Innovations in Large-Area Electronics Conference (innoLAE) 2015

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POSTER SESSION

February 2015

3-4

Downing College, Cambridge
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Posters are displayed in the Howard Building Lecture Room (first floor).

A drinks reception will be held in the Howard Building on Tuesday February 3rd from 18.10 – 19.30, prior to the conference dinner.

The Programme Committee will award prizes to the two best posters. These prizes are generously supported by our Gold sponsors

PLASTIC LOGIC

NOVACENTRIX

Poster presenters are requested to make sure that their poster is displayed in the appropriate board before lunch on Tuesday 3rd and removed at the conclusion of the lunch break on Wednesday 4th

Poster	Title	Authors	Institution
1	Vacuum-evaporated Organic Static Random Access Memory	J.A. Ávila-Niño,[a] D.M. Taylor,[a] H. Assender,[b] S.G. Yeates,[c] E.R.Patchett,[a] Z. Ding[b] J.J.Morrison[c] and G, Abbas[b]	[a] School of Electronic Engineering, Bangor University, [b]Department of Materials, University of Oxford, [c]Department of Chemistry, University of Manchester
2	Ferroelectric Field Effect Transistors (FeFETs) based on sprayed ZnO with copolymer gate dielectric	J. Cho, Y. T. Chun, A. J. Flewitt, W. I. Milne, D. Chu	Department of Engineering, University of Cambridge
3	High-Performance Solution-Based Hybrid Integration for Organic/Metal Oxide Logic Circuits	Vincenzo Pecunia, Henning Sirringhaus	Cavendish Laboratory, University of Cambridge
4	Novel, high-capacitance nanocomposite dielectrics for printed electronics	Dr Sheida Faraji, Prof M.L. Turner and Dr L.A. Majewski	School of Chemistry, University of Manchester
5	Comparison of 2V Organic Thin-Film Transistors fabricated on free-standing commercial PEN foils	S. Hannah, H. Gleskova	Department of Electronic and Electrical Engineering, University of Strathclyde
6	High density polyethylene, an inert additive with stabilizing effects on organic field-effect transistors	A.D. Scaccabarozzi[1], J.I. Basham[2], L. Yu[3], S. Heutz[1], A. Amassian[3], D.J. Gundlach[2], Natalie Stingelin[1]	[1]Department of Materials and Centre for Plastic Electronics, Imperial College London , [2]National Institute of Standards and Technology Gaithersburg, Maryland, United States, [3]Division of Physical Sciences and Engineering, King Abdullah University of Science and Technology (KAUST), Saudi Arabia
7	Single and Bilayer Metal Oxide Transistors Processed from Solution at Low Temperatures	Hendrik Faber, Yen-Hung Lin, Satyajit Das, Thomas D. Anthopoulos	Department of Physics and Centre for Plastic Electronics, Imperial College London,
8	Organic photon-multiplying down-converting coating to boost conventional solar cells beyond the Shockley-Queisser limit	Maxim Tabachnyk, T. Jellicoe, B. Ehrler, S. Gelinas, M.L. Bohm, B.J. Walker, K.P. Musselman, R. Friend	Cavendish Laboratory, University of Cambridge
9	Comparing the future costs of organic PV to established PV technologies	Ajay Gambhir, Philip Sandwell, Jenny Nelson	Imperial College London
10	Next generation solar cells based on graded bandgap structures utilising large-area electroplated semiconductors	I.M. Dharmadasa, O.E. Echendu	Materials & Engineering Research Institute, Sheffield Hallam University
11	Performance optimisation of P3HT:PCBM solar cells by controlling active layer thickness	Burak Y. Kadem, Aseel K. Hassan and Wayne Cranton	Materials & Engineering Research Institute, Sheffield Hallam University
12	Structural and dynamical characterization of P3HT-PCBM blends	G. M Paternò[1], F. Cacialli[1], V. García Sakai[2]	[1] London Centre for Nanotechnology and Department of Physics and Astronomy, University College London, [2]ISIS Pulsed Neutron and Muon Source; Rutherford Appleton Laboratory
13	Tuning Fullerene Intercalation in Poly (thiophene) derivative by Controlling the Polymer Degree of Self-Organization	G. M Paternò[1], M.W. A. Skoda[2], Robert Dalgliesh[2], F. Cacialli[1], V.G. Sakai[2]	[1] London Centre for Nanotechnology and Department of Physics and Astronomy, University College London, [2]ISIS Pulsed Neutron and Muon Source, Rutherford Appleton Laboratory

Poster	*Title*	*Authors*	*Institution*
14	Neutron Radiation Tolerance of Poly (thiophene) Derivatives	G. M Paternò[1], V. Robbiano[1], V. García Sakai[2], F. Cacialli[1]	[1] London Centre for Nanotechnology and Department of Physics and Astronomy, University College London, [2]ISIS Pulsed Neutron and Muon Source; Rutherford Appleton Laboratory
15	The use of controlled stress parallel superposition rheology for the measurement of commercial materials	James Claypole, Alex Holder, Davide Deganello, Rhodri Williams*	WCPC Swansea, *Swansea University
16	Molecular Electronics: a rapid bottom-up approach to investigate novel organo-metallic electronic building blocks on a single-molecule scale	Mario Lemmer, Michael S. Inkpen, Tim Albrecht	Department of Chemistry, Imperial College London
17	Electrical Readout Of Thermally-Induced Dielectric Bistability In Solution Processed Thin Films Of Spin Crossover Polymers	G. Bovo[1,2], I. Braeunlich[3], W. Caseri[3], N. Stingelin[2, 4], T. Anthopoulos[1, 2],D.Bradley[1, 2], K. Sandeman[1], P. Stavrinou[1, 2]	[1]Department of Physics, Imperial College London, [2]Centre for Plastic Electronics, Imperial College London, [3]Department of Materials, ETH Zurich, [4]Department of Materials, Imperial College London
18	Inexpensive Triboelectric Materials for Large-Area Energy Harvesting and Sensing Applications	Zhenhua Luo, Steve Beeby	Electronics and Computer Science, University of Southampton
19	Fabrication of thin film capacitors based on hybrid organic/inorganic nanocomposites with inkjet printed Ag electrodes on plastic substrates	E. Danesh[a], S. Faraji[b], D. J. Tate[c], K. C. Persaud[a], L. A. Majewski[b], S. G. Yeates[c], M. L. Turner[c]	[a]School of Chemical Engineering & Analytical Science, [b]School of Electrical & Electronic Engineering, [c]School of Chemistry, The University of Manchester
20	On-Going Improvements in Properties of Conductive Inks	Rudie Oldenzijl, Tony Winster	Henkel Electronic Materials NV,Belgium Henkel Ltd, UK
21	Solution-processable inorganic/organic conductors of high transparency and high refractive index	Luca Occhi (1,2), Natalie Stingelin (2,3), Donal D. C. Bradley (1,2), Paul N. Stavrinou (1,2)	Imperial College London (1) Department of Physics, Blackett Laboratory, (2) Centre for Plastic Electronics, (3) Department of Materials Imperial College London
22	Work function engineering of printable electrodes based on AgNWs and SWCNTs for flexible electronics	V. Robbiano[1], L. Santarelli1, A. Abdellah[2], F. Cacialli[1]	[1]University College London, Department of Physics and Astronomy and London Centre for Nanotechnology, [2]Institute for Nanoelectronics, Technische Universität München
23	Characterisation of multi-walled carbon nanotubes (MWNTs) thin films spray-coated over rigid and flexible substrates	L. Santarelli[1], V. Robbiano[1], A. Abdellah[2], E. Cagatay[2], P. Lugli[2], F. Cacialli[1]	[1]University College London, Department of Physics and Astronomy and London Centre for Nanotechnology, [2]Institute for Nanoelectronics, Technische Universität München
24	Novel low-cost conductive layers for printed electronics	Harry Cronin	DZP Technologies Ltd, Cambridge, UK and MiNMaT, University of Surrey, Guildford
25	Laser Ink Transfer for Printable Electronic Devices (LITPED) – A novel manufacturing	Zlatka Stoeva[1*], Vasilka Tsaneva[2], Mark R. Buckingham[1],	[1]DZP Technologies Ltd, Cambridge, UK, [2]Department of

Poster	Title	Authors	Institution
	method for mass customisation of large area electronics	Stephen Whiley[1], Bartlomiej A. Glowacki[2,3,4], Tsegie Faris[1], Dan Tonchev[1]	Materials Science and Metallurgy, University of Cambridge, [3]Department of Physics and Energy, University of Limerick, Ireland, [4]Institute of Power Engineering, Warsaw, Poland
26	Design of an advanced laser platform for high speed and high resolution manufacturing of organic electronics components	E. Biver[1 *], F. Zacharatos[2], St. Leyder[3], R. Geremia[1], D. Puerto[3], A.P. Alloncle[3], Ph Delaporte[3], D. Karnakis[1], I. Zergioti[2]	[1]Oxford Lasers Ltd, Didcot, UK, [2]National Technical University of Athens, [3]Aix-Marseille University, CNRS
27	The influence of laser pulse duration and spatial intensity distribution on the patterning of thin film layers for flexible electronic devices	C. Moorhouse[1], D. Karnakis[1], C. Kapnopoulos[2], A. Laskarakis[2], S. Logothetidis[2,], G. Antonopoulos[3], C. Koidis[3]	1Oxford Lasers Ltd, Didcot, UK, [2]Aristotle University of Thessaloniki, Greece, [3]Organic Electronic Technologies P.C. (OET), Thessaloniki, Greece
28	Large-Scale (1.4m wide) Roll-to-Roll Research Platform	Martin O'Hara	EPSRC Centre for Innovative Manufacturing in Ultra Precision, Cranfield University
29	Upscaling the manufacture of a printed resistive heating system for the build environment	Bruce Philip[1], Eifion Jewell[1], Peter Greenwood[1], Chris Weirman [2], Stewart Reid[2]	[1]SPECIFIC, Swansea Univ. [2]SPECIFIC, TATA steel COLORS
30	Advances in large area printed pressure sensors	Tim Mortensen, Y.Mouhamed, A.Holder, D.Deganello	Welsh Centre for Printing and Coating, Swansea University
31	Super Inkjet Printer Technology and Properties	Atefeh Y-Amin	Cavendish Laboratory, University of Cambridge
32	Super-Fine Inkjet In Practice	A. V. S. Parry[1], R. Saunders[1], J. Wheeler[1], V. S. Romaguera[2] S. G. Yeates[1]	[1]School of Chemistry, [2]Manchester Business School University of Manchester
33	Adhesion lithography – Applications of a Large Scale Nanopatterning Technique	James Semple, Gwenhivir Wyatt-Moon, Thomas D. Anthopoulos	Department of Physics and Centre for Plastic Electronics, Imperial College London
34	Large Area, Low Cost Fabrication of Novel, Lateral, Solution Processed LEDs	Gwenhivir Wyatt-Moon, James Semple, Thomas D. Anthopoulos	Department of Physics and Centre for Plastic Electronics, Imperial College London
35	Simultaneous Multiple Device Testing for High-Volume, Large-Area Production of Flexible Electronic Devices	A. Kumar, Q. Xu, K.M. Niang, A. Flewitt	Electrical Engineering Division, Department of Engineering, University of Cambridge
36	Organic Electronics & Applications - OREA Lifelong Learning Project	Satyajit Das	Department of Physics and Centre for Plastic Electronics, Imperial College London

Vacuum-evaporated Organic Static Random Access Memory

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

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Abstract

A roll-to-roll-compatible vacuum-evaporation route has been used to manufacture a six-transistor organic Static Random Access Memory (SRAM) cell. As seen in Fig. 1, the cell is formed from two, cross-coupled inverters accessed via transistors controlled by the word line (WL). The bottom-gate top-contact, organic thin film transistors (OTFTs) were fabricated on a PEN substrate. The aluminium gate and gold source/drain metallisation layers and the p-type semiconductor dinaphtho [2,3-b:2',3'-f] thieno[3,2-b]thiophene (DNTT) were all deposited by conventional thermal evaporation. The gate dielectric was deposited by flash evaporation and subsequent plasma 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].

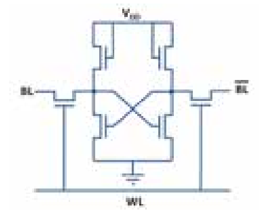

Fig. 1

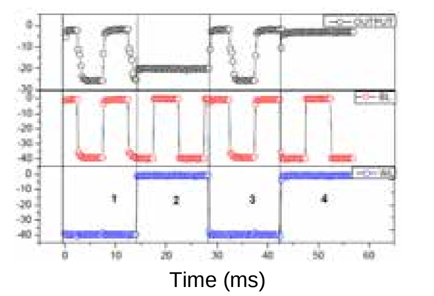

Fig. 2

In Fig. 2 is shown the dynamic response of the cell. Only when WL is activated (V=-40 V) does the signal labelled output (the state of the inverter connected to BL) follow the 100 Hz signal applied to BL. Also, the signal applied to BL is stored in the memory when WL switches off i.e. -22 V between 14 and 28 ms, and -2 V between 43 and 57 ms. The response speed of the cell is shown in Fig. 3. From exponential fits to the data, The rise time from ~ -2 V (low) to ~ -22V (high) is 389 μs while the fall time back to ~ -2 V is 60 μs.

The devices were measured two months after fabrication and showed no significant degradation after storage in a clear plastic container in normal laboratory ambient. No significant changes were observed either when the SRAM cells were connected to the voltage supply (-40 V) for more than 27 hours continuously. The discrimination between high and low even improved slightly.

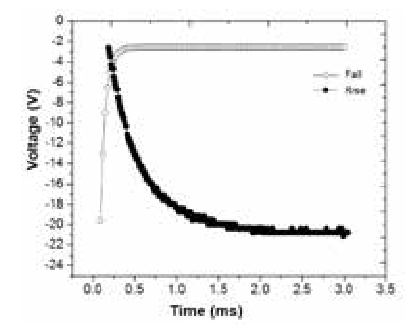

Fig. 3

We are now proceeding to fabricate a 4 x 4 array of cells and will report the results at the CIMLAE conference.

Reference

[1] G. Abbas, *et al.* 2011, *J Vac Sci Technol*, B 29, 052401

BIOGRAPHY

José A. Avila-Niño was born in Ciudad Valles, Mexico. He received his B.Sc. degree in Electronic Engineering and M.Sc. in Applied Science from the Universidad Autónoma de San Luis Potosí, Mexico in 2006 and 2008 respectively. He was recently awarded his Ph.D. by the same institution for his work on organic resistive memory devices. He is currently on a 9-month research visit to the Organic Electronics Research Group at Bangor University. Here he is gaining experience in the vacuum-fabrication of organic electronic circuits, specifically designing, fabricating and testing a static RAM array.

Ferroelectric Field Effect Transistors (FeFETs) based on sprayed ZnO with copolymer gate dielectric

J. Cho, Y. T. Chun, A. J. Flewitt, W. I. Milne, D. Chu

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Ferroelectric field effect transistors (FeFETs) have drawn a lot of attention due to their scalability, re-writability, nondestructive readout and their compatibility with conventional fabrication technology. In particular, Fe-FETs with ferroelectric polymers based on solution process are applicable for applications ranging from low-cost identification tags to switching devices for active matrix displays.[1,2] Oxide based semiconductors have also been employed in the manufacture of Fe-FETs based on particular features of their intrinsic characteristics including high carrier mobility, high optical transparency, high mechanical flexibility, good stability and large-area uniformity.[3] However, most previous work has focused on vacuum-based deposition of thin films or nanowire structures, which are more limited in manufacturability for large-area application.[3,4]

In this work, we present a Fe-FET based on sprayed ZnO. Poly(vinylidenefluoride-trifluoroethylene) (P(VDF-TrFE)) ferroelectric copolymer is employed as a dielectric layer without a buffer layer, which is spin coated onto the spray coated ZnO channel. Both of processes were performed in ambient air and the device exhibited a memory window of over 10V and a high drain current on/off ratio of ~10^5.

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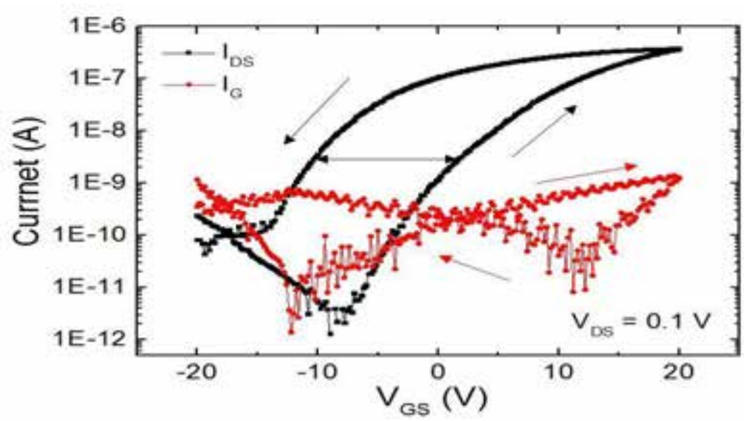

Fig 1. Transfer curves (I_{DS} - V_{GS}) of the top-gate FeFET memory device (W/L = 10)

Jun Hee Cho

Jun Hee Cho is a PhD student in the Electronic Devices & Materials (EDM) group in the Engineering Dept.the Univ. of Cambridge, under the supervision of Prof W.Milne. His main research topic is the application of metal oxide semiconductor materials mainly focused on spray pyrolysis process.

Jun Hee Cho has a B.Sc. in Electrical Engineering from Seoul National University (2009) where his research involved the fabrication and analysis of organic and inorganic thin film transistors (TFTs).

High-Performance Solution-Based Hybrid Integration for Organic/ Metal Oxide Logic Circuits

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Abstract

Organic and amorphous-metal-oxide semiconductors have a great potential for large-area circuit applications. Both classes of semiconductors have reached maturity both in performance and reliability, with the p-type organic materials suitably complementing the n-type metal-oxide ones.[1,2] Consequently, the field has witnessed a growing interest in the integration of these semiconductors into complementary transistor circuits.[3–6] Ideally, they should be processed from solution and at temperatures compatible with low-cost plastic substrates. [7]

Here we report our novel hybrid integration scheme that addresses the challenge of realizing organic/metal-oxide logic circuits via solution processing. The scheme allows the solution-based fabrication of top-gate n- and p-type transistors through the sequential deposition of an amorphous metal-oxide semiconductor and a polymeric semiconductor, patterned subtractively by dry etching and topped with a shared low-temperature polymeric dielectric. At a circuit level, the integration relies on a solution-processed photopatterned circuit dielectric, which allows the self-aligned deposition of the gate electrodes and the consequential minimization of device parasitics.

We implemented this novel process with an indacenodithiophene-based polymer and a precursor-based indium-zinc oxide as semiconductors, and a bilayer polymer insulator as gate dielectric. We obtained undegraded performance after integration, thus confirming the robustness of our process flow. Fundamental logic gates were produced, showing rail-to-rail switching, large and symmetric noise margins, and low-voltage operation. Ring oscillators were used to characterize the speed of our logic, which gave propagation frequencies in the megahertz region, due to the semiconductors' balanced mobilities in excess of 1 $cm^2\ V^{-1}\ s^{-1}$ and the self-aligned-gate approach.

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Biographical Information

Vincenzo Pecunia is a Research Associate at the Optoelectronics Group of the Cavendish Laboratory, University of Cambridge. His research interests include solution-based organic, metal-oxide and hybrid transistors, and process integration for flexible and printed electronics. Vincenzo joined the EPSRC Centre in May 2014 to work on the iPESS project.

Vincenzo carried out his doctoral work on organic electronics under the supervision of Professor Henning Sirringhaus at the University of Cambridge. Before his PhD, he completed his BSc and MSc in Electronics Engineering at Politecnico di Milano, Italy.

Henning Sirringhaus holds the Hitachi Professorship of Electron Device Physics at the Cavendish Laboratory, University of Cambridge. He has an undergraduate and PhD degree in physics from ETH Zürich (CH). From 1995-1996 he worked as a postdoctoral research fellow at Princeton University (USA). He has been working in Cambridge in the field of charge transport in organic semiconductors and their application in field-effect transistors since 1997. In 2000, he co-founded Plastic Logic Ltd., a technology start-up company commercialising printed organic transistor technology.

His research interests include charge transport through self-assembled organic molecules and polymer and high-resolution printing based fabrication of organic devices and applications of organic semiconductors in field-effect transistors and solar cells.

Novel, high-capacitance nanocomposite dielectrics for printed electronics

Dr Sheida Faraji, Prof M. L. Turner and Dr L. A. Majewski

The rapid development of organic semiconductor materials that can be processed from solution opens up the possibility of printing organic field-effect transistors (OFETs) onto a wide range of substrates to enable the development of low-cost, large area electronics. However, typical solution-processed OFETs operate at voltages that are too high for use in wearable/portable electronic devices or notably as aqueous sensors (V > 5 V). For these applications, transistors working in the range of 1.5 to 1 V are highly desirable. Lowering the operational voltage of OFETs can be achieved by reducing the threshold voltage and the subthreshold swing. These device parameters are largely controlled by the gate dielectric and the density of charge traps at the dielectric-semiconductor interface. Therefore, to achieve ultralow-operational voltages, high-capacitance, solution-processable gate insulators that form trap-free interfaces are essential.

With great promise in hybrid materials, a high-*k* dielectric material based on alternative organic-inorganic nanocomposite materials is developed that combines very high dielectric constant values intrinsic to ferroelectric ceramic materials (nanoparticles) with mechanical flexibility, low-cost and easy processing of polymers. A novel, solution processed high-*k* nanocomposite bilayer gate dielectric that enables the fabrication of organic field-effect transistors (OFETs) operate effectively at as low as 1 V in high yields is reported. High-*k* nanocomposite suspensions are prepared by meticulously incorporating a selection of nanoparticles poly (vinylidene fluoride-co-hexafluoropropylene) P(VDF-HFP) and cyanoethyl pullulan (CEP) polymer matrices. The solution-processed nanocomposite layer was subsequently coated with a thin capping layer to improve the surface roughness and dielectric-semiconductor interface and reduces the leakage current. OFETs were fabricated using solution-processed semiconductors, poly(3,6-di(2-thien-5-yl)-2,5-di(2-octyldodecyl)-pyrrolo[3,4-c]pyrrole-1,4-dione)thieno[3,2-b]thiophene) and a blend of 6,13-bis (triisopropylsilylethynyl) pentacene and poly (α-methylstyrene), in high yield (> 90 %) with negligible hysteresis, low operational voltage (< 3 V) and low leakage current density (10^{-9} A cm^{-2} at ± 1)).

Biography: Sheida Faraji

Having recently completed my PhD, I started my job as a postdoc research associate in Sept 2014 at the University of Manchester, OMIC group, working on high-capacitance, solution-processed nanocomposite dielectric materials. The 'proof of principle' funding, awarded through UMIP, is to exemplify and exploit the patent application filed in May 2014. I have submitted a manuscript with respect to the patent work to *Organic Electronics* which has been reviewed and is awaiting publishing.

COMPARISON OF 2 V ORGANIC THIN-FILM TRANSISTORS FABRICATED ON FREE-STANDING COMMERCIAL POLYETHYLENE NAPHTHALATE FOILS

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The large-area, roll-to-roll (R2R) fabrication of organic thin-film circuits on plastic foils demands low-cost manufacturing and the integration of devices onto flexible plastic substrates. We have developed a fully dry process [1] to fabricate low-voltage organic thin-film transistors (OTFTs) with 10-nm thick dielectric amenable to R2R processing. Two commercially available polyethylene naphthalate (PEN) plastic foils (DuPont Teijin [2]) were compared for use as possible flexible substrates. Teonex Q65FA features an adhesive layer on the bottom side to prevent its slippage during the R2R process, while Optfine PQA1 includes a planarisation layer on the top (device) side.

The PEN films were pre-annealed at 160°C for 24 hours prior to OTFT fabrication. 160°C is the maximum temperature used in our OTFT fabrication process and the pre-annealing should mitigate the layer-to-layer misalignment during the OTFT fabrication. Teonex Q65FA remained flat after the pre-annealing step, while the radius of curvature of Optfine PQA1 changed from ~17 cm to 1.5 cm after the anneal. Consequently, we fabricated Al/AlO_x/C_8PA/DNTT/Au and Al/AlO_x/DNTT/Au OTFTs on non-annealed Optfine and pre-annealed Teonex foils. Dinaphthothienothiophene (DNTT) was chosen due to its excellent air-stability and the addition of n-octylphosphonic acid (C_8PA) improves its growth. 15 nm of DNTT was deposited at room temperature at rates of 0.4 Å/s and 0.6 Å/s on the Teonex and Optfine, respectively.

The initial OTFT performance was evaluated by measuring the transfer characteristics between 0 and −2 V and extracting the field-effect mobility, threshold voltage, subthreshold slope, etc. Bias stress was performed approximately one week after the initial measurements at a gate voltage of −2 V while the source and drain were grounded. Referring to Table 1, one week of storage in vacuum between the initial and bias stress measurements, led to a reduction in OTFT threshold voltage and an increase in the mobility and the OFF-current. Figure 1 shows the as-fabricated OTFT parameters extracted from transfer characteristics measured at a drain voltage of −2 V. For both PEN substrates tested, the inclusion of the C_8PA monolayer increases field-effect mobility, ON-current and ON/OFF-current ratio and reduces subthreshold slope and OFF-current. The substrates affect OTFT performance in a mixed way. Comparing OTFTs with C_8PA monolayer Teonex PEN has a slightly lower subthreshold slope and OFF-current than the Optfine PEN film. However, the Optfine film exhibits about a factor of three higher field-effect mobility (0.14 cm^2/Vs) and about an order of magnitude higher ON-current. The OTFTs on Optfine PEN substrate also appear to remain more stable after the application of bias stress in terms of mobility, even though their threshold voltage at the beginning of the bias stress was ~ −0.4 V lower than that of OTFTs fabricated on Teonex PEN.

In conclusion, Teonex PEN was found to be easier to handle, since it remained flat upon heating at 160°C. However, the AlO_x/C_8PA transistors exhibited about a factor of three lower field-effect mobility when compared to Optfine PEN OTFTs. The planarisation layer on Optfine PEN leads to improved OTFT mobility compared to Teonex PEN; however the Optfine PEN curved significantly upon heating and therefore presents a significant challenge if used as a free-standing substrate with our OTFT fabrication procedure.

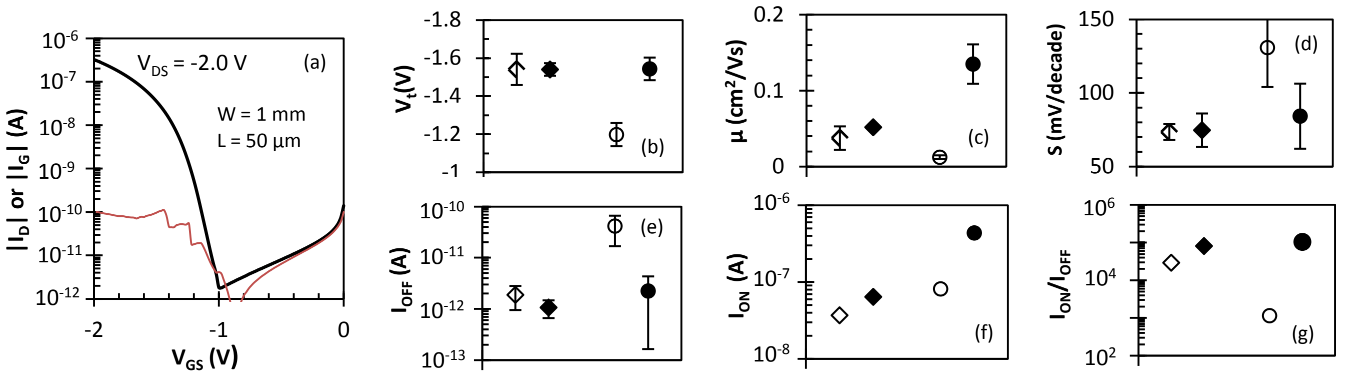

Figure 1: OTFT transfer characteristic for Teonex PEN substrate (a). OTFT parameters: threshold voltage (b), field-effect mobility (c), subthreshold slope (d), OFF-current (e), ON-current (f) and ON/OFF ratio (g) for Teonex and Optfine PEN. Empty and full symbols represent OTFTs with AlO_x and AlO_x/C_8PA dielectrics respectively; ♦◊ = Teonex and ●○ = Optfine.

Table 1: OTFT parameters for Teonex and Optfine PEN substrates before and after a 1000-second bias stress.

	Teonex Q65FA				**Optfine PQA1**			
	AlO_x OTFT		AlO_x/C_8PA OTFT		AlO_x OTFT		AlO_x/C_8PA OTFT	
	Before bias stress	1000 s of bias stress	Before bias stress	1000 s of bias stress	Before bias stress	1000 s of bias stress	Before bias stress	1000 s of bias stress
V_t (V)	−1.20	−1.75	−1.27	−1.70	−0.40	−1.58	−0.72	−1.33
µ (cm^2/Vs)	0.090	0.079	0.11	0.088	0.018	0.022	0.16	0.16
S (mV/dec)	85	68	78	74	166	111	112	103
$\|I_{OFF}\|$ (A)	$1.4x10^{-11}$	$1.3x10^{-12}$	$1.8x10^{-12}$	$1.1x10^{-12}$	$2.8x10^{-10}$	$1.2x10^{-11}$	$1.7x10^{-11}$	$6.5x10^{-12}$
$\|I_{LEAK}\|$ (A)	$1.4x10^{-10}$	$6.8x10^{-11}$	$1.1x10^{-10}$	$1.2x10^{-10}$	$3.1x10^{-10}$	$1.6x10^{-10}$	$5.8x10^{-10}$	$9.9x10^{-10}$

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[2] We thank Dupont Teijin for providing PEN substrates for this experiment.

Biography:

Stuart Hannah received the BEng (Hons) degree in ctronic and Electrical Engineering from the University of Strathclyde, Glasgow in 2013. He is currently studying towards a PhD in Electronic and Electrical Engineering at the University of Strathclyde, which is funded by an EPSRC Doctoral Training Grant scholarship. He is a student member of the Institution of Engineering and Technology (IET) and the Royal Society of Chemistry (RSC).

HIGH-DENSITY POLYETHYLENE, AN INERT ADDITIVE WITH STABILIZING EFFECTS ON ORGANIC FIELD-EFFECT TRANSISTORS

Alberto D. Scaccabarozzi[1], James I. Basham[2], Liyang Yu[3],
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Organic electronics have attracted considerable interest over the last decade promising an alternative to conventional, inorganic electronics platforms. There has been a rapid development in the area, and the drastic increase in device performance over the last few years has been driving these organic electronic technologies towards commercialization. To fully exploit the touted potential of this plastic electronics platform, however, other prerequisites need now to be fulfilled: for example, good mechanical stability, ease of processing and device reliability. Here we present a range of transistors comprising an inert, insulating component that provides for the introduction of such features into organic semiconducting device structures. Indeed, insulator:semicondcutor systems previously have been demonstrated to display favourable rheological and mechanical properties compared to the common donor:acceptor binaries.[1-5] Here, we will focus on blends comprising an electrically insulating material, high-density polyethylene (HDPE), blended with donor materials and with donor:acceptor combinations. We show how these blends can be applied to OFET applications and discuss the benefits of addition of HDPE to enhance device performance and reliability. We also show how these blends can be fabricated via blade and wire-bar coating, deposition techniques that allow the production of large area films with a reduced loss of material, compatibility with roll-to-roll processes and therefore promising the possibility of a scaling-up production.

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Corresponding author:
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Biography

Alberto Davide Scaccabarozzi was born in Merate (Italy) in 1987. After receiving his Diploma at Liceo Scientifico "Tito Lucrezio Caro", Cittadella (Italy) in 2006, he started his studies in Materials Engineering at University of Padua. In 2008 he spent one academic year at Instituto Superior Tecnico, Lisbon as part of the Erasmus Lifelong Learning Programme (LLP). In 2009, after obtaining the B.Sc. at University of Padua, he moved to Polytechnic of Milan where he attended the M.Sc. in Materials Engineering. In 2011 he joined the group of Prof. Natalie Stingelin at Imperial College London, first as a visiting student and later as a Ph.D. student in 2012.

Single and Bilayer Metal Oxide Transistors Processed from Solution at Low Temperatures

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A large drawback of solution processed metal oxide films has traditionally been the high conversion temperature (T_C > 400 °C) involved in the deposition. However, improvements in precursor selection and innovative processing steps such as UV irradiation [1] or combustion chemistry [2] lead to a steady decline of T_C the in recent years, even enabling the fabrication on plastic substrates. In this work, we employ aqueous solutions of zinc oxide hydrate and indium nitrate hydrate to deposit high performance single and bilayer transistors in the temperature range of 180 – 250°C.

Thin-films of indium oxide are deposited via ultrasonic spray pyrolysis, a technique especially well-suited for large area deposition and automation. High quality, smooth films with extended crystalline regions (30-60 nm) are obtained under optimized process conditions. Embedded into single-layer thin-film transistors (TFTs) they exhibit field-effect mobilities of 15-20 cm^2/Vs and high channel current on/off ratios of $>10^6$. Using this technique, low voltage devices as well as operation on flexible polymer substrates could be demonstrated

Additionally, the impact of bilayer structures created by a subsequent low-temperature deposition of an ultra-thin (~7 nm) layer of zinc oxide has been studied. High resolution transmission electron microscopy revealed the presence of a high quality crystalline hetero-interface giving rise to greatly improved charge carrier mobility that can surpass 40cm^2/Vs. Both temperature dependent charge transport properties and band structure are discussed to investigate this effect. Our approach shows the possibilities for large area deposition of low dimensional metal oxides films at low temperatures. Their increased performance when used in bilayer configuration shows a promising pathway for future developments.

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Biography

Hendrik Faber studied Materials Science at the Friedrich-Alexander University Erlangen-Nürnberg, Germany, where he received both the Diplomingenieur as well as PhD degree in 2008 and 2012, respectively. Since 2012 he is working as a post-doctoral researcher at Imperial College London focussing on solution-processed metal-oxides for large-area electronic applications.

Organic photon-multiplying down-converting coating to boost conventional solar cells beyond the Shockley-Queisser limit

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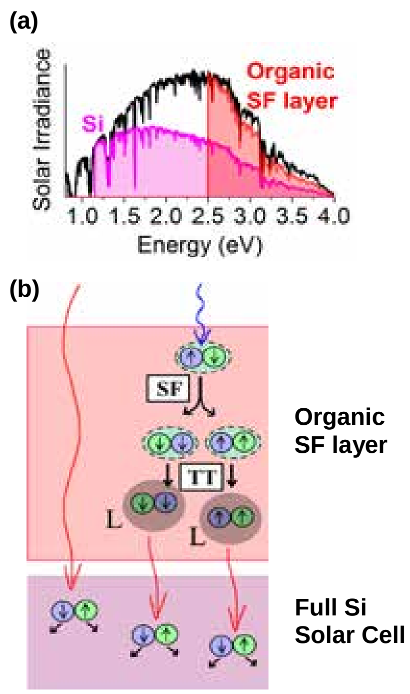
Co-Authors: Tom Jellicoe, Bruno Ehrler, Simon Gélinas, Marcus L. Böhm, Brian J. Walker, Kevin P. Musselman, Richard H. Friend and Akshay Rao

The power conversion efficiency of conventional single-junction photovoltaics (PV) is fundamentally limited by the Shockley-Queisser limit, mainly because excitations from high-energy photons rapidly cool to the semiconductor band edge and lose their excess energy, with respect to the bandgap, to heat. We introduce a photon-multiplying down-converting coating based on an organic semiconductor which emits up to two low-energy photons per absorbed high-energy photon.

As recently demonstrated, some organic materials can distribute the excitation energy of a highly photo-excited spin-singlet state into two lower excited triplet states, with half the singlet energy each.[1] If combining such a high-bandgap singlet exciton fission material with a low-bandgap semiconductor, the Shockley-Queisser limit rises from around 32% to 46%, by decreasing heat losses of excitations generated by the blue part of the solar spectrum. Figure **(a)** illustrates photocurrent contribution of an organic singlet fission (SF) layer combined with silicon (Si). The scientific challenge has been to capture the energy of triplet excitons.

Previous strategies tried to separate the charges of triplet excitons at material interfaces and external quantum efficiencies above 100% as well as internal quantum efficiencies approaching 200% have been demonstrated.[1,2] However, the power conversion efficiency of these approaches has been rather low because no efficient low-bandgap electron acceptor has been identified yet.



We recently demonstrated that triplet excitons resulting from singlet exciton fission can be transferred into inorganic nanocrystals on a ps-timescale and with a transfer efficiency above 95%.[3] 'Dark' triplets become highly emissive in inorganic nanocrystals because the nanocrystals contain heavy elements. The emission can be coupled into any conventional inorganic solar cell, such as widely-spread Si-based PV.

As shown in **(b)**, such a photon-multiplying down-converting coating (PDMCC) contains a high-bandgap organic semiconductor undergoing singlet fission (SF) which is doped with a low concentration of nanocrystals (L). The low concentration allows the PMDCC to be transparent in the red/near-IR. The organic absorbs the blue part of the solar spectrum. The excitations undergo SF in the organic and the resultant pairs of triplets are transferred to emissive nanocrystals. Per absorbed blue photon, the PMDCC emits two near-IR photons which are optically coupled into the independent Si solar cell, doubling the photocurrent in the blue.

Such an optical coupling is a promising route to a simple solution-processable integration of organic components into widely-spread and optimized inorganic device designs because there is no necessity for extra electrodes or tuning of interfaces. Because it is an independent component, it can be easily adapted to various solar cell technologies.

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<u>Biography:</u> Maxim Tabachnyk

EDUCATION AND QUALIFICATIONS:

10/2013 – …	University of Cambridge (Trinity College) PhD in Physics Supervisor: Prof. Sir R.H. Friend
06/2013 – 10/2013	Ludwig-Maximilians-University Munich Master of Science in Physics
10/2012 – 06/2013	University of Cambridge (Trinity College) MASt in Physics First Class Degree with Distinction
08/2011 – 09/2011	University of Kentucky, USA Fulbright Programme: Discover the USA
10/2009 – 06/2012	Ludwig-Maximilians-University Munich Bachelor of Science in Physics
09/2000 – 05/2009	Duerer Secondary School Nuremberg

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10/2013 – …	Winton Programme for Sustainability, PhD Grant
10/2013 – …	EPSRC, PhD Grant
10/2012 – 06/2013	Gates Cambridge Trust, MASt Grant
10/2009 – 09/2012	Stiftung Maximilianeum
02/2010 – 09/2012	Studienstiftung des deutschen Volkes
10/2009 – 09/2012	Max-Weber-Programme Bavaria
09/2005 – 05/2009	Talent im Land – Bavaria

PUBLICATIONS:

- <u>M. Tabachnyk</u>, B. Ehrler, S. Gélinas, M.L. Böhm, B.J. Walker, K.P. Musselman, N.C. Greenham, R.H. Friend and A. Rao, Resonant energy transfer of triplet excitons from pentacene to PbSe nanocrystals, *Nature Materials 13*, 1033–1038 (2014)
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- <u>M. Tabachnyk</u>, B. Ehrler, S. Bayliss, R.H. Friend, N.C. Greenham, Triplet diffusion in singlet exciton fission sensitized pentacene solar cells, *Appl. Phys. Lett 103, 153302 (2013)*

Comparing the future costs of organic PV to established PV technologies

Ajay Gambhir, Philip Sandwell, Jenny Nelson (Imperial College London)

There is an increasing focus on the future cost reduction potential of all solar PV technologies, following the significant recent cost reductions in crystalline Silicon, as well as continued reductions in CdTe and CIGS costs. Organic PV is also being considered as a technology which could achieve low solar PV costs, potentially surpassing existing, more mature technologies. This study first analyses the component-by-component cost reduction potential of c-Si, CdTe and CIGS PV modules by combining insights from recent studies on these technologies. It then assesses the impact of scale on manufacturing process costs for the different components of these technologies as well as other related technologies such as silicon chips, flat panel displays and low-emissivity glass. It applies these manufacturing scale economy projections to better understand the manufacturing process cost reduction potential of OPV, and combines this with an assessment of future OPV material costs to derive a complete OPV module manufacturing cost projection. Monte Carlo sensitivity analysis is used to understand the feasible range of future costs of OPV modules, where there is currently relatively less certainty on process and material costs as well as technology performance, owing to this technology's relative immaturity.

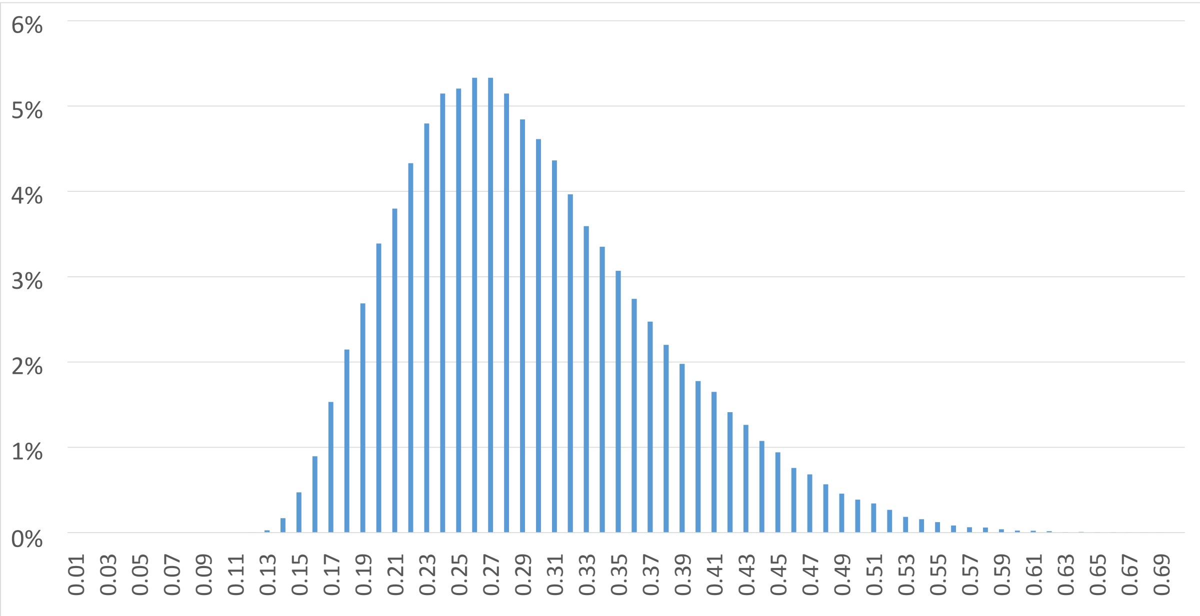

Figure: Distribution of module price ($/Wp) of commercial scale single junction OPV

The median OPV module cost is $0.27/Wp with interquartile range $0.22-0.33/Wp. This compares to a medium term cost projection for c-Si of $0.6/Wp, for CdTe of $0.4-0.5/Wp (depending on future Tellurium prices) and for CIGS of $0.35/Wp.

The implications of these relative costs will be discussed, and the impact of OPV module costs on the levelised cost of electricity generated will also be presented. The detailed estimates of these technology costs will be compared to recent expert elicitations on the future cost of solar PV, in order to compare such top-down estimates with component-by-component bottom-up estimates.

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Biography

Ajay Gambhir is a Research Fellow at the Grantham Institute at Imperial College London. His research focuses on the future costs of low-carbon technologies and the impact of these technology costs on technology choices and energy system costs within low-carbon transition pathways.

Next generation solar cells based on graded bandgap structures utilising large-area electroplated semiconductors

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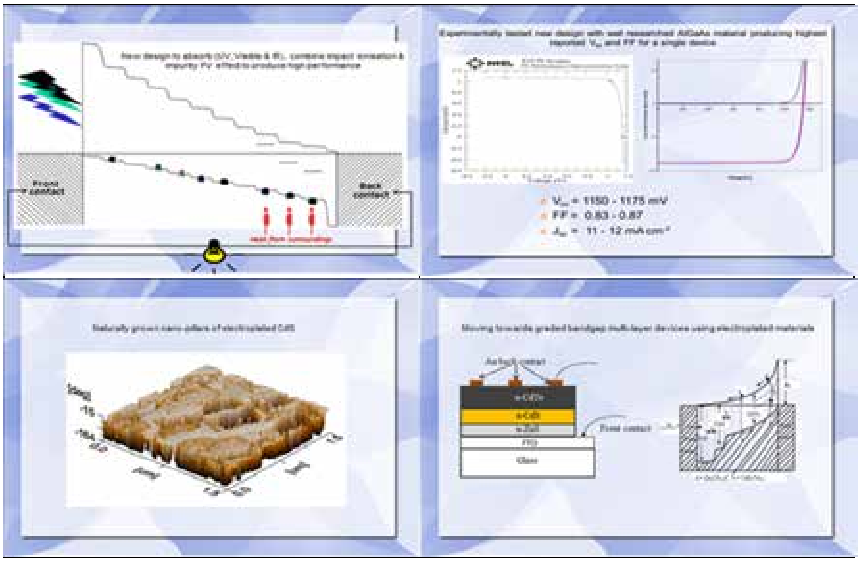
Abstract: A graded bandgap solar cell has been designed and experimentally tested using well-researched AlGaAs alloy, for moving towards the next generation high efficiency solar cells [1]. This solar cell reached highest reported open circuit voltage (V_{oc}=1170 mV) together with highest possible fill factor (FF=0.86) for a single device. These cells are capable of harvesting UV, visible and infra-red (IR) radiation, and combine "impact ionisation" and "impurity PV effect" within one device. Therefore, these devices are PV active even in complete darkness and produce V_{oc} values exceeding 800 mV, due to utilisation of IR radiation from the surroundings [2]. The second growth of this device using MOCVD-AlGaAs alloy produced ~20% efficient solar cells confirming the validity of the new design. Since the concept is experimentally proven, the present work is focussed on fabricating and developing graded bandgap multi-layer devices utilising low-cost and scalable electroplated materials. These materials consist of naturally grown nano- and micro-rod type grains and enable the exploitation of extra-ordinary electronic properties such as high charge carrier mobilities and reduced recombination process. Preliminary devices show 10-12% efficiency exhibiting expected high short circuit current density close to J_{sc}≈48 mAcm^{-2} [3]. The properties of over 10 semiconductors electroplated to date and suitable for large-area electronics will be discussed in this presentation.



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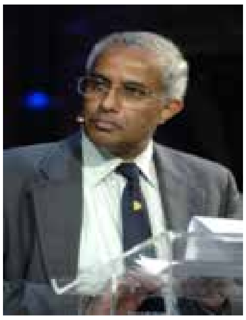

Biography of Professor I M Dharmadasa

I M Dharmadasa (IMD) is the Senior Staff Grade Professor of Electronic Materials & Devices at Sheffield Hallam University in the UK and Head of the Electronic Materials & Sensors Research Group within the Materials and Engineering Research Institute (MERI).

His research activities focus on the development of a new generation of low cost, high efficiency solar cells. He has four decades of experience in both industry and academia and his work has secured six GB patents, based on novel process developments. He has also sparked scientific debate by proposing two new scientific theories concerning development of photovoltaic solar cells. IMD has published over 100 refereed journal papers, 4 book chapters, single authored book on "Advances in Thin Film Solar Cells" and given over 200 conference presentations, including plenary and invited talks. In this process, he has successfully supervised 18 PhD theses, 14 years of postdoctoral research and examined 22 postgraduate candidates.

Earlier in his career, IMD graduated from the Univ. of Peradeniya in Sri Lanka by completing two BSc Honours degrees covering Chemistry, Physics and Mathematics. He won the Dr. Hewavitharana memorial prize for best performance for his Physics Special Degree in 1975, and joined the academic staff of the Physics Department in the Science Faculty at Univ. of Peradeniya. After winning an open commonwealth scholarship in 1977, he completed his PhD thesis in 1980 at the Univ. of Durham (UK), before returning to his post in Sri Lanka. A deep research interest generated by his PhD thesis led to his return to the UK in 1984, where he was an active solar energy researcher at Univ. College Cardiff and the British Petroleum Company (BP), before joining Sheffield Hallam University in 1990.

IMD is actively involved in the promotion of clean energy technologies for social development and the reduction of poverty. He helped establish and now leads an international Renewable Energy Promotional network (SAREP), which aims to accelerate the adoption of renewable energy technologies. He has designed, piloted and monitored "Solar Village" project, and this is now in the replication stage within and outside Sri Lanka.

IMD is a Fellow of the World Innovation Foundation and the UK Institute of Physics. He referees for over 12 international Journals and currently serves as Assessor/panel member for The European Commission (EC) and the Commonwealth Scholarship Commission (CSC). In the past he has served as an Assessor & panel member for the UK funding Council (EPSRC), Department of Trade & Industry (DTI) and The British Council (BC) for a period of 6 years each. IMD holds dual citizenship (British & Sri Lankan) and currently advising several Government Ministries for using renewable energy as a tool for social development and the empowerment of rural communities. IMD is one of the founding members of the APSL-UK charity (Association of Professional Sri Lankans in UK), and has served as the Vice President for 5 years and the President for two years (2009-2011).

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Performance optimisation of P3HT:PCBM solar cells by controlling active layer thickness

Burak Y. Kadem, Aseel K. Hassan and Wayne Cranton

Optimisation of organic solar cell (OSC) active layer thickness for improved performance has been investigated for P3HT:PCBM hybrid bulk heterojunction OSCs. Active layers in the range 65-266 nm were fabricated using a conventional structure ITO/PEDOT:PSS/P3HT:PCBM/Al. UV-visible absorption spectra revealed typical P3HT:PCBM absorption features for all obtained thicknesses. The dark J-V characteristics were employed to determine the charge carrier mobility using space charge limited conduction theory (SCLC) and series resistance of investigated devices were also derived. Series resistance was found to decrease with decreasing active layer thickness reaching lowest value of 33.9 Ohm for film thickness of 95 nm. On the other hand, charge carrier mobility was found to increase with decreasing thickness of the active layer, with a maximum mobility value of 1.37×10^{-5} $cm^2V^{-1}s^{-1}$ obtained for film thickness of 95 nm. Measurements of the PV characteristics of the investigated devices have revealed optimum performance when active layer thickness was 95 nm. Power conversion efficiency (PCE) as high as 3.86% was associated with the latter thickness, fill factor (FF) of 50%, short circuit current (J_{sc}) of 12.6 $mAcm^{-2}$ while the while open circuit voltage (V_{oc}) was kept in the range 0.6-0.62 V for all devices. Moreover, device stability was shown to be largely improved with optimised film thickness.

Wayne Cranton is the Assistant Dean, Research, for the Faculty of Arts, Computing, Engineering and Sciences at Sheffield Hallam University. His research is concerned with the study of thin film materials for electronic displays, sensors, and light emitting devices. Other interests also include research in the deposition and processing of phosphors, dielectrics, and metal oxide semiconductors, with recent emphasis on the localised photonic processing of materials for low temperature fabrication of flexible electronics and displays. Additional research includes the characterisation of visual interfaces. Wayne is editor in Chief for the `Handbook of Visual Display Technology', Springer Verlag (2012), ISBN-10: 3540795669.

Aseel Hassan B.Sc., M.Sc., Ph.D. in Physics, is a Senior Lecturer at the Faculty of Arts, Computing Engineering and Sciences of Sheffield Hallam University. He carries out research within the Materials and Engineering Research Institute and his interest lies in thin film technology mainly for application in chemical and biosensing, as well as for electronic device application. He uses optical techniques such as surface plasmon resonance and spectroscopic ellipsometry, as well as quartz crystal microbalance detection techniques, and employs organic thin films as active layers in organic solar cell research.

Burak Kadem B.Sc., M.Sc. in Physics. Is a PhD student at Sheffield Hallam University, Materials and Engineering Research Institute-Thin Film research center. He is carried out a research within organic solar cells. He is a Lecturer in Physics department, College of Science, Babylon University, Iraq. Interested fields: Organic Solar Cells, Composites materials, thin films, Sol-Gel. He is a Member of Iraqi Physics and Mathematics society and a Member of Iraqi computer society. He is a Member of editorial board in Advances in Physics Theories and Applications "Scientific Journal hosted by The International Institute for Science, Technology and Education, USA".

Structural and dynamical characterization of P3HT-PCBM blends

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State-of-the-art organic photovoltaic devices (OPV) are based on the bulk heterojunction concept (BHJ), in which the interpenetrated network between electron-donor and electron-acceptor materials provides the large interface area necessary for exciton splitting and charge generation [1]. The current paradigm for BHJ OPVs is represented by blends of poly (3-hexylthiophene) [P3HT] as electron donor and phenyl-C_{61}-butyric acid methyl ester (PCBM) as electron acceptor. As the morphology of the active layer is highly sensitive to processing parameters, many efforts have been made to gain an insight on the relationship between the structure of such a complex system and the performance of devices. However, relatively little effort has been devoted to the investigation of the dynamics inside the blend, with only two papers published on dynamics of the pure polymer [2, 3], to the best of our knowledge.

We report a study of the structure and dynamics of P3HT-PCBM solid blends cast from three solvents of varying evaporation rates, chloroform (CF), chlorobenzene (CB) and dichlorobenzene (DCB).[4] By means of X-rays and neutron diffraction, we found that whereas the blend cast from CB shows already a significant crystallinity in its "pristine" state, blends prepared from CB and DCB develop their order only upon annealing at 160 °C. In addition, quasi-elastic neutron scattering investigations (QENS) suggest that blending likely frustrates the polymer dynamics (figure 1). We believe that such change in dynamics might be related mainly to the polymer confinement within PCBM domains. However, no appreciable difference in the dynamics is observed as a function of the solvent choice.

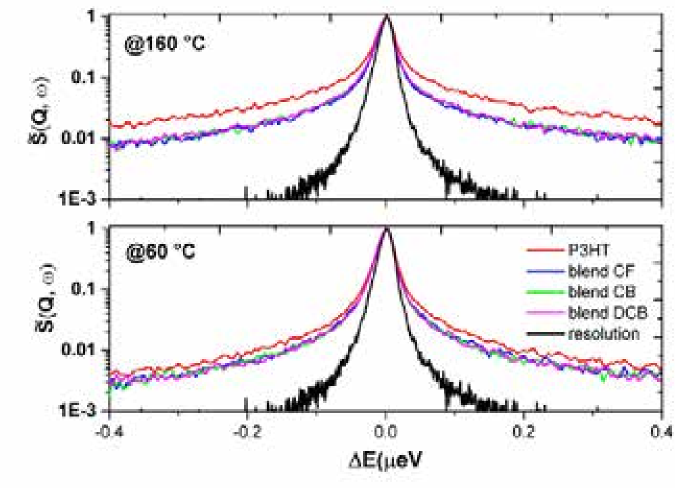

Figure 1: Measured structure factor as a function of energy transfer for pure polymer and all the blends at Q = 1.01 Å^{-1} . The black curve represents the instrumental resolution.

Validation and/or generalization of these results with regards to slower motions relating to the segmental modes of the polymer and the glass transition temperature requires further neutron spectroscopic studies on spectrometers that afford nanosecond time-scales.

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4. Paternó, G.; Cacialli, F.; García-Sakai, V. *Chemical Physics* **2013,** 427, (0), 142-146.

Biography- Giuseppe Maria Paternò

I have a background in Chemistry, having obtained a Bachelor's degree in Chemistry and a Master's degree in Chemistry of Materials. Besides, I conducted a 1-year master project focusing on physical-chemistry of macromolecules and, in particular, on the processes of crystallization that occur in conjugated polymers in confined geometry.

Currently, I am a PhD student at Physics & Astronomy department of University College London (supervisor Prof. Cacialli), and at ISIS-Neutrons & Muons source (supervisor Dr. Garcia Sakai).

I'm being involved in a rich research program which focuses on three key areas:

- Fabrication and characterization of organic electronic devices, such as solar cells, light-emitting diodes and field-effect transistors;
- Nanoscale structural and dynamical characterization of organic semiconductors using a range of Neutron and X-rays scattering techniques;
- Effect of neutron radiation exposure on device performances, to test their stability in a harsh radiation environment (i.e. for space or avionic applications).

Tuning Fullerene Intercalation in Poly (thiophene) derivative by Controlling the Polymer Degree of Self-Organization

G. M Paternò[1], M.W. A. Skoda[2], Robert Dalgliesh[2], F. Cacialli[1] and V. García Sakai[2]

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Here we report on the preparation and characterization of pseudo-bilayer organic solar cells comprising poly(2,5-bis(3-hexadecylthiophen-2-yl)thieno[3,2-b]thiophene)(PBTTT) as the electron-donor and [6,6]-phenyl-C_{61}-butyric acid methyl ester (PCBM) as the electron-acceptor. PBTTT-PCBM blends are in-fact useful systems for gaining a detailed understanding of optimal blend ratios and morphology. [1, 2]

In particular, we show that the degree of PCBM intercalation between PBTTT side-chains depends on the degree of self organization of the polymer, which in turn is controlled by the film formation rate. The temperature-dependent solubility of PBTTT, insoluble at room temperature but highly soluble above 70 °C in ortho-dichlorobenzene (ODCB), allowed us to deposit the polymer layer from hot solution and an overlaid fullerene layer from the same solvent but at room temperature. We cast the polymer via three different deposition techniques with different solvent evaporation rates: spin-coating, slow-drying and drop-casting, producing films with different morphologies.

By employing morphological and structural characterization techniques such as atomic force microscopy, x-ray diffraction (figure 1) and investigating the vertical segregation of the two components by means of neutron reflectivity, we observe that the morphology of the polymer layer affects the degree of PCBM intercalation, leading to large differences in terms of device efficiencies (from 1.13% to 0.02%).

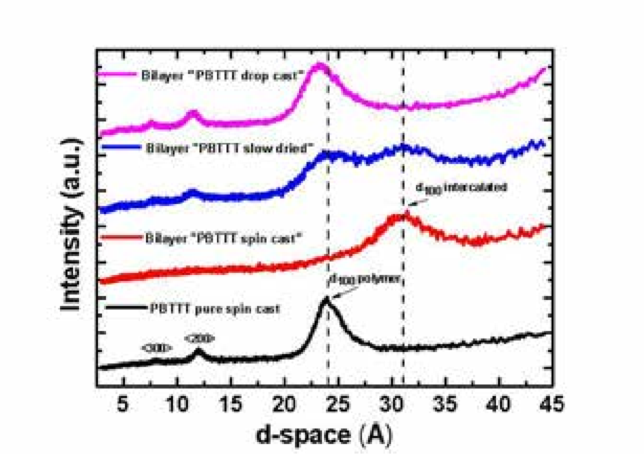

Figure 1: XRD pattern of PBTTT pure and PBTTT/PCBM films obtained by sequentially depositing the PBTTT layer via spin-coating, slow-drying or drop-casting, and the PCBM on top of the polymer films.

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Neutron Radiation Tolerance of Poly (thiophene) Derivatives

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Flexible and lightweight carbon-based electronic devices such as organic solar cells (OPVs), organic field effect transistors (OFETs) and organic light-emitting diodes (OLEDs) are likely to have significant industrial and social impact in the near future, owing to the promise of low manufacturing costs, high production throughput and large area applications. For all these reasons organic electronics devices may represent a valid alternative to their inorganic counterparts, especially for aviation and space applications where payload control is crucial. However, before such promising ideas become a reality, it is important to test the devices reliability in a radiation-harsh environment.[1-3]

Here we report, for the first time, a study on the neutron radiation tolerance of two poly(thiophenes) derivatives, namely poly(3-hexylthiophene-2,5-diyl), P3HT, and Poly(2,5-bis(3-tetradecylthiophen-2-yl)thieno[3,2-b]thiophene), PBTTT. By combining spectroscopic investigations (UV-Visible absorption, photoluminescence and Raman scattering) with field-effect transistor measurements (figure 1), we show that the two polymers behave differently upon neutron irradiation, with PBTTT exhibiting significantly higher radiation tolerance than P3HT. We explain this in term of superior structural and conformational stability of PBTTT, and use this understanding to propose potential strategies for designing neutron radiation-tolerant materials.

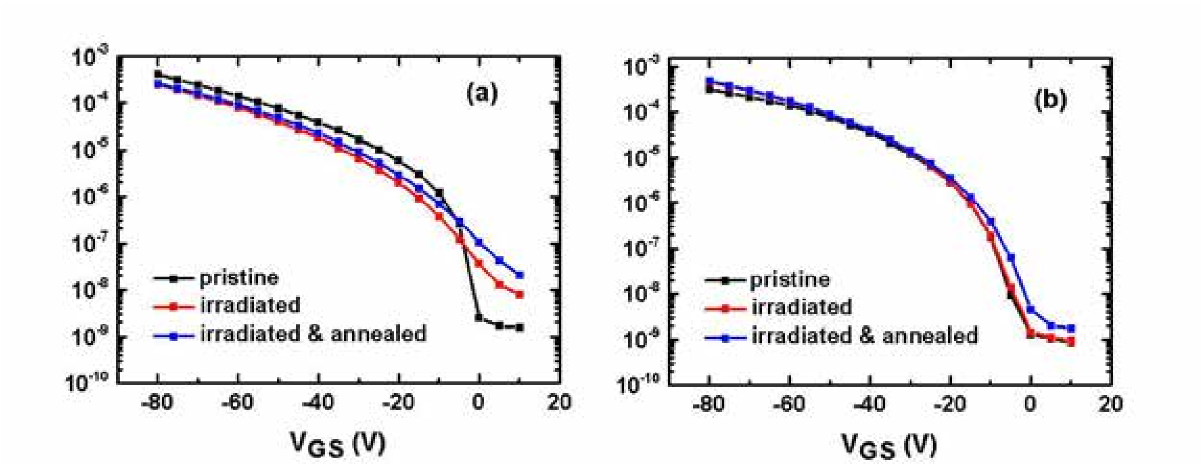

Figure 1: OFET transfer characteristics P3HT (a) and PBTTT (b) taken at -80 V.

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P15

The use of controlled stress parallel superposition rheology for the measurement of commercial materials

James Claypole[a], Alex Holder[a], Davide Deganello[a], Rhodri Williams[b]

a. WCPC & Swansea University b. Swansea University

Rheology plays an important role in every printing process, from high volume roll to roll coating through to low volume high precision processes such as inkjet. Each of these different processes subjects the inks to different levels of shear and extensional stress. Most conventional rheological tests look only at the viscoelastic properties of the inks when they are rest. In order to better understand and control the printing processes it is necessary to fully characterise how the viscoelastic properties of the inks change when they are exposed to press like conditions. In order to do this a method called controlled stress parallel superposition was used. This allowed for the study of the viscoelastic properties of a material when it is subjected to a constant shear stress. The controlled stress parallel superposition was applied to a number of commercially available materials including a screen printable silicone dielectric gel and PeDOT PSS. The results for the PeDOT PSS and other shear thinning fluids showed that they reach a Newtonian limit at a given shear stress. This is where the fluids phase angle tends to 90^{o} and begins to act as a Newtonian fluid. For gelling materials the phase angle at the gel point decreased and the gelation time increased with increasing the constant stress levels. This could then be attributed to an increase in the gel strength parameter with increasing constant stress.

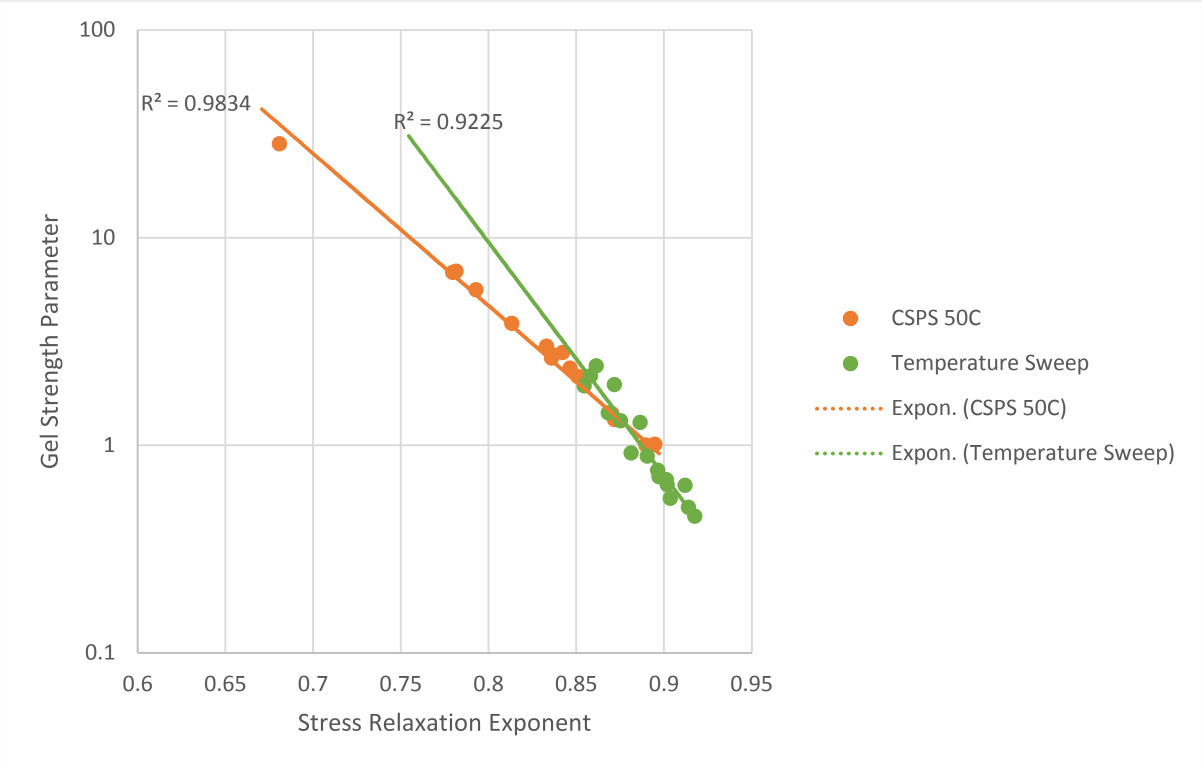

Figure 1 Gel strength parameter as a function of the stress relaxation component for the screen printable dielectric gel. Including data for both the CSPS measurements and temperature sweep data.

Biography: James Claypole has a degree in civil engineering from Cardiff University. He is currently finalising his PhD thesis for submission in December 2014 after studying for 3 years at the WCPC in Swansea University. The thesis concentrates on the advanced rheology of printable materials and its effect that it can have on printing phenomenon. He is now working on pad printing of electroluminescent and conductive materials and continued work on rheology.

Molecular Electronics: A rapid bottom-up approach to investigate novel organo-metallic electronic building blocks on a single-molecule scale.

Mario Lemmer, Michael S. Inkpen, Tim Albrecht*

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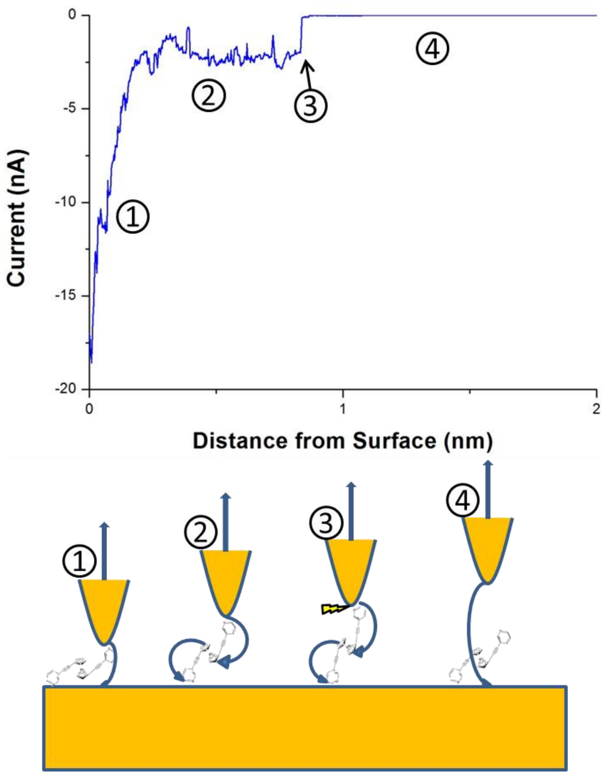
Department of Chemistry, Imperial College London, London, SW7 2AZ

With progress in printing technologies comes the increasing significance of large scale electronics. Synthetic chemistry provides a seemingly infinite number of possible candidates for molecules with different applications in large scale electronics. In order to effectively tailor molecules to a specific application, it is necessary to have an understanding of the electronic properties on the molecular level.

The scanning tunneling microscope (STM) provides a tool for screening the electronic properties of possible candidates for large area electronics and relating those to building blocks of molecules. We present an automated approach to rapidly investigate the conductance of single molecules using the I(s)-method[1]. In particular we are interested in investigating the charge transport on the molecular scale with a focus on quantum mechanical effects like quantum interference in branched redox-active molecules[2,3].

In the STM I(s)-method we span a molecule between the STM tip and a substrate. Under an applied bias we measure the current response while breaking the molecular junction (see figure). By repeating this process thousands of times to account for noise and variability in the junction it is possible to extract the conductance in ambient conditions. Together with a high grade of automation (ca. 10000 traces in 8 h) this provides a tool to rapidly screen molecules with properties interesting to the applications in large area electronics.



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Biography Mario Lemmer

2013 - current

PhD at Imperial College London (Physical Chemistry)

In 2013 I joined Imperial College to pursue a PhD in the field of "Molecular Spintronics". Central part of my research is the operation of a scanning tunneling microscope to conduct spectroscopy on single molecules. The desired outcome is a deeper understanding of charge transport processes on the nano-scale.

2007 – 2012

Material Science at Friedrich-Alexander-University in Erlangen

I received my Diploma (equivalent to Masters Degree) in December 2012 with grade 1.6 (equals A). During my Masters, I specialized in Materials for Electronics and Energy Technology. Here I learned the fundamentals of solar cells, transistors, LEDs and batteries.

2011 – 2012

CSIRO Melbourne

During my time at the Commonwealth Scientific and Industrial Research Organization, I was employed at the Flexible Electronic Flagship in the field of organic photovoltaics, transistors and LEDs. I completed my Master's Thesis on "Spray Coating of Metal Oxide Interface Layers in Organic Solar Cells".

2009 – 2010

University of Oslo (UiO)

I took part in the Erasmus scholarship program. During that time, I learned Norwegian and attended lectures in English, on functional- and nano-materials. In other lectures, I learned about composite materials and solid-state physics. I believe this time abroad strengthened my intercultural understanding and it was also a great opportunity to improve my fluency in English.

2005-2007

Physics at Friedrich-Alexander-University (FAU) in Erlangen

I did part of my pre-Diploma in chemistry and mathematics. I also gained some insight into theoretical physics. The lab work taught me how to coordinate work in a group. During independent project lab work, I gained practical experience and learned to design and carry out self-assigned experiments.

Electrical Readout Of Thermally-Induced Dielectric Bistability In Solution Processed Thin Films Of Spin Crossover Polymers

G. Bovo[1,2], I. Braeunlich[3], W. R. Caseri[3], N. Stingelin[2, 4], T. D. Anthopoulos[1, 2], D. D. C. Bradley[1, 2], K. G. Sandeman[1] and P. N. Stavrinou[1, 2]

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[2]*Centre for Plastic Electronics, Imperial College London, United Kingdom*
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Spin crossover (SCO) materials represent a remarkable example of spin state switching at the molecular level, where a transition between low spin (LS) and high spin (HS) configurations can be reversibly triggered by suitable external stimuli. The stimulus, often a temperature variation, may also result in a hysteresis of various physical properties and thereby a bistability that can be used to create a memory device [1].

In the present work we have studied the thermal SCO behaviour of a class iron(II)-triazole polymers where the chemical properties can be tailored to achieve solubility in common solvents. Two different compounds have been studied, with short and long sidechains. Characterisation of magnetic properties, performed on powders, gels and pellets served to highlight the impact of the molecular environment on the SCO.

Solution processing of the materials has further enabled the preparation and study of stable thick and thin films, better suited to device application, with optical characterisation confirming the retention of SCO thermochromic properties. As a first step to deploy these materials inside simple electronic devices, MIM structures (metal-insulator-metal) have been fabricated and tested by impedance spectroscopy. Our results show the presence of a thermal hysteresis loop in the dielectric function around room temperature, with values measured on cooling and on heating differing by up to 50%. We clearly demonstrate that in addition to the previous studies on bulk powders [2], electrical bistability can also be achieved for thin films devices [3], thus opening interesting new perspectives for the application of SCO polymers.

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Biography

Gialnluca Bovo is a PhD candidate in the Experimental Solid State Physics group and Centre for Plastic Electronics at Imperial College London, working under the supervision of Dr Paul N. Stavrinou and Prof Donal D.C. Bradley.

Gianluca earned his BSc and MSc summa cum laude in Materials Science from University of Padua (Italy) in 2009 and 2011 respectively, were he worked for one year on the integration of plasmonics with high electron mobility transistor structures for bio-sensing applications.

His current research project is in the field of molecular materials and involves the processing, characterisation and device application of spin crossover polymers in photonics and electronics, for which he received the Graduate Student Award at the 2014 E-MRS Spring Meeting.

Inexpensive Triboelectric Materials for Large-Area Energy Harvesting and Sensing Applications

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Electronics and Computer Science, University of Southampton, United Kingdom
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ABSTRACT

Triboelectrification is an effect that has been known for centuries. However, it was not until recently that an energy harvesting technology based on the triboelectric effect has been developed [1-3]. This technology is based on the different tendencies of materials to gain or lose electrons. When two materials with different polarities come into contact, the friction between their surfaces creates a charge transfer and results in a potential difference at the interface. If the outer surfaces of these two materials are connected in a circuit, induced charges are created on these outer surfaces and will be driven to flow in order to balance the potential difference at the interface. Therefore, electric currents are generated by compressing and separating these triboelectric materials. These currents can be used for energy harvesting and sensing applications. There are three factors that determine the size of the output electric pulses: firstly, the triboelectric polarities of the two materials composing the triboelectric system, because the charges are easier to be transferred between materials with large difference in polarities. Secondly, the roughness of the contacting surfaces between two triboelectric materials, because rough surfaces increase the friction and generate more charge. Finally, the separation distance of two materials after coming into contact, because large separation distance results in high potential difference. In this work we used a simple method to fabricate triboelectric system using inexpensive polymer materials: polydimethylsioxane (PDMS) and polyethylene terephthalate (PET). In order to increase the friction between the contacted surfaces, cone shaped patterns are fabricated on the PDMS surface by moulding the PDMS solution in a 3D printed polyvinyl chloride (PVC) mould, and reactive-ion etching (RIE) is used to increase the roughness of the PET by creating nanowire structure on its surface. This system can produce output electric pulses with peak voltage of 1.7V at 1MΩ of resistive load, by applying only 5N of compressive force. These triboelectric materials are inexpensive and their fabrication methods are relatively simple to scale up, thus has good potential to be used in large-area energy harvesting and sensing applications.

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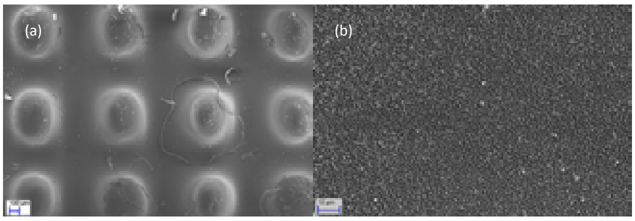

Fig. 1: SEM images of (a) patterned PDMS surface and (b) RIE treated PET surface.

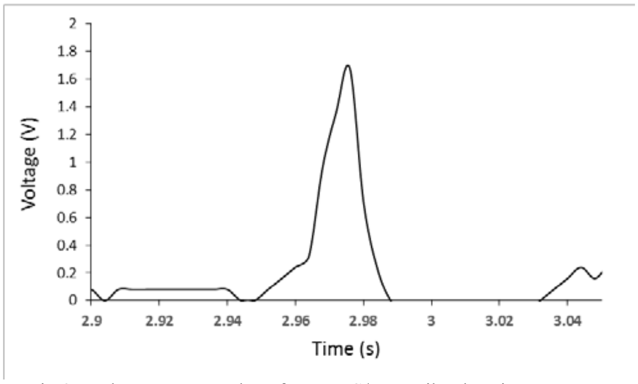

Fig.2: Voltage output pulse of a PDMS/PET triboelectric system at 1MΩ of resistive load and under 5N of compressive force.

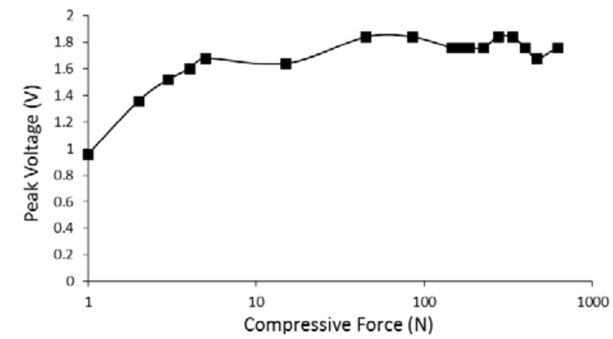

Fig. 3: Peak output voltage at 1MΩ of resistive load and as a function of compressive forces.

Biography Zhenhua Luo

I am a research fellow at Electronics and Computer Science, University of Southampton, UK. I graduated from University of New South Wales in Australia, with PhD research on PZT and lead-free piezoelectric ceramic. After PhD I worked as a R&D manager in a start-up company to develop energy harvesting products, and then came to UK to join the energy harvesting team of Prof. Steve Beeby in Southampton. My current research focuses on developing organic piezoelectric materials to harvest energy from human motion, for the applications of powering on-body sensors and wearable devices.

Fabrication of thin film capacitors based on hybrid organic/ inorganic nanocomposites with inkjet printed Ag electrodes on plastic substrates

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[c] *School of Chemistry, The University of Manchester, Manchester, M13 9PL, UK*

A high-capacitance dielectric material that is solution-processable at low-temperatures (T<150 °C) is highly desirable for fabricating various plastic electronics devices such as capacitors in high energy-storage applications and gate dielectrics for low-voltage organic field-effect transistors (OFETs). Nanocomposites made by incorporation of inorganic high-κ nanoparticles into a polymer matrix have emerged as suitable candidates for this purpose. These hybrid materials combine the advantages from polymers (i.e., low-T solution-processability, flexibility and low cost), with superior dielectric properties of inorganic nanoparticles. We have developed various hybrid nanocomposite dielectrics using barium strontium titanate (BST) and barium zirconate (BZ) nanoparticles as the filler, and poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) and cyanoethyl pullulan (CEP) high-κ polymers as the matrix.

Here, we report on the fabrication of all-solution-processed capacitors on a polyethylene naphthalate (PEN) substrate. Silver electrodes (width 500 μm) were patterned on the substrate using a Dimatix DMP-2831 inkjet printer. The hybrid nanocomposites were deposited by spin coating, and the thin films were coated by a cross-linked polymeric capping layer in order to modify the surface properties. Metal-insulator-metal (MIM) crossovers were completed by inkjet printing of the top Ag electrode. The performance of the prepared MIMs was assessed by comparing their capacitance, dissipation factor and breakdown strength. The results indicate that these hybrid nanocomposites have the potential to be used as the gate dielectric in flexible OFETs operating at low voltages.

Biography

Dr. Ehsan Danesh is currently a Research Associate at the Organic Materials Innovation Centre in Manchester. He received his MSc degree in Polymer Engineering from the Tehran Polytechnic in 2008. He then spent two years as an R&D researcher in the field of specialty polymers for food and dairy packaging industries. In 2011, he was awarded with the Marie Curie Actions fellowship, and joined Prof. Krishna Persaud's research group at the School of Chemical Engineering & Analytical Science in the University of Manchester, to work on the FlexSmell project. Funded under FP7, the FlexSmell project aimed at the design and realisation of printed chemical sensing RFID tags for smart food packaging. His PhD thesis focused on the development of novel conducting polymer-based gas sensors on plastic substrates.

On-Going Improvements in Properties of Conductive Inks

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In order to support the drive to flexible, large area printed electronics Henkel has developed a series of new, highly conductive and high speed printable silver inks.

Main differentiator of the new inks compared to available inks is their very high electrical conductivity combined with high levels of flexibility. Unlike commercially available high conducting nano-inks these new materials show adhesion levels identical to that of other PTF (polymer thick film) Ag inks. Conductivity levels of 2.5 mOhm/sq @ 25mil (1,6X conductivity of metallic silver) can be achieved using standard ink processing conditions at 120-150°C. On the one hand, these inks open up new possibilities for printed electronic applications and on the other hand they offer the possibility to significantly reduce the total cost of ownership in existing print applications by reducing track width and/or height.

Besides the high conductive inks, a high speed printable conductive UV-ink was developed. Apart from very easy handling on the flexo press, this material offers good conductivity and high coverage, which make it very suitable for Large Area Electronics.

***Biography* - Tony Winster**

Tony Winster studied metallurgy and materials science. During his career, Tony has worked on the design, development and manufacture of high-reliability modules. More recently, he has worked as part of Henkel's global technical service team, providing support for new and existing die attach materials, inks and encapsulants

Solution-processable inorganic/organic conductors of high transparency and high refractive index

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Achieving high performance in organic optoelectronic devices increasingly relies on electrical and optical matters of both the active materials and the attendant charge injection/extraction layers. Even with the best-performing active materials, unwelcome limitations in device performance frequently arise when attempting to achieve maximal light management within the device. Light management can typically involve either the in-coupling of incident radiation, in the case of photovoltaic cells and photo-detectors[1, 2], or out-coupling in the case of light-emitting diodes. The challenge in reaching highest device performance is to optimize simultaneously both the electronic attributes along with the overall refractive index profile, frequently hampered by additional constraints. One such example in solution-processed devices lies with the thickness of the ubiquitous conductive poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) layer – often kept at a minimum due to optical losses. Such constraints place limits when effective management of the light distribution within the structure is desired – recalling it is the optical length, i.e. the product of the refractive index and physical thickness that is useful here. In this regard developing materials with the ability to tune optical properties (e.g. the refractive index) whilst maintaining sufficient conductivity, would prove useful for contemporary device design. We present here a versatile, solution-processable inorganic/organic hybrid material, composed of PEDOT:PSS and titanium oxide hydrates[3, 4]. We show that both the optical and electronic properties can be manipulated and tuned through a change of composition. A number of characterization techniques are used to demonstrate material systems exhibiting higher refractive indices and lower absorption loss than PEDOT:PSS while still maintaining a good conductivity. The new hybrid materials can be readily deposited from solution to provide high-quality coatings with negligible roughness scattering. We discuss the underlying chemistry of this novel class of materials, the thin-film fabrication and processing supported by a number of optical and electrical characterization techniques. We will also demonstrate their operation as interlayers in multilayer optoelectronic devices such as organic solar cells and light-emitting diodes.

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3. M. Russo, M. Campoy-Quiles, P. Lacharmoise, T. A. M. Ferenczi, M. Garriga, W. R. Caseri and N. Stingelin, J. of Pol. Sci. Part B: Pol. Phys. 50 (1), 65-74 (2012).
4. M. Russo, S. E. J. Rigby, W. Caseri and N. Stingelin, Adv. Mater. 24 (22), 3015-3019 (2012).

Biography - Luca Occhi

Doctor of Philosophy (PhD) ***candidate*** (Imperial College London) - Plastic Electronic Materials
Supervisors: Professor Donal D. C. Bradley, Dr Paul N. Stavrinou, Professor Natalie Stingelin http://www3.imperial.ac.uk/plasticelectronics/pecdt/pecdtstudents/cohort4/lucaocchi

2013-2016 (planned) - Doctor of Philosophy

Imperial College London

2012-2013 - Master of Research - Plastic Electronics Materials

Imperial College London

Merit

2009 2012 Master of Science – Material Science and Engineering

Università degli Studi di Genova

110/110 cum laude

2006 2009 Bachelor of Science – Material Science

Università degli Studi di Genova

110/110

Publications

"Photochromic and photomechanical responses of an amorphous diarylethene-based polymer: a spectroscopic ellipsometry investigation of ultrathin films", C. Toccafondi, Luca Occhi, O. Cavalleri, A. Penco, Rossella Castagna, A. Bianco, C. Bertarelli, D. Comoretto and M. Canepa, *J. Mater. Chem. C* **2**, 4692-4698 (2014)

"Organic/inorganic hybrid films doped with PEDOT:PSS for novel optoelectronics and photonic applications", L. Occhi, N. Stingelin, P. N. Stavrinou, D. D. C. Bradley - *ECME 2013* (3-7 September 2013), London (United Kingdom) - Poster

"1D polymer photonic crystals doped with photochromic materials: optical characterization", L. Occhi, C. Toccafondi, R. Castagna, C. Bertarelli, M. Canepa, D. Comoretto - *EOSAM 2012* (25- 28 September 2012), Aberdeen (Scotland) - Poster

"Plastic photonic crystals: fluorescence enhancement in conjugated systems", G. Canazza, F. Gagliardi, P. Lova, L. Occhi, S. Ottonello, V. Robbiano, S. Congiu, M. Alloisio, D. Comoretto – *FUTURMAT 2* (16-20 September 2012), Brindisi (Italy) - Poster

"Ellipsometric investigation of photochromic transition in ultrathin films of diarylethene polymers", C. Toccafondi, L. Occhi, R. Castagna, C. Bertarelli, D. Comoretto, M. Canepa - *7th Workshop Ellipsometry* (5-7 March 2012), Leipzig (Germany) - Poster

Work function engineering of printable electrodes based on AgNWs and SWCNTs for flexible electronics

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2 – Institute for Nanoelectronics, Technische Universität München, 80333 Munich, Germany

Abstract

We have investigated the modification of the work function (ϕ) of spray-coated thin films of silver nanowires (AgNWs), single-wall carbon nanotubes (SWCNTs) and mixed silver nanowires – single-wall carbon nanotubes induced by the physisorption of PEI (polyethylenimine), as a surface modifier that is expected to shift the work function by introduction of a surface dipole. We find that the work function of our bare thin films is lowered after the deposition of PEI by approximately 0.5 up to 1 eV with respect to the value measured on the pristine films, thereby yielding electrodes with minimum work functions of ~ 3.75 eV. This value makes the films suitable as cathodes in light-emitting diodes (OLEDs) or electron-collecting electrodes in organic photovoltaics (OPVs). More generally, such results are of relevance to the implementation of flexible and stretchable electronics, as work function tunability is crucial for electrodes engineering, and both AgNWs and SWCNTs are among the best candidates for flexible electrodes in printable electronics.

Experimental and Results

The thin films had been prepared by spray-coating of the silver nanowires and CNTs dispersions onto glass substrates. The samples under investigations included one AgNWs, two AgNWs-SWCNTs thin films with increasing thickness (5 and 7 "spray-depositions" respectively), and a SWCNTs sample as a reference.
For the work function characterisation we have used a macroscopic Kelvin probe (KP) in air (at room temperature) calibrated against a freshly-cleaved highly-oriented pyrolytic graphite, HOPG, surface. We estimate the uncertainty on these measurements to be ±0.05 eV.
The samples were treated first by spin-coating and then by drop-casting of a PEI methanolic solution, with additional thermal treatments in between and after spin-coating and drop-casting.

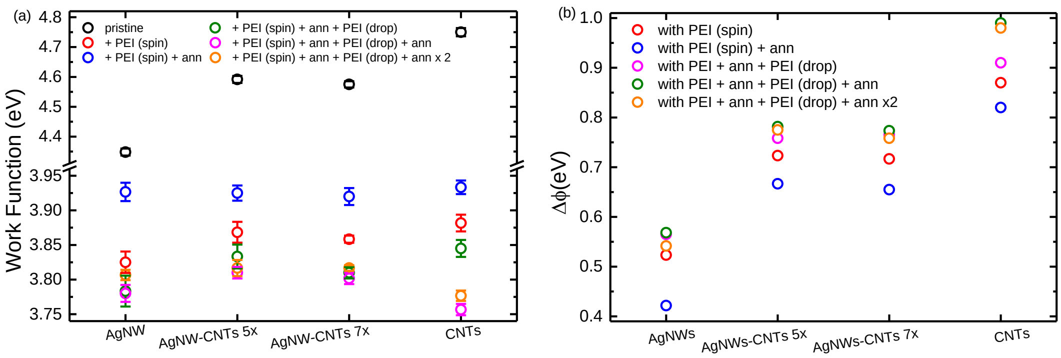


Figure 1: (a) work function of the pristine transparent electrodes (black) and after subsequent deposition of PEI. (b) work function variation induced by the physisorption of PEI. For SWCNTs films the variation was up to 1 eV respect the pristine film

In conclusion, we observed a modification of the work function of AgNWs, SWCNTs and mixed AgNWs-SWCNTs thin films following spin-coating or drop-casting of PEI. The work function of the AgNWs films is reduced from 4.34 eV to 3.78 eV; the work functions of the mixed films are reduced from 4.57-4.59 eV to 3.78-3.81 eV and the work function of the carbon nanotubes is reduced from 4.75 eV to 3.75 eV. These results confirm that these films should be suitable as flexible cathodes/electron collecting electrodes for flexible OLEDs/OPVs.

Biography

I am a second year PhD student, funded by Marie Curie Initial Training Network CONTEST (COllaborative Network for Training in Electronic Skin Technology) at UCL at Prof. Franco Cacialli's Organic Semiconductors group, UCL London. I obtained a Master's degree in Materials Science and Engineering at the University of Genova, thesis title "Plasmonic structures in photonic crystals: preparation and characterization". My work is focused on the preparation and characterization of photonic systems suitable for flexible optoelectronic devices (e.g. OLEDs OPVs). This work will include different preparation methods of photonic structures and optoelectronic devices as well as different optical-morphological characterization techniques such as polarized transmittance and reflectance angle resolved spectroscopy, steady-state and time-resolved photoluminescence spectroscopy, Kelvin probe and AFM.

Characterisation of multi-walled carbon nanotubes (MWNTs) thin films spray-coated over rigid and flexible substrates

L. Santarelli[1], V. Robbiano[1], A. Abdellah[2], E. Cagatay[2], P. Lugli[2] & F. Cacialli[1]

1 – University College London, Department of Physics and Astronomy and London Centre for Nanotechnology, Gower street, WC1E 6BT London, UK

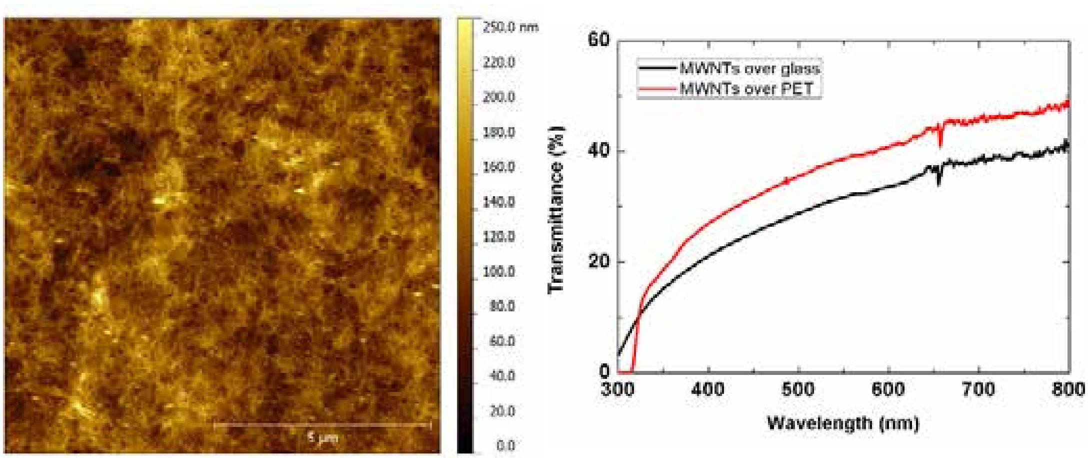
2 – Institute for Nanoelectronics, Technische Universität München, 80333 Munich, Germany

Abstract

We report the optical, electrical and morphological properties of multi-walled carbon nanotubes (MWNTs) thin films coated over rigid and flexible substrates, namely glass and polyethylene terephthalate (PET), obtained via a spray-coating technique. We investigated the suitability of such coating technique to obtain flexible devices. Interestingly, we find that such films feature almost the same characteristics regardless of the substrates onto which they have been coated. The sheet resistance of the films is found to be between 1.45 KΩ/sq and 1.6 KΩ/sq. Both MWNTs over glass and PET feature a work function of 4.54 eV. The light transmittance at 550 nm for films over glass is 30.5%, whereas this is 35.14% for those on PET. Atomic Force Microscopy (AFM) reveals that the percentage of substrate surfaces covered by MWNTs films is higher than 97% in all cases. Due to the high values of their sheet resistance and their low light transmittance, these films are not ideal to act as electrodes in organic optical devices. Nevertheless, there are plenty of other applications in which MWNTs thin films can be employed, such as gas-sensing devices, by exploitation of the dependence of their electrical conductivity on the exposure to gases such as CO_2 or O_2, or in field-emitter arrays to be embedded in flexible field-emission displays (FEDs). We conclude that spray-coating of MWTNs is a promising technique for the development of MWNTs-based flexible devices, since spray-coated films over flexible substrates show similar or even better properties of those spray-coated over rigid substrates.

Methods

MWNTs have been dispersed in an aqueous solution along with a surfactant, sodium carboxymethyl cellulose (CMC), and subsequently spray-coated by means of an air atomising nozzle. The electrical characteristics have been investigated via a Kelvin probe in air (for the work function) and a 4-probes multimeter setup (sheet resistance). The topology of the film has been analysed by means of an AFM in tapping mode. The MWNTs light transmittance has been measured via UV-VIS spectrofotometer. The thin films were prepared at TUM, and characterised at UCL.



On the right, an AFM image of a MWNTs thin film spray-coated over PET. On the left, light transmittance curves of MWNTs over glass and PET.

Biography: Luca Santorelli

Luca Santarelli is a second year PhD student. The research he is carrying on is part of the project "Initial Training Network CONTEST (COllaborative Network for Training in Electronic Skin Technology)" and he is funded by a Marie Curie Early Stage researcher (ESr) scholarship.

Born in Lanciano (Italy) the 10th June of 1984, Luca has received a BSc degree in Biomedical Engineering in 2007 at the University of Pisa with the dissertation "Design and implementation of a development platform for serial communication devices built for technical aids for disabled people". He has obtained his MSc in Electronics Engineering in June 2013 at the University of Pisa with the dissertation "Construction of a scanning thermal atomic microscope (SThM) for nanopatterning of advanced functional materials".

From September 2012 until May 2013 he did an internship at University College London (UCL) funded by the European Erasmus Placement project.
Since September 2013 he is member of Prof. Franco Cacialli's group at the department of Physics and Astronomy of UCL, in London, UK.

Luca's research is mainly focused in:

- Development and characterization of organic devices, such as p-LED, solar cells and sensors, made onto flexible and stretchable supports;
- Investigation into properties of electrodes made by carbon nanotubes and silver nanowires;
- Thermal and optical lithography of polymer semiconductors through a Scanning Thermal Microscopy (SThM).

Novel low-cost conductive layers for printed electronics:

Harry Cronin
DZP Technologies Ltd, Future Business Centre, Kings Hedges Rd, Cambridge CB4 2HY, UK and EPSRC Centre for Doctoral Training in Micro- and NanoMaterials and Technologies, University of Surrey Guildford, GU 2 7XH

All printed electronic devices require some form of electrical interconnection to the outside world. This is commonly achieved by the use of metal nanoparticle-based inks, which achieve the desired conductivity when sintered. However, such inks are relatively costly due to the expensive fabrication of the nanoparticles, and often use undesirable solvents. We report the novel extension of intense visible light photo-curing to water-based inks containing cheaper, 1-3 µm sized flake silver. We find that the conductivity of such inks after treatment matches that of nanoparticle inks at a significant cost advantage. Scanning Electron Microscopy (SEM) analysis was used to investigate the mechanism of increased conduction, and revealed an increase in the mean particle size after the photo-curing, implying particle coalescence and neck formation are improving the percolation in the samples. Photo-curing is a high throughput technique suited to roll-to-roll applications, which can be applied on a range of substrates without substrate damage.

Biography Harry Cronin

Harry Cronin is an EngD research engineer working jointly at DZP Technologies in Cambridge and the University of Surrey. Harry received his MSci in Physics from Imperial College London and started his doctoral research in 2013. His research is focused on materials and process development for printed electronics, with a focus on printed solar cells.

Laser Ink Transfer for Printable Electronic Devices (LITPED) – A novel manufacturing method for mass customisation of large area electronics

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2) Department of Materials Science and Metallurgy, University of Cambridge, 27 Charles Babbage Road, Cambridge CB3 0FS, United Kingdom

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Laser Ink Transfer for Printable Electronic Devices (LITPED) is a new technology which can be used for the production of high-resolution silver or carbon conductive patterns for the printed and plastic electronics industry. The LITPED process utilises the jetting and transferral of functional material, in the form of an ink-paste, directly onto a substrate, which can be rigid or flexible, by the use of concentrated laser irradiation. This is an additive fabrication method that can be used to produce either one-off items, small series, or high volume electronics and spare parts. The novelty of LITPED is in the unique nature of the laser-material interactions that enable the transfer and printing of a diverse range of functional materials.

Importantly, LITPED enables the mass customisation of electronics manufacture in a production plant or at the point of use from a library of digital files with extremely low lead times. The LITPED printer can be added to an existing industrial printing or coating line, for example to add new customised features to flexography or screen printed large area electronics; or used as a stand-alone printer to produce prototypes. LITPED does not require tooling or masks, or significant capital expenditure, thus contributing to dramatic cost reduction in the production and maintenance of portable, light-weight electronics and opto-electronics.

This poster will present the LITPED concept together with an investigation of the mechanism of the laser transfer process and characterisation of the silver conductive material. A range of characterisation techniques, including optical and scanning electron microscopy (SEM), profilometry and chemical analysis, have been utilised to develop an understanding of the underlying scientific principles, and optimise the laser transfer parameters.

Biography – Dr Zlatka Stoeva, DZP Technologies Ltd

Dr Zlatka Stoeva is a co-founder and managing director of DZP Technologies Ltd. The company was formed in 2008 and is based in Cambridge, UK. DZP is renowned for being a highly innovative and dynamic company which bridges scientific blue-sky research with industrial innovation. The company has a broad portfolio of technologies including large-area conductive printing, laser assisted deposition for high resolution metal patterning, graphene printing, and novel hybrid materials for thin-film photo-voltaics. DZP Technologies offer a range of business relationships ranging from supply of research consumables to contract product development, patent licensing and joint technology development.

Dr Stoeva has a strong background in advanced materials and new process development. After completing a PhD degree on polymer electrolytes for energy storage at the University of St Andrews in 2001, she spent several years as a post-doctoral research fellow working on lithium battery materials and published a number of peer-reviewed articles in high-profile academic journals. Dr Stoeva is an experienced technology transfer professional, having spent 4 years working at Cambridge Enterprise Ltd, the technology transfer arm of the University of Cambridge. She also holds an MBA degree from the University of Nottingham.

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Design of an advanced laser platform for high speed and high resolution manufacturing of organic electronics components

E. Biver[1 *], F. Zacharatos[2], St. Leyder[3], R. Geremia[1], D. Puerto[3], A.P. Alloncle[3], Ph Delaporte[3], D. Karnakis[1] and I. Zergioti[2]

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In this work we present an advanced laser digital processing platform which combines laser micro/nano-patterning with high speed laser printing and sintering of metallic nanoparticle inks in order to manufacture high spatial resolution organic sensors.

For high speed printing we used LIFT (laser-induced forward transfer), a versatile, non-contact and high-resolution laser printing technique. Fast DPSS picosecond and nanosecond pulsed lasers were used to study the laser printing of metallic nanoparticles inks (Cu and Ag). The dynamics of the LIFT process was investigated by time resolved imaging in a µs time scale. Adding a titanium dynamic release layer below the donor printing material resulted in smoother and lower velocity (20-50 m/s) jetting behavior for a wide laser process window. We printed long and continuous lines at both low and high repetition rates (up to 1 MHz) with velocities up to 10 m/s.

We performed selective sintering of spin coated Ag nanoparticles ink on PEN substrates (Tg =120 °C) and showed that it is highly reproducible at 532 nm over a wide laser fluence window. Measured resistivities were close to bulk Ag ($6*10^{-6}$ Ω.cm). Laser sintering was combined with laser ablation to constitute a fully autonomous micro-patterning technique of homogeneous metallic features, with a minimum feature size of 50 µm. We investigated spatial beam shaping in order to define the optimum configuration for the laser platform. Sintering was successful for both Gaussian and reshaped tophat laser intensity profiles, with superior morphological characteristics produced by the latter.

After sintering these lines have been used as electrodes for humidity sensors on flexible substrate. We incorporated carbon nanotubes into a nonconductive polymer matrix to form a conductive polymer composite whose resistance depends on humidity. After depositing this composite on the electrodes (Fig. 1a), we obtained a fully functional sensor with consistent and reproducible changes in resistance (5 – 80 %) and a quick response time (Fig. 1b).

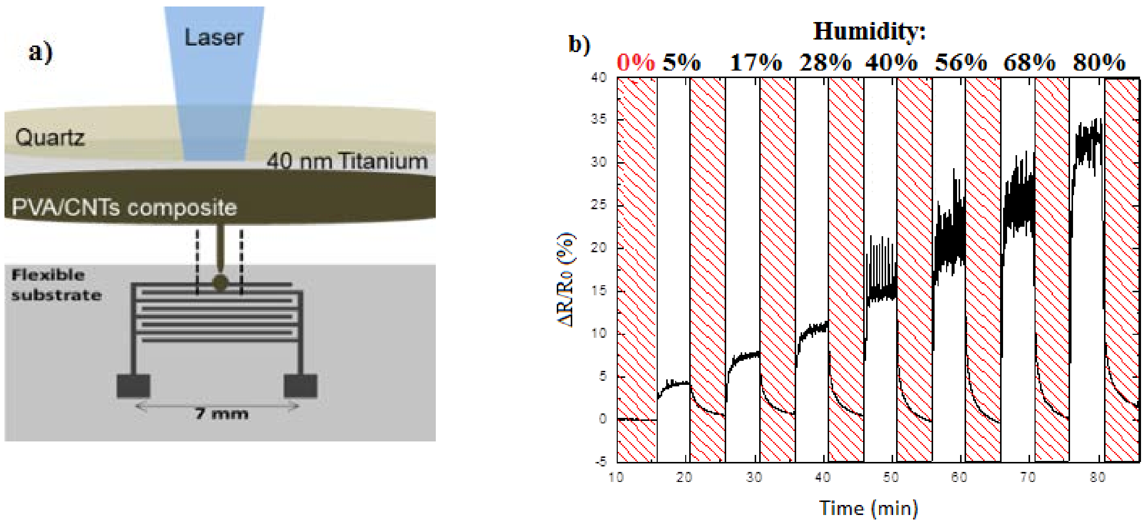

Figure 1. a) Scheme of the laser printing of the polymer composite on the electrodes for the fabrication of a humidity sensor, b) Sensor response for different levels of humidity.

Biography: Emeric Biver

Emeric Biver obtained an international engineering Master's Degree in Micro and Nanotechnologies for Integrated Systems from the Institutes of Technology of Grenoble (France), Turin (Italy) and Lausanne (Switzerland). Early 2010 he was recruited as an engineer in the Lasers, Plasmas and Photonic Processes (LP3) laboratory, a joint research unit of CNRS/Aix-Marseille University, France. There he worked on laser thin film etching and patterning in collaboration with Nexcis, a French company producing photovoltaic panels. He subsequently started a Ph.D. in the same laboratory, under the supervision of Dr. Philippe Delaporte, on the subject "Laser processes for the development of 3D-System In Package microelectronics". He studied both the etching of cavities in polymers modified to enhance laser ablation and the Laser-Induced Forward Transfer (LIFT) of metallic nanoparticles inks. He demonstrated and characterized the high speed deposition of conductive lines by LIFT. He obtained his Ph.D. in July 2014 and his works led to five publications in international journals. He was recruited as a Marie-Curie post-doctoral researcher at Oxford Lasers on October 2014 in the frame of the European LaserMicroFab project . His work includes beam shaping and its influence on laser thin film patterning as well as the design of a laser platform for the integration of laser patterning and printing processes.

The influence of laser pulse duration and spatial intensity distribution on the patterning of thin film layers for flexible electronic devices

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[2]*Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece*

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Lightweight, flexible substrates coated with multiple thin film layers <0.2µm thick are highly desired for modern electronic devices to allow a reduction in size, weight, power consumption and material cost. For example, organic photovoltaic (OPV) devices are attracting increasing commercial interest due to their flexibility and partial transparency, which allows them to be used on the exterior windows of cars & buildings. Direct write laser processes are particularly attractive as alternative patterning techniques to photolithographic/printing methods, and P1, P2, P3 laser scribes are shown in Figure 1. However, for complex devices with multiple thin layers, the quality requirements for laser scribing are extremely high to prevent damage/short circuits of individual thin film layers compromising the device performance and also to provide a suitable topography for subsequent layers to be deposited upon. Hence, the choice of the laser characteristics is critical for a number of emerging thin film materials used in flexible electronic devices such as indium tin oxide (ITO), pedot:PSS, silver nanoparticle inks, amongst others. This report outlines the influence of laser pulse duration and spatial beam shaping techniques for high quality diode-pumped solid state (DPSS) thin film laser patterning and discusses their implications for laser system design.

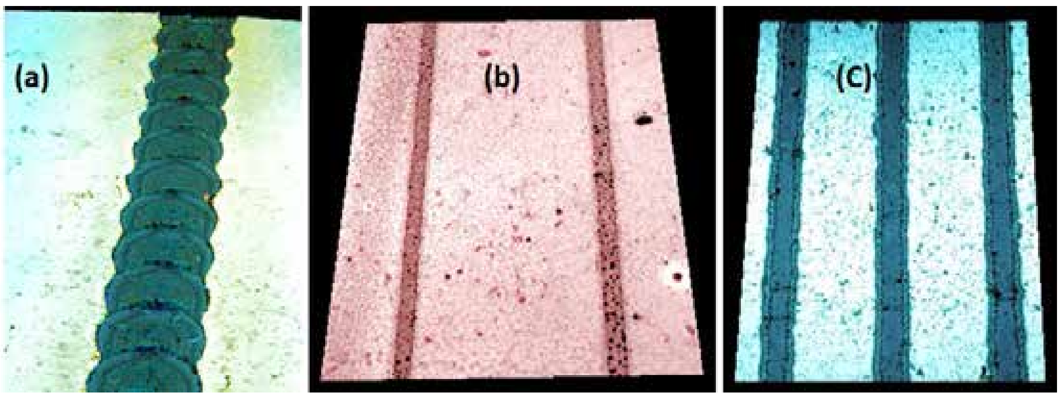


Figure 1 Laser scribes for (a) P1, (b) P2 and (c) P3 patterning steps for OPV devices.

Large-Scale (1.4m wide) Roll-to-Roll Research Platform

Martin O'Hara
EPSRC Centre for Innovative Manufacurting in Ultra- Precision, Cranfiedl University

Abstract:

The Centre for Innovative Manufacturing in Ultra Precision have developed a large scale (1.4m web width) roll-to-roll research platform for use in investigating the requirements of machinery, processes and technologies to operate at this scale of production. The platform will be available to access for research activities from industrial partners and ad-hoc projects once fully commissioned. Processing stages already designed include embossing/ imprint, coating, UV-curing, metrology and in the future metallisation and lamination will be available on a second processing stage.

Martin O'Hara - Biography

Martin is the National Strategy Manager for the EPSRC Centre in Ultra Precision. He has a proven background in the electronics and technology industry of over 25 years in design innovation and management roles working for businesses such as Ferranti, Motorola, Danfoss and several SME's. He has a Bachelor degree in Applied Physics, a Masters degree in Physical Measurement and Instrumentation and a Masters in Business Administration. He is the author of the book "EMC at the Component and PCB Level" and founded the Automotive EMC Network.

Upscaling the manufacture of a printed resistive heating system for the build environment

Bruce Philip[1], Eifion Jewell[1] & Peter Greenwood[1], Chris Weirman [2]& Stewart Reid [2]

Abstract

Resistive heating through the floor provides a practical means by which energy can be supplied for temperature control. it has many advantages over wet systems in that can be more readily controlled, it can be localised, it has lower ongoing maintenance costs, improved occupant wellness, it can be installed in shorter time and provides install flexibility. In the commercial and retail build environment, the dominant flooring design is based around raised access floor (RAF) tiles where individual floor tiles (600 mm x 600 mm) are arranged in a grid resting on pedestals which maintain the tile a fixed distance from a base floor. Incorporation of modular heating elements within the RAF tile offers commercial promise as it marries the flexibility of electrical heating with a high volume (3 million tiles in UK alone) standardised product. The large area, volume and thin form factor of the product provides an ideal opportunity for printed conductive / resistive heating elements. The paper describes the strategy employed in bringing the concept of an electrically printed RAF tile to near commercial fruition by understanding market needs, economic limits, regulatory needs, material technology, printing and scale production issues.

Screen printing was deployed as the manufacturing process of choice as the process is mature, materials are commercially available, it has a low capital cost and is able to deposit a thick film capable of carrying the currents necessary for effective heat generation. Initial carbon material formulations were found to be functionally adequate but suffered in terms of number of passes required and material usage. Batches of 30 tiles, capable of $200Wm^2$ output, were printed and these were sufficiently robust to pass through all subsequent high pressure and temperature tile manufacturing, storage and installation processes. These were subsequently deployed in a controlled environment test room and have been operational for over 12 months without any detrimental issues. Subsequent, material reformulation identified alternative resin and solvent systems which reduced the film thickness required, processing times and volumes by 60% and 70% respectively. The process was shown to be robust to changes in squeegee pressure, angle and hardness providing repeatable with predictable controlled responses altering the conductive sheet resistance within 5% operational window. Thus a repeatable manufacturing process with fine tuning capability has been established although some optimization of the drying process remains. A pilot production run of 300 tiles has demonstrated at economic manufacturing rates of around 100 tiles / hour and the viability of the product and its installation in an office building has been completed. This installation has provided both practical large scale installation best practice and is now providing continuous real world data.

Although the product is comparatively simple in concept, the transition from lab demonstrator to large scale pilot manufacturing and installation has provided scientific, engineering, business and market challenges which are pertinent to any large area electronic technology making the difficult transition from “lab to fab”.

1 – SPECIFIC, Swansea University

2 – SPECIFIC, TATA steel COLORS

Advances in large area printed pressure sensors.

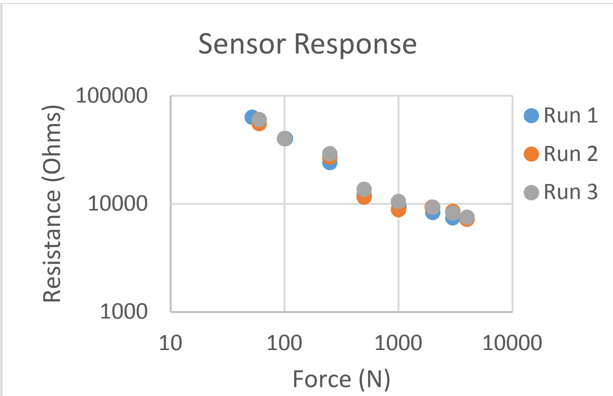
Tim Mortensen, Y.Mouhamed, A.Holder. D.Deganello
Welsh Centre for Printing and Coating, College of Engineering, Swansea University, Singleton Park, Swansea, SA2 8PP

Abstract:

Recent advances in printed pressure sensors at the WCPC have allowed the production of increasingly robust, capable and affordable sensor arrays. We discuss the capabilities of this new generation of sensors and outline a number of potential applications with a focus on low cost standalone applications as typified by the Internet of Things (IoT).

The use of functionalised inks allows for the formation of a piezo-resistive pressure sensor with a very large range of sensitivity. Additionally, the ink is exceedingly robust and sensors are able to withstand forces of 5000 N/cm^2 without displaying any signs of damage.

A 1cm^2 prototype was subjected to calibrated forces using a Houndsfield compressive tester. The sensor showed a reproducible change in resistance in the range of 0 to 3000 N. The equipment was unable to satisfactorily apply forces in the range 0-50 N, and these forces require testing through the application of fixed static loads.



The use of thin substrates has allowed the creation of thin sensors which are flexible and remain sensitive to pressure whilst flexed. Measurement of the sensors can be performed using low cost electronics, and a series of prototypes have been designed to enable easier use of sensor arrays on a large scale. Hardware to interface with a 16x16 sensor array has been produced, and the feasibility to scale this design to support 65.5k sensors has been investigated.

Dr Tim Mortensen, WCPC Swansea.

Tim studied his MPhys degree in Swansea and went on to complete a PhD with the Positron group in 2013. In his thesis he investigated techniques to manipulate the magnetron orbits of non-neutral positron plasmas. This research required building bespoke hardware and software control systems for a positron accumulator, which made him well suited to develop novel new design of positron accumulator for an experiment into the effects of gravity on antimatter. After a year in Paris working on the GBar experiment Tim returned to Swansea in 2014. Since his return he has put his software and electronics experience to use designing and building printed pressure sensors with the WCPC.

Super Inkjet Printer Technology and Properties

Atefeh Y-Amin
Cavendish Laboratory, University of Cambridge, UK

For commercial-scale processing of printable electronics there is an expanding demand of applying inkjet technology for precise patterning applications. Inkjet printers using piezoelectric or thermal method fire droplets with volumes of several pL, corresponding to droplet diameters around 10μm. While this droplet size is ufficient for tonal control of photographic image quality, it is yet insufficient for the precision required when aiming for printable electronics applications. In other words, smaller dot sizes are favorable.

This poster introduces the capabilities and the technology of our newly aquired Super Inkjet System (SIJ) in the Centre for Innovation Manufacturing in Large Area Electronics (CIMLAE) at Cambridge. The SIJ allows ultra-precision printing on the sub-micrometer scale by producing femto-litre droplets, that are 3 orders of magnitude smaller than conventional droplets. Using the SIJ allows us to print finger structures with sub-micrometer dimensions, in a very fast and maskless process.

Biography: Atefeh Y-Amin

Dr Atefeh Amin is a Research Associate in the Optoelectronics Group at the Cavendish Laboratory, University of Cambridge, with a research focus on flexible low voltage complementary circuits. Atefeh's other research interests include Self Assembled Monolayers, interface engineering of organic semiconductors and process optimisation. She is working under the supervision of Professor Sirringhaus on the EPSRC Centre's iPess project.

Atefeh completed her PhD under the supervision of Professor Marcus Halik in the Organic Materials and Devices Group at the University of Erlangen-Nuremberg working on the interface modification in organic low-voltage Field Effect Transistors(FETs) based on ultra-thin hybrid dielectrics and Self Assembled Monolayer FETs.

Super-Fine Inkjet In Practice

A. V. S. Parry[1], R. Saunders[1], J. Wheeler[1], V. S.-Romaguera[2] and S. G. Yeates[1]

[1]*School of Chemistry, University of Manchester, Manchester, UK*
[2] *Manchester Business School, University of Manchester, Manchester, UK*

We present Super-Fine Inkjet (SIJ) printing, a drop-on-demand (DoD) electrohydrodynamic printing technique for patterning on the sub 20 μm scale. This printing process is perfect for fast, fine feature patterning of complex designs without the need for a master template. This presentation will demonstrate several applications where the SIJ printer can compete with other micron scale patterning methods such as microcontact printing and its usefulness as a new paradigm in printed electronics.

Microcontact printing has long been used to pattern monolayers on surfaces on the micron scale. Applications include micromachining, surface chemistry, microelectronics and cell biology.[1,2,3] Although there are many advantages to this printing method, including ease of processing and high resolution (sub-micron), each new pattern requires a master stamp that must first be made using specialised and time consuming techniques, such as photolithography.

Further, conventional DoD printing techniques produce picolitre (10^{-12} L) drops which allow for resolutions down to 20 μm. These printing techniques benefit from being non-contact allowing the design and implementation of patterns to be simple and quick and deposited on to a large range of surfaces.[4,5]

The SIJ promises to bring the benefits of both of these techniques together. Using electrohydrodynamics and very fine capillary nozzles (0.1 – 10 μm) the SIJ printer is able to produce droplets with femtolitre (10^{-15} L) volume. These fine droplets dry rapidly improving the resolution and increasing the choice of solvents, viscosities and surfaces that can be used with this method.[6]

Here we look at some applications for the SIJ printer, what practical resolutions are achievable and how it compares to more conventional printing methods.

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[6] N.Shirakawa *et al*, *Jpn. J. Appl. Phys.* **2013,** 52, 05DB19

Adam Valentine Sheridan Parry

Dr. Adam Parry is currently a postdoctoral researcher at the Organic Materials Innovation Centre (OMIC) at the University of Manchester working on inkjet printing for RFID sensors and applications for Super-Fine Inkjet printing. He acquired his Masters in Physics from the University of Manchester in 2005 and went on to complete a PhD titled "Small Molecule Organic Field Effect Transistors: Vacuum Evaporation and Solution Processable Monolayer Devices" under the supervision of Prof. Michael Turner. Adam then had a short 6 month postdoctoral position in the school of Electronics and Electronic Engineering working on functionalised hydrogels for soil nutrient sensing before starting his current position with Prof. Stephen Yeates in OMIC.

His research interests include; organic electronics, sensing, printed electronics and state of the art printing technologies.

Adhesion lithography – Applications of a Large Scale Nanopatterning Technique

James Semple, Gwenhivir Wyatt-Moon and Thomas D. Anthopoulos

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Department of Physics and Centre for Plastic Electronics
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London, SW7 2BW

The future of large-area printable electronics is reliant on the ability to process device electrodes using a similarly low cost, high throughput technique. Many methods have shown promise in this regard over the past years, including screen printing, roll to roll nanoimprint lithography, soft lithography and inkjet printing. However, while these techniques are versatile in terms of large area applications, they suffer in the ultimate device resolution attainable.

Here we present our recent work on a scaleable large-area nanopatterning technique, adhesion lithography (a-lith). The technique, which relies on the ability to tune the surface energy of an electrode using self assembled monolayers (SAMs), and subsequent removal of overlapping electrodes using scotch tape, is capable of producing a gap between electrodes on the order of 10 nm. A further advantage of this technique is that it may be used to fabricate nanogaps between asymmetric electrodes, a feat which is difficult to realise using conventional techniques.

As a demonstration of the versatility of this technique, we have fabricated fast organic photodetectors via spin casting the organic donor-acceptor blend of poly(3-hexylthiophene) (P3HT) : [6,6]-phenyl-C61-butyric acid methyl ester (PCBM) directly onto prefabricated coplanar Ti-Au nanogap electrodes. Using the same technique we are also able to fabricate low-voltage self-aligned gate (SAG) transistors based on a coplanar device architecture. Low power operation is achieved through the use of a SAM gate dielectric while indium oxide, processed at low temperatures from an aqueous precursor solution, has been used as the channel semiconductor. Resulting devices exhibit electron mobilities of over 1 cm^2/Vs, a minimal parasitic overlap capacitance and high-speed operation. The combination of this simple yet highly effective and reproducible fabrication process with solution processable, low-power electronics shows promise for a host of applications in the field of printed large-area electronics.

Biography

James Semple is a research assistant and PhD student in the Department of Physics and the Centre for Plastic Electronics at Imperial College London. He received his B.A. Mod. in Physics from Trinity College, Dublin at the top of his class in 2012. Since then he has pursued his PhD studies at Imperial College with research focusing on the nanopatterning of electrodes and solution processable high speed electronics.

Large Area, Low Cost Fabrication of Novel, Lateral, Solution Processed LEDs

Gwenhivir Wyatt-Moon, James Semple and Thomas D. Anthopoulos

Email: g.moon13@imperial.ac.uk

Department of Physics and Centre for Plastic Electronics
Imperial College London, Blackett Laboratory,
London, SW7 2BW

As the resolution of devices in the electronics industry has hit the nanoscale, device fabrication costs have rapidly increased. Whilst commercial technologies such as photolithography are able to produce nanoscale feature size, they are costly and unsuitable for large area printable electronic. Currently in the display and lighting industries there a strong focus on developing high throughput low cost optoelectronic devices.

Adhesion Lithography (a-lith) is a simple, highly scalable fabrication technique that uses unique properties of self-assembled monolayers (SAMs) to create planar nanogap electrodes. Using this novel electrode fabrications technique in conjunction with solution processable semiconductors, highly scalable, low-cost, lateral architecture LEDs are demonstrated. A-lith was used to create asymmetric electrodes separated by sub 10nm gaps on various substrates. Poly[(9,9-di-n-octylfluorenyl-2,7-diyl)-alt-(benzo[2,1,3]thiadiazol-4,8-diyl)] (F8BT): Tetrahydrofuran (THF) was subsequently spin casted on the electrodes to create coplanar organic light emitting diodes (OLEDs) with turn on voltages between 5-7V. Further work utilising nanocrystal materials to create LEDs has also been investigated. The combination of a-lith with electroluminescent materials, demonstrates the capability of simple highly reproducible technique to create nano-junction LEDs and shows great promise for large scale printable high density LEDs for ultra-high resolution display technology.

Biography

Gwenhivir Wyatt-Moon is studying a PhD in Physics as part of the Advance Material Devices group at Imperial College London. She received a BEng in Electrical and Electronic Engineering from Swansea University. Subsequently she worked as for a medical start-up company developing novel gas sensors and rheometry equipment. She then went on to complete an MRes in Plastic Electronics at Imperial College London.

Simultaneous Multiple Device Testing for High-Volume, Large-Area Production of Flexible Electronic Devices

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Printed and flexible devices, such as TFTs, LEDs, solar cells, and antenna systems, have the advantage of being low-cost and are suitable for large-scale production. Significant research activity has been ongoing to improve the device performance, large-area manufacturing, and subsequent integration into electronic circuits (1, 2, 3). The likelihood of defects being present increases with both the area of a device and the speed of manufacture, and consecutively the inline testing and repair of such devices produced by a high speed printing process are absolute essential to maintain a high quality of product (4). Nonetheless, there is relatively little research activity to develop the science and technology of inline testing of such devices in a fast and continuous manufacturing process. Conventionally this has been achieved in non-printed electronics by employing probe cards and multiple communication channels where each device is tested individually. However, the speed of such testing methodology is relatively slow when considered on a 'time per unit area' basis and it is not cost effective for testing low-cost printed devices. Therefore, there is imperative need to develop the next generation of contact and non-contact testing methodologies compatible with high volume of production of printed and flexible devices.

In this report we begin by overviewing a library of contact and non-contact mode testing techniques commonly used for various types of devices. Thereafter, we will present a novel sub-system circuit level testing approach, where the sub-system could be a printed logic circuit, a printed antenna, an energy harvester, or a simple output. The sub-system is produced by a series of process steps on single substrate and tested before different sub-systems would be integrated together to form a system. This approach of 'Simultaneous Multiple Device Testing' (SMuDT) of the sub-system could be fast and cost effective to pass/fail the set of devices in the sub-system.

The SMuDT approach was demonstrated in two type of devices, one each for a contact and non-contact mode of testing. In the first demonstration, we investigated contact mode electrical testing of TFT devices where the sub-system was designed by connecting several TFTs to form an invertor. Odd numbers of invertors were temporarily connected to form a Ring Oscillator (RO) circuit with the aim of simultaneously testing all of the TFTs in the oscillator. The approach was first validated by SPICE circuit simulation and then demonstrated by experimentally fabricating the RO via temporary using metallic tracks which were later removed in the production process. The functional parameters of the test RO, such as frequency, voltage amplitude and voltage rise/fall time were measured in a single test and the pass/fail criteria established. In second demonstration, we investigated non-contact mode testing of an RFID tag antenna produced by high speed printing. Here the sub-system consisted of a printed antenna with an adjustable matching circuit for antenna tuning. The resonant frequency of the test antenna was determined by non-contact inductive coupling using calibration antenna and scanning through the frequency. The resonant frequency value was first used to establish the pass/fail criteria of the sub-system. Thereafter the antenna can be tuned to match the ideal frequency of 13.56 MHz by connecting suitable capacitance from a bank of printed capacitors.

The SMuDT methodology is economically viable. We estimated that the proposed SMuDT methodology is up to ten times faster than the conventional method of testing individual invertors and has the potential to test up to 1,500,000 invertors per hour at a cost less than 0.03 cent USD/invertor.

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Acknowledgments: C. Ramsdale, J. Wiltshire, and R. Price from PragmatIC Printing Ltd.

Biography: Abhishek Kumar

Abhishek is a Postdoctoral Research Associate at Electronic and Device Materials Group (EDM) at Electrical Engineering Department, University of Cambridge. He completed his PhD under the supervision of Prof Neil Greenham at Optoelectronics Group in Cavendish Laboratory, working on the interface modification in organic PVs and polymer LEDs. Before PhD, he gained 2 years of work experience as process and equipment engineer in semiconductor industry at Micron Technology Inc (TECH), Singapore, and completed his masters from National University of Singapore (NUS) researching on electrospinning technique to make nanofibres for dye solar cells. He was awarded NRF Clean Energy scholarship from Singapore EDB to pursue PhD degree, and NUS-Research scholarship to pursue Master degree.

Abhishek is currently working with Dr Andrew Flewitt on the development of novel test concept for large-area electronic devices. His research interests include solution processed solar cells, light emitting diodes, amorphous oxide TFTs, inkjet printing, and electrospun nanofibres.

Lifelong Learning Project

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Abstract

The main objective of the Erasmus LLP Project 'Organic Electronics & Applications' – OREA is to design and construct the curriculum of a two year MSc joint degree in the modern field of organic semiconductors. The project main output is going to run as a joint European MSc degree and it will refer to graduate students of Physics, Chemistry, Material and Electrical & Electronic Engineering Departments.

The OREA consortium consists of several higher educational institutions as well as companies. This synergy is expected to lead to a curriculum that will provide the program graduates with the qualifications to satisfy the market demands in the modern field of organic electronics.

Given the great potential of this young discipline a number of innovative applications are expected, including flexible, wearable, and large area electronics. Research and development in this field requires personnel that are not only trained in the fundamental theories of organic electronics and devices, but also in how to use this knowledge to solve engineering problems. This MSc course will provide these foundations by offering one year of theoretical training and a whole year of practical research training in a University or an Industrial Laboratory.

The OREA consortium includes the following members: TEI of Crete (coordinator), Imperial College London (UK), University of Oxford (UK), Politechnico di Milan (IT), University of St-Andrews (UK), Cyprus University of Technology (CY), Johannes Keppler University of Linz (AT), University of Groningen (HOL), Friedrich-Alexander Universitat Erlangen - Nürnberg (GER), Institute of Electronic Structure and Laser – IESL (GR), Technion Israel Institute of Technology (ISR), NanoForce Ltd (UK), Ceradrop (FR), Beneq (FIN), Aixtron (GER).

Biography Satyajit Das

Satyajit Das completed his undergraduate degree (Bachelor of Engineering Hons in Electronic Systems Engineering) and Master of Science in Nanoelectronics from the University of Manchester, UK (2008-2011 B.Eng and 2011-2012 MSc). He then joined Imperial College London for Master of Research (MRes) in Plastic Electronic Materials from 2013-2014. Currently, he is pursuing his PhD at the same institution in the department of Physics working on low-dimensional solution processable metal oxide semiconductors for optoelectronic devices.

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