nanopatterning to large-area physical sensors and biomimetic structures. She is author of more than 70 scientific papers and owner of 6 patents.

S1.3 A 16 % organolead halide perovskite solar cell incorporating an ITO free flexible transparent self-adhesive top electrode

Daniel Bryant, Peter Greenwood, Joel Troughton, Mathew Carnie, Matthew Davies, Konrad Wojciechowski*, Henry J. Snaith*, Trystan Watson, and David Worsley

SPECIFIC IKC, Swansea University, Baglan Bay Innovation Centre, Central Avenue, Neath and Port Talbot, UK, SA12 7AX.

**Photovoltaic and Optoelectronic Device Group, Department of Physics, Oxford University, UK*

The field of thin film hybrid organic inorganic photovoltaics has been recently reinvigorated by the development of solid state organolead halide perovskite solar cells [1,2] achieving over 15% performance at lab-scale [3]. Attention is now starting to turn to the manufacturing processes required to scale these lab devices into modules, for high volume output roll to roll processing on low cost substrates such as metal foils and plastic sheeting.

To enable the manufacture of a metal mounted perovskite we have begun to address a number challenges. Firstly, in order to create a reliable and conformal TiO_2 charge injection / blocking layer we have developed a novel bar-castable coating which avoids the requirement for either spin coating or multiple pass spray pyrolysis and can be cured in seconds with near infrared radiation (NIR). This not only allows charge injection on perovskite devices but prevents unwanted back reactions for other solid state third generation HOPV. The second challenge we will present in this paper is that of application of the active layer. We have developed a new coating method in which inert nano-particles are incorporated that act as sites for nucleation and allow for a dense perovskite film to be created with very few of the defects that reduce cell efficiency. In addition, this can be applied without spin coating using an air blade and cured using NIR in a matter of seconds allowing for rapid throughput. Thirdly in laboratory devices, charge collection at the counter electrode is achieved via sputtering or evaporating of an opaque metallic contact, typically gold or silver. This is entirely unsuitable for metal devices where light penetration is required through the counter electrode and adds significant cost to any other device. We have developed a unique dual purpose transparent contact providing conductivity, hole extraction and mechanical adhesion [4]. This new system is a blend of an acrylic emulsion pressure sensitive adhesive (PSA) with a very low loading (0.018 volume fraction) PEDOT:PSS. This creates a dual phase polymer to be formed which is not only transparent (~80%) and conductive but also adhesive in nature. This is combined with a PET top sheet material that incorporates nickel grids providing extremely high conductivity (1.2 Ω□). In assembled cells on glass identical performance levels to evaporated contacts (up to 15.8% efficiency) have been achieved. In a reverse architecture on metals we have achieved a PCE of 10% and we are aiming to reduce the absorption of some of the conductors in the organic layer to increase this further.

References

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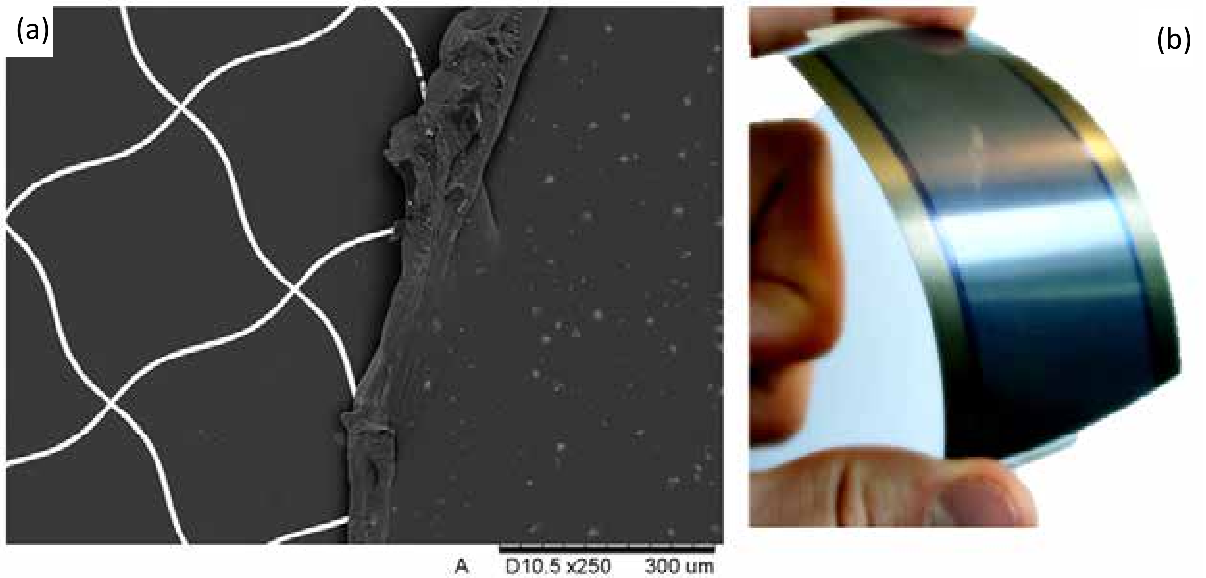


Figure 1. (a) SEM micrograph of a transparent conducting laminate applied to an embedded Ni grid on PET (b) Photo of the laminate applied to a steel substrate. Performance levels of this flexible contact are similar to that of an opaque evaporated metal.

Biography

Trystan started his academic career with a Chemistry degree at Swansea University spending a year out as an analytical chemist at 3M. He then transferred to the College of Engineering to carry out a Doctorate in Steel Technology. As part of this doctorate he used scanning electrochemical techniques to characterise corrosion phenomena such as Filiform corrosion on packaging substrates. He also co-invented a novel packaging coating to inhibit corrosion during high temperature heat treatments.

Trystan then moved to Corus Strip Products as a product development engineer as well as a theme leader for the process technology group in the engineering doctorate scheme. It was there that he became a chartered engineer with the Institute of Materials Minerals and Mining.

In 2007 Trystan returned to academia to take up a post doctoral research position on the development of dye-sensitized solar cells on metal substrates. In this time he has published work in a range of areas from fast sintering, induced scattering, in-situ monitoring of dye uptake and corrosion testing of novel substrates as well as UV photodegradation of the devices in long term testing. He is the co-inventor of a sintering method capable of reducing the titania sintering step from 30 minutes to 12 seconds. His current research activities are in the scaling of thin film photovoltaics including CZTS and organolead halide perovskites.

Trystan is a senior lecturer in Photovoltaics at SPECIFIC

S1.4 New continuous Production method of large area EL-Systems

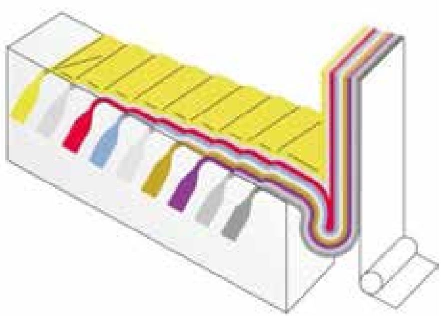
Moritz Graf zu Eulenburg
InovisCoat GmbH, Rheinparkallee 3, D-40789 Monheim am Rhein, GERMANY

InovisCoat GmbH has developed a completely new technology for large area electroluminescence systems for different types of substrates like films, textiles and papers. Electroluminescent devices were usually produced sheet by sheet through screen printing with pastes including organic solvents. Now InovisCoat can produce EL-systems by applying continuously, simultaneously and mixing freewater based multilayer-systems. In addition to this some physical parameters of these systems were dramatically improved.

InovisCoat stands as a spin-off from AGFA in the long-lasting tradition of high-tech functional and optical coating. A variety of applications, such as OLEDs, photovoltaic components, security or electroluminescent devices, are built from a stack of multiple functional layers which are positioned on top of each other.These layers are usually applied one after another using a crosslinking or annealing step in between if they are applied from the liquid phase. Inoviscoat is using a cascade coater where it is possible to transfer a coating package consisting of up to nine differently functionalized layers onto a substrate without intermixing of the adjacent layers. Using a roll-to-roll process coating width from 210 up to 1.100 mm can be realized.

The process and the resulting products have the following advantages:

1. Production of large formats possible (roll-to-roll)
2. Environmentally sustainable
3. Economical production (multiple layers in one step)
4. High precision and productivity
5. Highly flexible films



Schematic drawing of a cascade coate

A 5m2 electroluminescent film

The electroluminescent systems are manufactured in various colors and can be tailored and combined with any product. It will be integrated into security signage, protective clothing (e.g. police, army), ambient light systems (inside and outside), advertising and other markets. The system is characterized by a low operating voltage of only 50-100 V.

Biography

Mr. Graf zu Eulenburg graduated from the European Business School, London, in 1998. He worked a few years as a partner in a consulting company before he became the sales director at Coatema Coating Machinery GmbH in Dormag y.en, German After six successful years of machinery construction of high-tech coating machinery for production and research use he became the Managing Directorat InovisCoat GmbH.

S1.5 High resolution digital fabrication of organic transistors with laser-assisted inkjet printing and laser-induced forward transfer (LIFT)

D. Karnakis[1*], R. Geremia[1], L.Winchester[2], S.Ogier[2], R.Artigas[3], C. Florian[4], F. Caballero- Lucas[4], J.M. Fernández-Pradas[4] and P.Serra[4]

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[2]*Centre for Process Innovation (CPI), NETPark, Sedgefield, TS21 3FG, United Kingdom*

[3]*Sensofar-Tech S.L., Parc Audiovisual de Catalunya, E-08225, Terrassa, Spain*

[4]*Departament de Física Aplicada i Òptica, Universitat de Barcelona, Martí i Franquès 1, E-08028, Barcelona, Spain*

Digital fabrication of low cost organic electronics devices on rigid or flexible substrates is quite attractive for mass customisation in a range of applications [1]. But often it is limited by low printing resolution. To improve resolution costly and time consuming lithographic steps are typically necessary posing a barrier to further technology adoption. We report here on a new idea that combines UV DPSS picosecond laser maskless direct-write to prepare a surface with either controlled surface wetting or guide-channel microtracks followed by subsequent “self-guide” inkjet or LIFT printing of conductive inks. LIFT printing is a versatile non-contact technique that offers several advantages such as near-optical achievable resolution and clogging-free printing. It is also compatible with a wide range of ink viscosities. LIFT printing was also demonstrated for conductive line defect repair. On demand high resolution printing of conductive lines for logic devices with line widths less than 10μm was realised with these two methods. The results were also compared with printing in deep reactive ion (DRIE) etched guide tracks. Straight, angled or curved lines were investigated for controlled ink self-guiding exploiting capillary droplet propagation and a hydro/oleophobicity contrast with glass. Such techniques could pave the way for fully digital high-resolution large area printing of logic devices (Fig.1). High speed defect registration and defect repair methods were devised which are also compatible with R2R operation.

This work was part-funded by OLAE+ EU project Digiprint No. 620056 (2012-2014).

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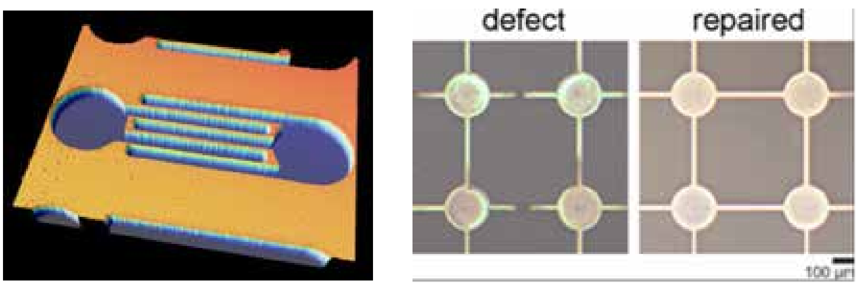


Fig.1 Laser-assisted high resolution printing in guiding tracks (<10μm linewidth) and printed defect repair was demonstrated in OLAE+ project Digiprint

Biography

Dimitris Karnakis (PhD, Hull University) is currently Technical Manager for R&D Projects at Oxford Lasers Ltd (UK) having spent time as Applications Engineer and Project Leader since joining in 2003. He is responsible for collaborative research and technology development for advanced laser micro/nanofabrication applications. Dimitris has 24 years' experience in the laser technology sector having previously held various research and junior management positions at Exitech Ltd (Oxford), Japan Atomic Energy Research Institute (Osaka) and Hull University (Hull). He presents frequently at international conferences (> 66 papers) in the field of laser pplications and referees regularly for optical engineering journals.

S2.1 Integration of printed electronics with silicon for smart sensor systems (iPESS)

Vincenzo Pecunia[1], Atefeh Amin[1], Henning Sirringhaus[1]
Ehsan Danesh[2], Daniel Tate[2], Krishna Persaud[2], Steve Yeates[2], Michael Turner[2]
EPSRC Centre for Innovative Manufacturing in Large-Area Electronics
[1]University of Cambridge, Cavendish Laboratory, Cambridge CB3 0HE
[2]University of Manchester, Organic Materials Innovation Centre, Manchester M13 9PL

Over recent years there has been tremendous progress in developing low-temperature, solution-processible organic and oxide semiconductors that provide high charge carrier mobilities for both p-type and n-type field-effect transistor operation, good operational stability and other functionalities, such as sensitivity to specific analytes. In this presentation we will introduce the iPESS project which is aimed at integration of solution-processed transistor circuits and gas sensing elements on flexible substrates for the realisation of integrated gas sensors that can be interfaced with silicon microcontrollers.

Biography

Prof. Henning Sirringhaus, FRS is the Hitachi Professor of Electron Device Physics at the Cavendish Laboratory and works on the charge transport, photo- and device physics of polymer and molecular semiconductors. He is co-founder of the spin-off companies, Plastic Logic and Eight-19 Ltd, commercializing organic transistor and organic solar cell technology, respectively.

S2.2 Heterogeneous Integration Technologies for Conformable Electronics

Metin Koyuncu
Robert Bosch GmbH

Future electronic systems require not only a high packaging density to integrate digital and analog functions into one package but also a well engineered form factor for miniaturization and seamless integration of intelligence and communication into everyday objects. Functional diversity like processing, sensing, power autonomy and communication are essential for e.g. hardware for the IoTs, wearables and ever increasing use of electronics in the automotive technology. Form factor and conformability play a key role to render electronics adaptive to its surrounding, efficient use of space, and unobtrusive integration. Foil based electronic systems (System-in-Foil) and molded interconnect device (MID) technologies are two approaches which in essence address the points. They differ from conventional electronics in that the conductive traces become conformal to the shape of the objects and the components do not have to be mounted onto a common plane. SiF owes this property to the flexibility of the substrate and partly to that of interconnects and components whereas MID is able to form conductive traces on surfaces of three dimensional objects and mount components onto these surfaces. The former results in a very high packaging density in z-direction and suited for large area electronics, MID provides substantial design flexibility. In both cases innovative and heterogeneous integration technologies become critical to integrate components of diverse functionalities and disparate characteristics. These are discussed with examples of ICs (integrated circuits), foils based components (sensors, batteries, photovoltaic components), foil-to-foil interconnections, mechatronic parts based on the MID technology. An outlook is presented with potentials and challenges for their industrialization.

Biography

Dr. Metin Koyuncu is a senior project manager at the corporate research division of Robert Bosch GmbH, Germany. He is active in the field of electronic packaging for the last 15 years. After his responsibility for development projects leading to mass production for the automotive industry, he switched to research on conformable and high density electronic packaging. During the last four years he coordinated an EC funded project “Interflex” that focused on the development of heterogeneous integration technologies for a hybrid System- in-Foil. Together with his team Mr. Koyuncu is active in the field of flexible electronic systems, additive manufacturing for electronic packaging and molded interconnect devices. He is the author and co-author of a number of publications and patents in these fields.

S2.3 The Future Vehicle Interface Challenge

Lee Skrypchuk
Jaguar Land Rover Limited

This will be a general presentation and discussion around how the future of how humans interact in the vehicle might affect or shape how future large scale electronic systems are manufactured. By looking at the trends and future challenges associated with user experience in the car a roadmap of needs will be presented showing where the potential applications and opportunities for innovation will be in the automotive industry.

Biography

I completed a Bachelor's degree in Electronics & Computing at the Nottingham Trent University followed by a Master degree is Display Technology, Systems & Applications at Dundee University. I then joined Alpine Electronics in 2003 working on the development of touchscreen interfaces for use on Jaguar & Land Rover Products. This development was unique in that it was the first to make use of Macromedia Flash in an OEM production environment and I was solely responsible for the development of this element. I have always taken a keen interest in displays and was also responsible for developing display concepts with Jaguar Land Rover Research. In 2007 I left Alpine and joined Jaguar Land Rover Research working on Human Machine Interface systems with a specialism in Display Technology. Here I worked on a number of technology projects including Dual View, Haptic Interface Technology and introduced optical performance modelling to the business. In 2011 I was promoted to position of Human Machine Interface Technical Specialist where I focus on researching future interface technologies for us on Jaguar Land Rover products. This covers all technical aspects of interface technologies such as engineering, human factors and psychological aspects. I have since been technical lead on projects such as Head up Display, Driver Facing Camera, 3D display's and am responsible for future technology research roadmaps in this subject area. I am currently studying for a PhD in engineering from the University of Cambridge.

Research Interests

- Future Interface technologies for Premium Vehicles
- Advanced Input & Output systems
- HMI as a System
- Understanding User Needs & Managing Interface Distraction
- The Impact of Autonomous Systems
- Human Interface Performance

S2.4 Vacuum Evaporation Route to Organic Large Area Electronics

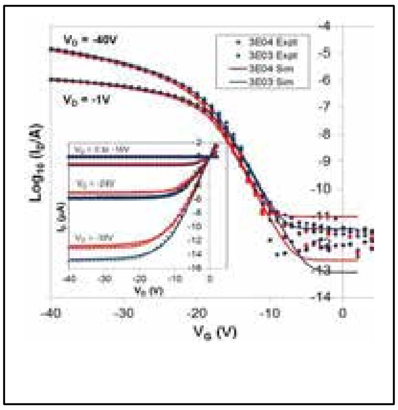
D.M. Taylor,[a] H. Assender,[b] S.G. Yeates,[c] E.R.Patchett,[a] A. Williams,[a] Z. Ding[b] J.J.Morrison[c] and G, Abbas[b]

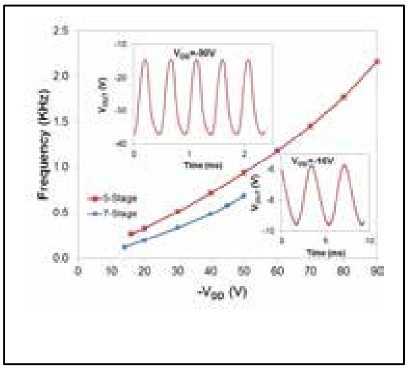
[a] *School of Electronic Engineering, Bangor University, Bangor, LL57 1UT*

[b] *Department of Materials, University of Oxford, Oxford, OX1 3PH*

[c] *Department of Chemistry, University of Manchester, Manchester, M13 9PL*

In this contribution it will be shown that organic thin film transistors (OTFTs) with mobility ~ 1 cm2/Vs can be produced in batches of 90 on 5 cm x 5 cm PEN substrates at high yield (≥ 90%) by vacuum evaporation of all the material components – metal, semiconductor and dielectric. In these devices the dielectric is produced by flash evaporation and in- situ polymerisation of the monomer tripropyleneglycol diacrylate (TPGDA) in a vacuum roll-to-roll environment at a web speed of up to 25 m/min[1]. The semiconductor is highly purified dinaphtho [2,3-b:2',3'-f] thieno[3,2-b]thiophene (DNTT). Typical characteristics of two identical transistors together with simulated plots for parameter extraction using Silvaco's UOTFT software are shown in Fig.1. Results will be presented which show that the baseline technology can be used to manufacture functional logic circuits including inverters, NOR/NAND gates, S-R latches[2] and 5- and 7-stage ring oscillators[3]. As seen in Fig. 2 ring oscillators produced using the technology begin to operate at a supply voltage, $|V_{DD}|$, as low as ~15 V albeit at relatively low frequency (~200 Hz) which increased to over 2 kHz with $|V_{DD}|$ = 90 V. By reducing gate overlap capacitances, a doubling of output frequencies has been achieved.





OTFTs and circuits are both electrically and environmentally stable[4]. Only electrical stress at high humidity or under illumination causes a shift in threshold voltage. Devices and circuits will be shown to operate satisfactorily even after 12 months of storage in a transparent plastic box in normal laboratory conditions. Nevertheless, a barrier layer process has been developed and deposited successfully onto OTFTs in a vacuum roll-to-roll environment.

Recently initiated work is concerned with developing routes for additively patterning organic layers by organic vapour phase deposition of both DNTT and TPGDA onto a moving substrate. Initial results look promising – OTFTs with mobility ~0.5 cm^2/Vs have been produced with no attempt made to optimise the process.

The remaining issues that need to be resolved to bring the technology to TRL6 will be highlighted and discussed.

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Biography

Professor Martin Taylor holds a Personal Chair in the University of Wales and heads Organic Electronics Research at Bangor. He gained both his BSc in Electronic Engineering and PhD from the University of Wales the latter awarded for a thesis entitled "Electrical Characteristics of Polymeric Materials". Professor Taylor is a Fellow of the Institute of Physics (IOP) and has served on the Committee of the IOP Static Electrification Group for many years. He is also a Member of the Institution of Engineering and Technology and a Chartered Engineer.

He has published many papers on the electrical properties of thin films, including insulating polymers, silicon dioxide, Langmuir-Blodgett films and semiconducting organic materials. This last interest led to his current research programmes - interfaces in organic MIS devices, organic thin film transistors and circuits, the development of a vacuum-evaporation route to the fabrication of plastic electronic circuits and organic resistive RAMs. These programmes have been funded by EPSRC, Welsh Assembly, TSB/Innovate and industry.

He is a member of EPSRC's Peer Review College, an External Advisory Board Member for Imperial College's Doctoral Training Centre and the Centre for Plastic Electronics and for Cambridge University's EPSRC Centre for Innovative Manufacturing in Large Area Electronics and an EU FP7 project reviewer

S2.5 Printable Flexible Energy Storage Devices

Zari Tehrani, Tatyana Korochkina, Marta Gunde[1], Manu Petal[1], Jože Moškon[1],Tim Claypole and David Gethin
Welsh Centre for Printing and Coating (WCPC), College of Engineering, Swansea University
[1]National Institute of Chemistry, Ljubljana, Slovenia

There is a very wide range of applications for energy supplies that allow practically self-contained operations of different functional systems, e.g., wireless sensors in building automation, medical sensors for patient examination and monitoring. These applications demand very low cost, small size, lightweight and flexible power supplies. It is anticipated that printed energy storage components using a roll-to-roll (R2R) process will become an expected manufactured solution as it offers a low-cost, high volume process route capable of realising power storage on flexible substrates. For the time being, there are major hurdles in formulating a printable solution due to challenges in handling the electrolyte. It needs to printable and it needs to remain wet and stable for the length of the energy storage component life. As far as we know no printable solution has yet been formulated, which prevents production of an energy storage component on an industrial scale.

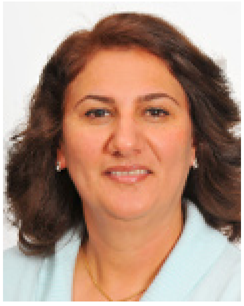
This study involves developing a printable electrolyte and electrodes that can be integrated into a fully screen-printed system offering a flexible energy storage component on a PET or other substrate.

A thin all polymer printable battery where the anode and cathode are based on the conducting polymer such as poly (3, 4-ethylenedioxythiophene) (PEDOT) will be discussed. The led to the development of a solid state electrolyte forming a rechargeable battery that has a practical specific capacity of about 5.5 mAh/g.

In addition a primary Zinc-Silver oxide battery was manufactured by screen printing requiring the development of the printable functional materials to make up the several layers. The fabricated batteries were characterized using galvanostatic measurements and electrochemical impedance spectroscopy. A high practical specific capacity of 238 mAh/g was achieved which is higher than that of a conventional rechargeable Li ion battery.

All-solid-state flexible supercapacitors were fabricated using activated carbon electrodes and a gel electrolyte. Dependent on size, these have a capacity from 50mF to 450mF. Moreover, these supercapacitors showed excellent stability and much longer life time when compared with aqueous electrolyte based supercapacitors.

Biography



Zari Tehrani is currently a researcher at the Welsh Centre for Printing and Coating in Swansea. She joined the WCPC group from 2013, focusing on development and application of printing techniques for the deposition of functional materials to manufacture devices that use energy harvested through photovoltaic technology.

She completed her PhD, in 2012, on the Functionalisation of Semiconductor Surfaces for Biosensor Applications and has worked with the MNC and CNH from 2011.

She has a multidisciplinary background. Zari's work is focused on developing specific sensors – fabricated by functionalising a conductive nano-channel surface with an antibody biomarker, for instance those indicative of particular cancer risks. She has experience work on device fabrication in a Class1000 Clean Room. Device functionalization including Conjugation chemistries, immobilization and conjugation of antibodies in portable sensor devices for Point of Care use in medical applications in a Class 10,000 BioClean Room.

Zari has knowledge of Electrochemistry, surface science (chemical analysis and scanning microscopy techniques), nano/micro device fabrication and electron microscopy. Other areas of expertise include semiconductor materials and devices, lithography and fabrication, sensors, biotechnology, organic electronics, electron microscopy.

She was researcher and trouble shooter at the Research Institution for the Petroleum Industry, National Iranian Oil Company (N.I.O.C.) in Tehran, Iran, and at the Arak Petrochemical Company (supervision and employee support in the Department of Exploration) for 13 years.

S 3.1 Integrated Circuits for a flexible world

Dr Richard Price
PragmatIC Printing Limited

Ultra-thin and low-cost flexible microcircuits, incorporated into mass-market objects and packaging, are poised to revolutionise everyday living by providing consumers with real-time information about every aspect of their environment. PragmatIC enables printed electronic logic circuits that introduce intelligence and interactivity into a wide range of products and applications, in form factors that are not possible using silicon chips. The talk will describe PragmatIC’s approach to flexible ICs, including design-for-manufacture and production scalability.

Biography

Dr Richard Price is co-founder and Chief Operating Officer of PragmatIC Printing, a Cambridge-based technology company specialising in flexible integrated circuits. Richard has over 15 years’ experience in development and commercialisation of early-stage technology and IP. Richard previously worked as a Venture Manager with UMIP, the commercialisation arm of the University of Manchester, leading the formation, funding and early-stage development of various start-ups including Nano ePrint, CableSense and Arvia Technology. Richard has held research roles at the University of Durham, the University of Bath and ELAM-T. He is inventor/co-inventor on more than 15 patents/ patents-pending covering (opto)electronic materials, devices and fabrication processes.

S3.2 Physical Modelling of Large area semiconductor devices

Dr Ahmed Nejim
Silvaco Europe Ltd

Physical simulation software can provide significant insight for the semiconductor device designers. Many areas that can be difficult to measure and probe on the bench, can be successfully modelled using powerful software tools. The predictive nature of these tools require a reasonable expression of the carrier transport physics in play. Once a continues model of the device behaviour under DC and transient conditions is obtained, the full available design space can be tested for optimum geometries. Furthermore, such models can be extended into circuit compact models which are needed to design large area products for the new disruptive display and other technologies.

Biography

Ahmed Nejim obtained his PhD in 1990 in Ion-Solid interaction and ion beam modification of polymers from the University of Salford in Manchester. A wide experience in ion implantation and semiconductor processing was obtained in 17 years of research in material science, semiconductor physics and microelectronic design. Experience in lecturing, mentoring and facility management. 10 years of technical project management, European multinational projects, Liaison research fellow of a UK national research facility at the University of Surrey. Since 2001 he has been working at Silvaco supporting TCAD software users and developing collaborative projects. He acts as an R&D Project Manager for Silvaco Europe.

S3.3 Large Area Skin for Robots

Ravinder Dahiya
School of Engineering, University of Glasgow, UK

The microelectronics technology and subsequent miniaturization that began almost immediately after the transistor was invented have improved our lives through computing and communication revolution. The exponential rate of advancement that is described in Moore's Law has been propelled by $1Tr of investment over 50 years. Recent advances in the field pursued through non-roadmap "More than Moore" technology and propelled by applications such as wearable electronics and bendable displays relate to realizing electronics on unconventional substrates such as plastics. The possibility to realize sensitive electronics systems on large area will further open new application avenues such as intelligent robotics enabled by conformable electronic skin that can be wrapped around the body of a robot or artificial limbs. This lecture is about the latter application with a focus on the high-performance conformable and large area electronics. The lecture will begin with the design and development of large area robotic skin using off-the-shelf sensors and electronic components on flexible printed circuit boards (PCB). This will be followed by the novel approach of obtaining tactile or electronic skin from printed silicon nanowires.

The research covered in this lecture has been supported by EPSRC and European Commission through projects such as ROBOSKIN, RobotCub, FLEXSENSOTRONICS, CONTEST, FLEXELDEMO, and PRINTSKIN.

Biography

Ravinder Dahiya is Senior Lecturer and EPSRC Research Fellow in the School of Engineering at the University of Glasgow. He received Ph.D. from Italian Institute of Technology, Genoa (Italy), and University of Genoa (Italy).

His multidisciplinary research interests include Flexible and Printable Electronics, Electronic Skin, Tactile Sensing, and wearable electronics. He has published more than 90 research articles in journals and peer reviewed international conferences, one book (Robotic Tactile Sensing – Technologies and System) and 2 patents. He has worked on the many international projects and currently leading a European Commission funded Initial Training Network and the EPSRC Fellowship for Growth – Printable Tactile Skin.

He is on the Editorial Boards of IEEE Transactions on Robotics and IEEE Sensors Journal and has been guest editor of 4 Special Journal Issues. He represents the IEEE Robotics and Automation Society in the Administrative Committee of IEEE Sensors Council.

Dr. Dahiya is an EPSRC Fellow and received Marie Curie Fellowship in past. He was awarded with the University Gold Medal for securing First Class First Position in the University and received best paper awards twice in the IEEE sponsored conferences.

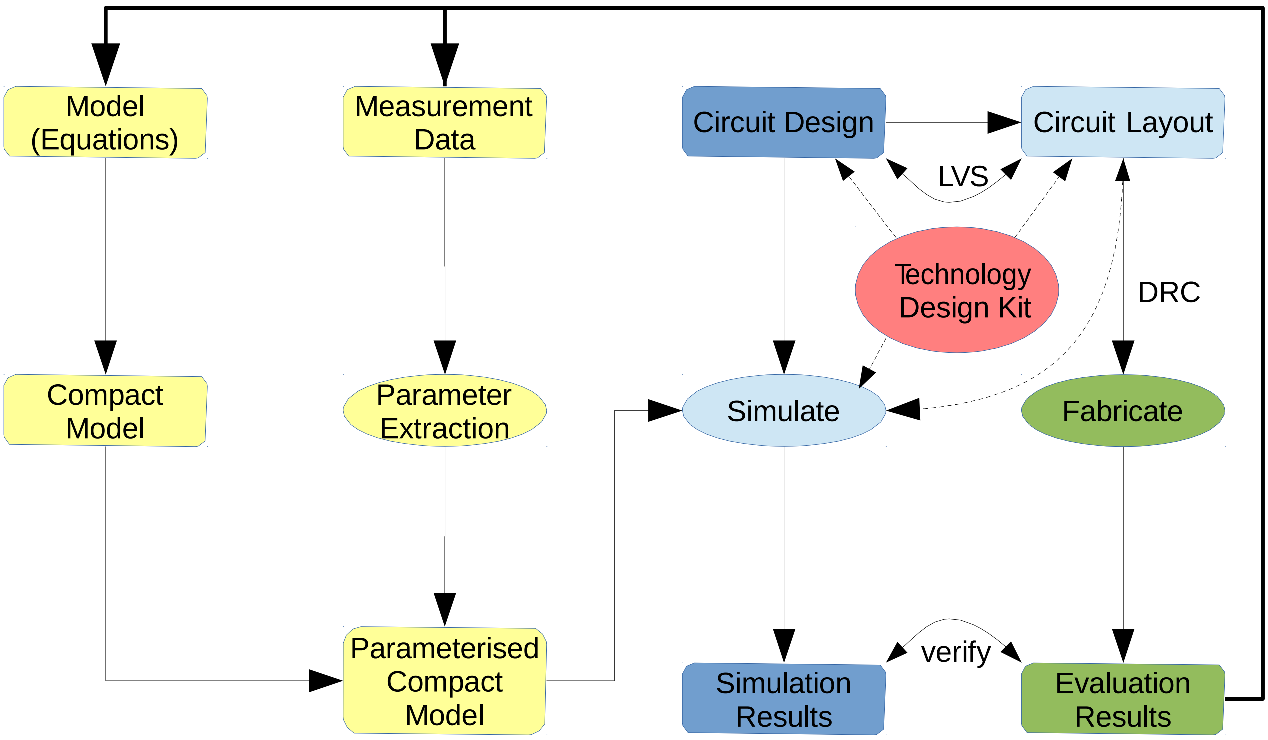
Personal website – www.rsdahiya.com

Official webpage - http://www.gla.ac.uk/schools/engineering/staff/ravinderdahiya/

S3.4 Design Flow for Organic Integrated Circuit Design

Antony Sou
Optoelectronics Group, Department of Physics, Cavendish Laboratory University of Cambridge

The University of Cambridge and Plastic Logic have been collaborating on functional integrated plastic systems for several years. These projects have integrated organic logic, e-ink displays and printed components onto a single flexible transparent plastic foil. To achieve "right-first-time" robust designs and reliable fabrication, we have developed design flows and methodologies to model transistors, simulate circuits, verify designs, and estimate manufacturing yields. We have eschewed expensive mainstream EDA software choosing instead to use low-cost tools and custom software. A technology design kit was developed, incorporating an in-house SPICE model, technology rules, and DRC/LVS decks. We have successfully produced working samples of several designs with transistor arrays, digital logic gates, and an inkjet programmable logic array.



Biography

Antony Sou is a researcher in the Optoelectronics Group of the Cavendish Laboratory, University of Cambridge investigating the modelling and design of organic field effect transistors and circuits, cooperating closely with Plastic Logic on flexible applications. Before coming to Cambridge, Antony enjoyed an expansive career in the silicon VLSI industry working for several major global technology companies in worldwide locations, and was also the founder of a high echnology start-up company with offices in Europe, US and Asia.

Keynote 2 R2R Production of Printed Electronics at Thin Film Electronics

Christian Brox-Nilsen (PhD)
Thin Film Electronics ASA

Thin Film Electronics ASA (Thinfilm) is a company specialising in printed electronics such as memories and various system products. Stand-alone memories is a current product that can be roll-to-roll (R2R) printed in large volumes, while some work on R2R printing of organic thin-film transistors (OTFTs) has been initialised. Thinfilm has recently installed its own R2R print line and been setting this up for mass-production of memories on plastic webs that are 500 mm wide (Fig. 1). The print line can do rotogravure, rotary screen and flexo-printing as well as slot-die coating. The current memory stack consist of six layers that are made with rotogravure printing, rotary screen printing and slot-die coating.

In the laboratory-to-fabrication work, Thinfilm found that there are several key parameters that needs careful monitoring during the memory fabrication. Throughout the R2R manufacturing process these key parameters are monitored and logged. While the first layer is printed, each repeat length is marked for later identification. This is done by adding roll and repeat length numbers on the web as barcodes with an in-line inkjet marker. These identification numbers can later be used to relate the repeat lengths to the actual system parameters as well as test results. The control system for the print line is logging actual temperatures, tension values and web speed among several other settings. An in-line registration camera can also record the registration accuracy for the various printed layers and during the slot-die coating of the memory polymer there is also an in-line thickness monitor that can log the thickness of up to seven locations simultaneously in cross-direction. Electrical characterisation of the memories is done in one of two custom made R2R step-and-go memory testing and programming systems by sampling after certain printed layers as well as the finished roll (Fig. 2).

Thinfilm is currently developing its own manufacturing execution system (MES) to handle all the gathered information and for organising the work on the print line. The MES will be used to manage all the different log-files and for monitoring the system performance. In addition to this, the MES will also give various statistical information and keep track of consumables.

Fig 1 Thinfilm's R2R print line

Fig 2 R2R step-and-go memory tester and programmer

Biography

Christian Brox-Nilsen received his BEng in Electronics from University of Manchester Institute of Science and Technology (UMIST) in the UK in 2003. This was followed by a PhD on fabrication of ultrasonic transducers at The University of Manchester in the UK in 2009.

From 2007 to 2009, during his PhD, he had an 80% position at Phoenix Inspection Systems Ltd where he worked on a new high frequency ultrasonic transducer to be used in a new scanner head being developed for medical and industrial applications. From 2010 to 2011 he had a position as Research Associate at The University of Manchester, but the work was done for a company called Nano ePrint, with focus on printed ZnO TFTs. In 2011 he started as a Process and Print Engineer at Thin Film Electronics, a company on the forefront of printed electronics, where he mainly works with printed memories.

Plenary High mobility organic semiconductor materials and low temperature fabrication processes for flexible electronics applications

Simon Ogier, Keri Goodwin, Simon Rutter, Ben Coombs, Tim Pease

Centre for Process Innovation Limited, Thomas Wright Way, NetPark, Sedgefield, UK

CPI operates the UK's National Printable Electronics Centre (established in 2009) and has a growing reputation for collaborative R&D in the field of plastic, printed and organic electronics. Recently CPI has commissioned a Gen2 (370 x 470 mm substrate) pilot line for high resolution patterning using photolithography and wet/dry etching techniques. The equipment is set up for the processing of plastic films laminated onto glass, and the systems process cassettes of substrates with robotic handling throughout. Patterning is achieved via a Tamarack stepper projection lithography tool allowing 4 µm feature resolution and 1 µm overlay/stitching accuracy with integrated auto-alignment. Coupled with even more recent acquisitions such as R2R atomic layer deposition (ALD), this provides companies in the UK with a valuable resource to develop good quality demonstrators and pilot products using industrial scale toolsets.

Using this pilot line OTFT arrays have been produced that are suitable for use within logic and display applications on flexible substrates. The current OTFTs use the small molecule and high-k binder composition being marketed under the name FlexOS™ *. The OSC is patterned using dry etching techniques to achieve the necessary on/off ratio of $>10^6$ whilst maintaining a hole mobility of between 3 and 4 cm^2/Vs. Despite the polycrystalline nature of the materials we have shown excellent uniformity of on-current, with standard deviations of less than 10% possible across arrays of devices within a batch of substrates. Flexibility of the backplanes on plastic has also been demonstrated, showing minimal degradation in the performance of OTFTs after 10,000 cycles at bend radii as low as 1 mm. Overall, this work demonstrates the potential for organic electronics in flexible display applications and demonstrates large-area batch manufacturing using scalable production equipment. The transistors could also be used in applications such as chemical or bio sensing where signals require amplification, processing and conditioning close to the point of detection.

* FlexOS™ is a registered trademark of NeuDrive Limited. For more information on the small molecule high k binder compositions please contact info@neudrive.com

Biography

Simon Ogier has worked in the development of organic semiconductors for over 12 years. In his current role at CPI he has been instrumental in the establishment of the UK's National Printable Electronics Centre. Simon was involved in the specification and procurement of equipment sets for large scale TFT and OLED/OPV fabrication. In addition he has been leading a team of 10 scientists developing proprietary high performance organic semiconductor formulations suitable for flexible OLED display backplanes.

S4.1 An Adaptable, Flexible Transistor Platform to Accelerate Market Development

Simon Jones
Plastic Logic Ltd

Public Interest in plastic, unbreakable and flexible electronics is higher than ever, and the longer-term forecast market potential for flexible electronics is without doubt. However, in the next couple of years what's needed from new technology providers is the ability to offer adaptable and flexible prototyping and manufacturing capabilities to more rapidly converge on the needs of end users.

Plastic Logic has the manufacturing expertise and foundation transistor technology to play the lead role in developing this fresh flexible market development story. We will give an update on our transistor platform and how we are using this to create market engagements across several markets: displays, sensor arrays, and systems on plastic.

Biography

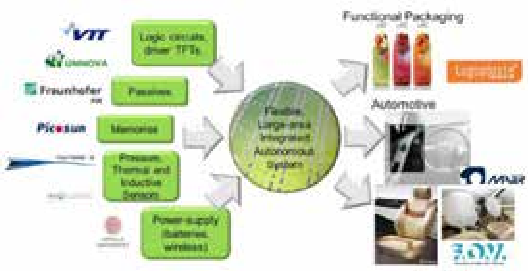
Simon has focused his career on planning and executing commercialization strategies for new electronics technologies and products. His areas of expertise include business development, strategic marketing, general management and sales. He has recently re-joined Plastic Logic from Dow Corning where he led several major innovation programs as Business and Innovation Development Director. Before that he worked with a number of electronics start-ups. Previous roles include VP Business Development at Liquivista (now part of Amazon) and VP Product Development at Plastic Logic. Simon holds a Bachelor of engineering in electrical engineering from the University of Sheffield, and a Master of Business Administration from Henley Management College.

S4.2 Latest innovation technology and projects in Large-Area, Printed Electronics

Himadri Majumdar
Printed and Hybrid Functionalities, VTT Technical Research Centre of Finland, Finland.

I will present the latest results on low-temperature (~ 200°C) scalable manufacturing of metal- oxide based TFTs[1]. Devices with mobilities up to 5 $cm^2/V.s$ will be presented. Usage of combined UV and temperature in a scalable manufacturing scenario will be discussed.

I would also like to introduce two recently initiated research projects funded by European Union within the FP7 and H2020 program. Both the project involves creation of innovation for next- generation of Printed Electronics with special focus on sustainability and commercialization.

GREENANOFILMS is an EU-funded research project within the FP7 program. It is a 36 months project that started in February 2014. The goal of the project is to utilize bio-based substrates and materials, namely cellulose nanofibrils (CNF) and glycopolymers, for electronic and sensing applications. At VTT we are fabricating CNF films in a roll-to-roll pilot environment that is then further modified and functionalized using nano-imprinting lithography (NIL) techniques. These films, subsequently, will be utilized for fabricating **organic bulk-heterojunction solar-cells** using **block copolymers (BCP) functionnalized and self-assembled**. Transparency, oxygen and humidity barrier properties and smoothness of the CNF films are few of the properties that are investigated and optimized for such applications.	GreeNanoFilms FP7-NMP-2013-SMALL-7 Project Identity 603519 SEVENTH FRAMEWORK PROGRAMME 
ROLL-OUT is a research project short-listed (in Grant agreement preparation phase at the time of submission of abstract) for EU-funding under the ICT3 call of H2020 program. The project is expected to start in January 2015. The goal of the project is to create a multi-purpose technology for, thin, large-area, high-performance, smart, and autonomous *systems* comprising integrated circuits, sensors, and electronics, advancing the packaging, automotive interiors and textile industries beyond their traditional scope. The key features are high-performance circuits and components. To fabricate high-performance circuits, the project intends to use novel, hybrid, moderate-temperature, roll-to-roll processes, namely sputtering, Atomic Layer Deposition (ALD) and screen-printing on thin, flexible, large-area substrates.	ROLL-OUT 

[1] J. Leppäniemi et al, *Applied Physics Letters*, **105**, 113514 (2014); H. Majumdar et al, *Electronics System-Integration Technology Conference (ESTC)*, 2014; DOI: 10.1109/ESTC.2014.6962762

Biography

Dr. Himadri Majumdar is a Senior Scientist in the Printed and Hybrid Functionalities group of VTT Technical Research Centre of Finland Ltd. His research interests include Printed Organic and Inorganic systems consisting of active and passive opto-electronic components, namely diodes, transistors, OLEDs, OPVs and sensors. He focuses on development of printed electronics on sustainable substrates, namely nano-cellulose, paper, silk, etc. The application focus are artificial skin, wearable (stretchable) electronics and other consumer products. He has 35+ publications in international scientific journals with a h-index of 13 (ISI). He teaches and supervises post-graduate and doctoral students in the capacity of Adjunct Professor at Åbo Akademi University and Tampere University of Technology, both in Finland.

S4.3 Towards roll-to-roll solution processing of OLED devices on an industrial scale

Pit Teunissen, Eric Rubingh, Ike de Vries, Guy Bex, Pim Groen, Jeroen van den Brand
Holst Centre, High Tech Campus 31, 5656 AE Eindhoven, Netherlands

For the manufacturing of large area electronic devices such as OLEDs and solar cells, solution based production methods operating at atmospheric pressure are a very promising alternative to high vacuum deposition technologies. In order to become commercially competitive with more traditional approaches, however, solution processing needs to be developed towards high reliability, large scale production and compatibility with industrial manufacturing processes. In this respect, roll-to-roll processing using flexible substrates is an especially attractive option, since it allows a continuous production mode at potentially very high throughput.

To operate a roll-to-roll production line at its highest possible efficiency, all individual processing steps obviously need to be harmonised with respect to their speed, since the slowest process will determine the overall output capacity. Whereas for most functional electronic materials, fast printing and coating technologies are available, post-deposition treatments like drying, curing and sintering are frequently the rate determining step. Other challenges to be met for roll-to-roll electronics solution processing are the exact alignment of multiple functional patterns on top of each other, the accuracy of materials deposition, and the mechanical sensitivity of many functional surfaces which necessitate the application of non-contact technologies.

In this contribution, we present our research activities on the transfer of manufacturing technologies for solution processed large area OLED panels from sheet-to-sheet to roll-to-roll based production. For that purpose, we have designed and constructed a number of pilot roll-to-roll lines which have been used to study and optimise individual steps of the OLED production process. Examples for such processes are the printing of conductive metal based inks and pastes on plastic foils to produce shunting lines for large area transparent electrodes for bottom emissive OLEDs. In parallel, the printing of dielectric materials on metal foils for top emissive OLEDs has been investigated on these lines as well. Also coating technologies for highly homogeneous thin films of electronic materials like conductive transparent or light emitting polymers have been implemented and optimised. For many of the relevant functional materials, simple exposure to high temperatures using hot air ovens does not proceed quickly enough to allow high overall processing speeds. Therefore, roll-to-roll compatible tools for faster and more selective alternative post-deposition treatment technologies have been developed. A prominent example is photonic flash curing which uses short light pulses of high intensity to dry, cure and sinter functional inks with high efficiency.

In order to demonstrate the applicability of our pilot lines to printed electronics production, we have prepared OLED panels of 8 x 8 cm^2 using roll-to-roll solution processing technologies. Currently, research is being carried out to harmonise the different process steps in order to integrate them into a single big roll-to-roll line, as well as to apply the current technologies also to the roll-to-roll production of printed solar cells.

Biography

Pit Teunissen finished his B.Sc. in 1999 and subsequently joined the group of Prof. D. J. Broer at Eindhoven University of Technology where he participated in various research projects on functional polymers. In 2006 he started a position at the Polymer Technology Group B.V. as a research fellow, working on inkjet-printing of liquid crystals for security and sensor applications. Since 2011, he is a process engineer at Holst Centre for inkjet-printing of conductive structures for OLED, OPV, RFID, touch panel and smart label applications

S4.4 Organic materials for Printed Electronics

Dr. Aurelie Meneau, Dr. Mark James
Merck Chemicals Ltd

The progress in mobility of organic semiconductors has slowed somewhat over recent years. Whilst some academic groups have maintained the momentum, at many research commercial centres the emphasis has been primarily on processability (including printability and photo-lithographic processing) and operational stability. This is particularly true at Merck where we have developed a portfolio of both active and passive materials and formulations designed to support application performance but also to enable real manufacturing processes such as high through-put printing. In addition to OTFT we will discuss the status of solution-processed organic materials for other applications, such as Organic Photodetectors and OPV.

Biography:-

Aurelie is a research scientist working on TFT development at Merck Chemicals, based near Southampton. Prior to joining Merck in 2013 she completed a PhD in Physics from the University of Cambridge where she studied the physics of charge carrier transport in solution-crystallised molecular semiconductors, under the supervision of Prof. Henning Sirringhaus.

S4.5 Towards a Printed Internet of Everything – Printed Energy Harvesting and Storage and High-Speed Flexible Circuitry

Prof. Donald Lupo
Department of Electronics and Communications Engineering, Tampere University of Technology, PO Box 692, 33100 Tampere, Finland
donald.lupo@tut.fi

There is a lot of talk about putting electronic sensors "everywhere", enabled both by miniaturization of classic Si electronics and advances in printed electronics. However, sensors everywhere require power everywhere, and the idea of billions of small objects fitted with batteries is a waste disposal nightmare. An alternative is the harvesting of ambient energy, e.g. from light, RF radiation and movement, but some kind of interim storage is needed, and miniature printable , fully non-toxic supercapacitors appear to be a promising alternative. Furthermore, if the project huge numbers of distributed devices are to be realised, an alternative to silicon will eventually be needed. This talk will focus on our work on developing viable printed energy harvesting and storage systems based on harvesting of RF energy, light and motion and interim storage in non-toxic supercapacitors and their integration with functional devices. In addition, our new FiDIPro project aiming at developing advanced energy harvesting and storage and high-speed, energy thrifty flexible circuitry will be introduced.

Biography

Donald Lupo joined the Department of Electronics and Communications Engineering at Tampere University of Technology as professor for electronic materials and the Head of Laboratory for Future Electronics (LFE) in August 2010 after a diverse career in industrial research and development in functional materials for photonics and electronics. He obtained his Ph.D. in physical chemistry at Indiana University-Bloomington, USA in 1984 and spent the next 24 years working in chemical, electronic and display industries, and as an independent consultant, working for and with companies such as Hoechst AG, Sony Europe, NTera, Samsung, UPM Kymmene and Merck. During his industrial career he lead groundbreaking work in organic nonlinear optics, polymer LEDs, solid state dye solar cells and paper-like displays. He is author on over 60 publications and inventor on over 40 patents and applications. He serves as an external expert in the OLED and printed electronics fields for the European Commission, is an active member of the Organic Electronics Association roadmap team, speaker of the OE-A Education group and has served on the technical advisory boards of Thin Film Electronics AB, Nano Eprint Ltd., Centre for Process Innovation (CPI) and the EPSRC Centre for Innovative Manufacturing in Large Area Electronics (CIMLAE).

S5.1 Interfacing with the brain using organic electronics

George Malliaras
Department of Bioelectronics, Ecole des Mines de St. Etienne, France
malliaras@emse.fr

A visible trend over the past few years involves the application of conducting polymer devices to the interface with biology, with applications both in sensing and in actuation. Examples include biosensors, artificial muscles, and neural interface devices. The latter are of particular interest, as conducting polymers offer several distinct advantages compared to incumbent technologies, including mechanical flexibility, enhanced biocompatibility, better electrical performance and capability for drug delivery. As such, they promise to yield new tools for neuroscience, enhancing our understanding of how the brain works and delivering new therapies. After a brief introduction, I will present a few examples of cutaneous, implantable, and *in vitro* devices that utilize conducting polymers. Their fabrication, electrical characteristics, properties such as mechanical flexibility and biocompatibility, and *in vivo*/*in vitro* performance will be discussed.

Biography

Professor **George Malliaras** is the Head of the Department of Bioelectronics of the Ecole des Mines de St. Etienne (France). His research has been recognized with awards from the NY Academy of Sciences, the US National Science Foundation, and DuPont. He is a Fellow of the Royal Society of Chemistry. He received his PhD from the University of Groningen (Netherlands), did a postdoc at IBM Research, was a faculty member in Materials Science and Engineering at Cornell University, and served as the *Lester B. Knight* Director of the Cornell NanoScale Science & Technology Facility

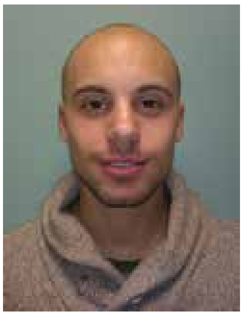
S5.2 Organic electronics for the treatment of the injured spinal cord

M. Donegà [1], E. Giusto [1], A. Campana [2], T. Cramer [2,3], M. Murgia [2], G. Foschi [4,5], A. Dumitru [6], S. Casalini [4], P. Greco [5], R. Garcia [6], F. Biscarini [4] and S. Pluchino [1]

[1] Department of Clinical Neurosciences and Wellcome-Trust Medical Research Council Stem Cell Institute, University of Cambridge, UK;
[2] CNR-ISMN Consiglio Nazionale delle Ricerche, Istituto per lo Studio dei Materiali Nanostrutturati, Bologna, Italy;
[3] Department of Physics and Astronomy, Alma Mater-Università di Bologna, Italy;
[4] Life Sciences Department, Università di Modena e Reggio Emilia, Italy
[5]SCRIBA Nanotecnologie Srl, Bologna, Italy; [6] Instituto de Ciencia de Materiales de Madrid (CSIC), Madrid, Spain.

Neural prosthetics is an emerging field in regenerative medicine, which may open new frontiers for the treatment of highly debilitating pathologies of the central nervous system (CNS), such as spinal cord injury (SCI). Within the EU Project iONE-FP7 we aim at exploiting biocompatible and largely biodegradable organic electronics devices able to i) provide a combination of local electro-chemical stimuli to promote CNS plasticity after injury and ii) release drugs/small molecules to control the *in situ* foreign body reaction (FBR) elicited by device implantation. The biodegradable poly(lactic-co-glycolic) acid (PLGA) has been chosen as substrate material, its FBR characterized *in vitro* using astrocytes, microglia and primary macrophages. We show that Minocycline, a third generation tetracycline known for its anti-inflammatory and neuro-protective actions, is able to reduce PLGA-driven FBR. Ultra-thin, organic electrolytically-gated transistors (EGOFETs) have been fabricated on transparent PLGA layers. These devices have been used *in vitro* to perform the stimulation of neuronal networks obtained either from neural progenitor cells (NPCs) or primary cortical neurons growing onto the devices. By combining electrical stimulation with EGOFET and Ca^{2+} imaging we reproducibly show highly efficient activation of the networks by bi-phasic electrical pulses at different current intensities and frequencies. Flexible implantable devices have then been fabricated and recently implanted into laboratory animals. Their ability to generate electro-neuro-graph (ENG) signals via stimulation of the dorsal aspect of the spinal cord was assessed. Recording extracellular signals and the efficacy in promoting long-term plasticity (chronic implants) in the injured spinal cord are currently under study. This work was supported by EU-project I-ONE-FP7 "Implantable Organic Nano-Materials" NMP4-SL-2012, grant agreement n.280772.

Biography



In 2010 I received a master degree in Biotechnology at the Università degli Studi di Milano-Bicocca (Italy). During my master internship I joined Angelo Vescovi's lab working on the combination of hydrogels (self-assembling peptides) and biomaterials for the treatment of acute and chronic experimental spinal cord injury (SCI). After my graduation I joined Stefano Pluchino's lab at the San Raffaele Research Institute (Milan, Italy), within the Institute of Experimental Neurology (INSPE), Neuroimmunology Unit. In his lab I mainly worked on the transplantation of neural stem/progenitor cells (NPCs) into laboratory animals affected by experimental SCI. We have been investigating the therapeutic plasticity of NPCs in promoting CNS regeneration after injury, uncovering some aspects of their neuroprotective and immune modulatory capacities. In 2011 I moved with the Pluchino lab in Cambridge (UK) as Research Assistant. Initially I was responsible for the set-up of our in vivo models of neurodegenerative diseases (SCI and a rodent model of Multiple Sclerosis). In 2012 I have been awarded with a PhD studentship in the Department of Clinical Neurosciences in the Pluchino lab. My PhD project focuses on the development of an implantable organic nano-electronic device (iONE) to interface with the central nervous system. Within the EC funded project we aim at developing a multifunctional, biocompatible and biodegradable electronic device able to deliver loco-regional stimulations (both electrical and chemical) and to record electrical signals from the tissue. During the first two years of my PhD I have worked at the in vitro characterization of the efficacy and biocompatibility of the integrated device and its different materials and electrical components. Currently we are implanting iONE devices into rodents affected by SCI in order to promote tissue plasticity and functional recovery.

S5.3 International Standards for Printed Electronics

Dr Alan Hodgson
3M Chadderton, and Chair of IEC TC119

This presentation will give an overview of the work of IEC TC119, the International Standards body for Printed Electronics. It will also examine some of the advantages that participation can offer the Large Area Electronics community in terms of networking, technology development and market access.

Biography

Dr Alan Hodgson has a BSc in colorant chemistry and a PhD in instrumentation, both from the Department of Chemistry at UMIST (now the University of Manchester). After 22 years in the photographic industry, Alan worked on consultancy projects that led him into Printed Electronics. In 2008, he joined 3M in the UK as Technical Development Manager specialising in print solutions for high security documents.

Alan is active in Printed Electronics, both as a practitioner and Chair of the IEC standards initiative on Printed Electronics IEC TC119. His particular interest is in the potential of paper of all forms as a substrate for printed electronics. He is President of the IS&T and a past Chair of the Institute of Physics Printing and Graphics Science Group.

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S5.4 A Strategy to Promote Innovation and Growth in High Value Manufacturing

Dr Andy G Sellars
Lead Technologist, High Value Manufacturing, Innovate UK

Innovate UK aims to accelerate economic growth by stimulating and supporting business-led innovation. UK Manufacturing has seen resurgent growth in recent years, with many activities being re-shored after decades of off-shoring to lower cost economies. This paper describes support from Innovate UK for UK manufacturing as part of our High Value Manufacturing strategy, including key areas for growth and investment. It also outlines the 2015 strategy refresh, which aims to identify global trends in emerging science, engineering and management, and how they can be exploited for the benefit of UK manufacturing.

Biography

Andy joined ***Innovate UK*** (the new name for the Technology Strategy Board) in 2013 as Lead Technologist in High Value Manufacturing. Previously, Andy completed an industrially sponsored PhD at Strathclyde University, which was commercialised by Diagnostic Monitoring Systems.

Following University, Andy developed high voltage transmission equipment for Rolls Royce Industrial Power Group, electronic instruments for Spirent Communications PLC, financial transaction software, and photon detection sensors while working with Abbott Diagnostics in Dallas.

As an independent consultant, Andy developed lighting to film James Bond and set up an events management company. Andy holds an Executive MBA from the Adam Smith Business School at Glasgow University.