Journal of the

Institute of Circuit Technology

2013 Events

2nd /5th April *Tuesday - Friday* — **ICT Annual Foundation Course** at Loughborough University bill.wilkie@InstCT.org

5th June *Wednesday* — **ICT Annual Symposium** at the Heritage Motor Museum, Gaydon, Warwickshire bill.wilkie@InstCT.org

25th September *Wednesday* — I*e*MRC 2013 Conference at Holywell Park, Loughborough iemrc@lboro.ac.uk

26th September *Thursday* — **ICT Evening Seminar** at Newton House Hotel, Hayling Island bill.wilkie@InstCT.org

24th October *Thursday* — 9.30 Conformal Coating Reliability Seminar NPL & SMART Group event at NPL, Teddington Tony Gordon info@smartgroup.org

5th November *Tuesday* — **ICT Evening Seminar** at Darlington St George Hotel, Durham Tees Valley Airport, DL2 1RH 01325 332631 bill.wilkie@InstCT.org

2014 Events

February or March — *Proposed* **ICT Evening Seminar & AGM** bill.wilkie@instCT.org

14th -17th April *Tuesday - Friday* — **ICT Annual Foundation Course** at Loughborough University bill.wilkie@InstCT.org

7th - 9th May — **ECWC13 (13th Electronic Circuits World Convention)** at Nuremberg eipc@eipc.org

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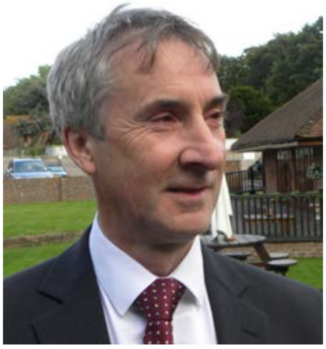
Vol.6 No.4 October 2013



Editorial

For this month's editorial, I was given the brief to make it as uplifting and positive about the pcb industry as possible. Make it about our bright innovative future I was told! Don't dwell on the past! This has been fortunate timing, because, at last, after some really difficult years, manufacturing and pcb production in the UK appears to be on the upward trend.

The general economic forecast for the UK is encouraging and this has been reflected in the performance of pcb manufacturers this year. It is pleasing to report that investment is up and companies are actively recruiting. Not saying that things are back to the glory days (can any of us still remember those times!) but it is looking really positive for the future.

The Eurozone remains weak, however, and still has some way to go to achieve some meaningful growth. Exports to this area remain a challenge.

And what of the future?

Where is the technology taking us ?

a) The drive still seems to make pcb's smaller, faster and less expensive and our investments and techniques will support this trend.

b) Hole sizes are becoming smaller and we have seen an increase in blind and buried via technology.

c) Time to market is increasingly more important and this is seen in some quite aggressive lead times and also explains the increased activity seen in "on-shoring". The tide may well be turning !

d) Some exciting developments in chemical processes and these have been highlighted in previous issues of the *Journal*. The challenge remains - getting chemistry into smaller and deeper holes !

e) Increased performance is leading to improved FR4 materials for faster processing speeds. The increasing requirement for wireless and RF application is continuing to push these high end materials. the forecast is that we will also see an increase in halogen free and polyimide material in Europe.

f) Ink jet printing is going to play an increasing role in the manufacturing process. It currently occupies a significant role in the application of ident directly from the electronic data. The technique can be seen developing into the direct application of conductive ink in the manufacture of inner layers giving significant improvements in raw material costs and processing times. Some small scale production being done on undemanding layers but the technology is pushing towards finer tracking

g) Further advantages in the technique can be seen in the application of soldermask especially with the demands for finer and finer dams between features.

h) Final finishes will continue to evolve and increase the latitude of multiple lead free soldering operations

In summary, the PCB INDUSTRY appears to be heading into a very positive phase with some exciting technology changes and real investment in equipment and people. The good times may be coming back with a bang !

Tom Parker
Council Member

Membership

New member notified by the Membership Secretary

10297 Alastair Bennett M.Inst.C.T.

Members regraded

10189 Jason Barnett M.Inst.C.T.

10207 Stacey Driver M.Inst.C.T.

Corrections and Clarifications

It is the policy of the Journal to correct errors in next issue
Please send corrections to : - brucer@john-lewis.com

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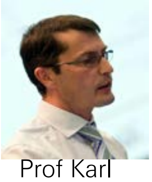
Brief Review

Encoding First Meeting of Novel Solder Flux Project

10th June 2013

Solder Flux Workers



Prof Karl Ryder

Dr Andrew Ballantyne

Chris Zaleski.

DrRobert Harris

The first progress meeting for a new project investigating the use of a type of ionic liquids called "deep eutectic solvents" (DES) as a novel solder flux. The work, funded by the IeMRC, is being carried out at the University of Leicester by Professor Karl Ryder, Dr Andrew Ballantyne, Dr Robert Harris and Chris Zaleski.

The Meeting, hosted by Dr Patrick Webb of the Manufacturing Technology Centre (MTC), Coventry, was held on Mon 10th June 2013 and detailed the first results towards the project aims of replacing the harmful, expensive rosin based systems for a cheap, environmentally friendly DES based flux.

Dr Webb provided an introduction to the MTC detailing the impressive facilities that have been developed for microelectronics processing in addition to other heavy manufacturing processes. Dr Ballantyne showed some exciting solder spread testing results which reveal good solder spread across both copper and electroless nickel immersion gold (ENIG) substrates. He then sectioned these samples for examination under a scanning electron microscope (SEM) revealing intermetallic formation on the Cu substrate and limited intermetallic formation on the ENIG samples.

He also detailed work that has been ongoing with other project partners such as solder wetting balance testing with Nick Hoo, ITRI and the preparation of standard test PCB boards by Dennis Price at Merlin PCB. With the results presented and the opportunities that were discussed during the meeting the project has gotten off to a flying start.

Andrew Ballantyne
June 2013

Left-right: Prof Karl Ryder,Dr Alex Goddard, Chris Zaleski, Nick Hoo, Dr Patrick Webb, Pete Starkey, Dr Andrew Ballantyne, Dennis Price, Prof Martin Goosey.

Review of papers presented at the
Institute of Circuit Technology
Hayling Island Seminar on 26th September 2013

by Pete Starkey

Young People Don't Lick Stamps

The Institute of Circuit Technology Hayling Island Seminar has become established as a must-attend event in the calendars of the UK PCB community. This year it broke with tradition. Spirit Circuits' Steve Driver and ICT's Bill Wilkie, put together a programme designed to offer an alternative to conventional "grey suit brigade" contributions and focus on the importance of bringing new minds into the industry, of introducing new ideas and of recognising that a younger generation might have different thoughts on how to do business.

What was the significance of Steve Driver's "Young People Don't Lick Stamps" headline? He explained that they don't need to – young people don't write letters any more, their communication electronic; it depends on technology. Young people use text, Twitter, Facebook, Instagram, Pinterest, Flickr, YouTube and blogs to communicate. He acknowledged that it could be a challenge to understand the language, but suggested that older people could search the internet for information on how to speak properly! Quoting Ofcom, he stated that text-based communications were surpassing traditional phone calls as the most frequent ways of keeping in touch. The changes were being led by teenagers and young adults, increasingly socialising with friends and family online and through text messages despite claiming that they preferred to talk face to face. Hours were spent accessing social networking sites and e-mail, or using a mobile to access the internet, whilst for the first time ever fewer phone calls were being made on both fixed and mobile phones.

In spite of all this technology, there was high youth unemployment. Why? Driver listed some possibilities: Maybe youngsters did not want to work. Maybe the extended retirement age has held up job creation. Maybe the recession, maybe the effect of China, maybe mismatch of communication between generations. Maybe it was a combination of everything, but it was very obvious to him that we all needed these young people in our businesses.

Referencing a presentation he made four years previously, Driver said the PCB industry was created in fifties by the Pioneers, in the sixties and seventies we had the Engineers, in the eighties and nineties came the Mavericks, in the noughties we had the Thinkers. Now it was the turn of the Geeks. Geek is cool! he was pleased to welcome four enthusiastic young speakers – all very proud Geeks, confident that they could deliver some exciting insights on how business would be done in the future.

Alastair Bennett

First presenter was Alastair Bennett, a Design Engineer at Rainbow Technology Systems with a Master's degree from Strathclyde University, who gave a technical overview of liquid photoresist technology with specific reference to the characteristics of 100% solids UV-curable liquid etch resist in comparison with dry film and conventional liquid photoimageable resists. Rainbow's solvent-free wet resist was coated at a thickness of only 5 microns, compared with 25-35 microns for dry film and 8-15 microns for liquid photoimageable, and exposed with the phototool in direct contact.

The very short optical path of typically 8 microns compared with 69 microns for dry film gave substantial benefits in resolution capability with non-collimated light and the very high photo-speed enabled almost instantaneous curing using a low-energy LED UV source. Environmental benefits included low wastage and the absence of solvents and associated oven-drying. The process was very economical to operate and occupied minimal floor space.

Michael Bode

Michael Bode came from Polar Instruments' North American office in Beaverton, Oregon, to deliver a perspective of the PCB industry in the USA from the viewpoint of young professionals. Michael's degree was not directly related to his work at Polar – he graduated in civil engineering before realising that was not where his vocation lay – but he had then risen to an opportunity offered by Polar and found that he fitted well into the position.

He commented that engineers in North America were "getting kinda old" and there were not enough skilled people coming in to take their place. The economy was showing signs of picking up; there was an ongoing re-shoring of manufacturing and a need to encourage youth into the industry. Manufacturing was becoming highly technical and highly mechanised, and needed clever people to make sure it was carried out correctly.

The American educational system was focused on 4-year degrees, with a dated perception of manufacturing industry and a "blue-collar" stigma. Michael had been one of the fortunate ones: The system turned out large numbers of college graduates with mountains of debt and qualifications they could not use, ending up in careers unrelated to their university majors. He advocated apprenticeship and internship to give students the chance to learn about the profession before investing in the education and increasing their prospects of finding success in a relevant career. From the employers' point of view, they increased the likelihood of finding good people and guiding their education, lessening the risk and ending up with quality employees.

If the North American PCB industry was going to be competitive in the global race for innovation advantage, it needed new ideas and perspectives from the next generation of engineers and manufacturers, combining advanced technical knowledge with an awareness of societal and environmental needs, continually realising new levels of efficiency.

Stacey Driver

Stacey Driver, Business Development Manager at Stickleback Manufacturing Ltd gave her views on the "real world" she encountered after leaving university with a law degree. Her further education leaders had encouraged her to believe in a "promised land" and to expect a comfortable management position after graduation, but had not prepared her for just how "real" the "real world" would be and left her wondering whether the "promised land" had ever existed.

In her presentation, she recounted her personal experiences in the UK manufacturing industry and commented upon the changing image of the businessman, the industry behind the hobbyist, and the introduction of Government initiatives to increase the interest of young people in "STEM" careers – those based on Science, Technology, Engineering and Mathematics subjects.

Stacey recounted how she had set out to re-brand the Stickleback business, make it graduate friendly and give it an on-line personality through social media like Twitter. One of her innovative ventures was Ragworm, which she described as a "community PCB platform" taking designs from anywhere in the world, combining them into composite panels for manufacture, sharing the panel set-up cost and pricing on a per-square-centimetre flat rate. Geeks were on hand 24/7 to provide technical support and assistance, and Ragworm PCBs were differentiated from the norm by their bright orange solder mask.

To support the growth of her PCB community Stacey had established a forum called Rock Pool, to share, review and debate all things techy and creative. She had exhibited Ragworm at many UK events and presented at schools and colleges to encourage interest in electronics and engineering. She acknowledged the success of Raspberry Pi, the 25-dollar computer developed to get young people programming again, which had already sold over a million units, and described her active participation in the Bloodhound

Education Programme , devised to inspire the next generation of scientists and engineers.

Daniel Jubbs

Stacey Driver's reference to the Bloodhound Project nicely set the scene for rocket engineer Daniel Jubb's dynamic keynote presentation, which epitomised the commitment of a young person to confronting and overcoming the seemingly impossible. Almost entirely self-taught, "I left school at 13", his interest in rockets was encouraged by his grandfather. They founded an amateur rocket group called The Falcon Project in 1995 and, having built and launched a number of rockets, project became a commercial enterprise in 1997 and went on to make rockets for a variety of civilian and military applications. Now in his late 20s, Daniel is recognised as one of the world's leading rocket scientists, and is also well-known for his remarkable handlebar moustache

Focused on his passion for rockets, his entrepreneurial journey and the encouragement of young people into science and engineering, the central theme of Daniel's presentation was the development of a propulsion system for the Bloodhound supersonic car project, with many anecdotes and illustrations of successes and setbacks during the programme. The Bloodhound is a jet and rocket powered car designed to push the land speed record beyond 1,000 miles per hour and the Falcon Project has been involved since 2005, as a technical adviser but later as a sponsor of the project, directly concerned with the design and development of a hybrid rocket engine to provide the additional thrust needed once the engine from a Eurofighter-Typhoon had got the speed up to 300 miles per hour. The hybrid rocket would burn a mixture of solid and liquid propellants, and almost a ton of liquid oxidiser needed to be pumped into the burner within a 20-second period using a pump originally developed for a nuclear cruise missile, driven by a Cosworth Formula-1 racing engine. Scary stuff! The record attempt was scheduled to take place in 2014 on a dried-up lake bed in South Africa.

A significant feature of the Bloodhound Project is that it is not veiled in secrecy. Quite the opposite: it aims to create a national surge in the popularity of Science Technology, Engineering and Mathematics (STEM) subjects through an iconic project which will inspire the next generation of engineers and scientists. Daniel explained how the Bloodhound SSC STEM Ambassador Programme is designed to inform, advise and enthuse teachers and students about the project and encourage them to join the adventure, by explaining the technology behind Bloodhound and keeping them informed of the research, manufacturing and testing progress.

Steve Driver

If Steve Driver has anything to do with organising it, be prepared to expect the unexpected. Continuing the theme of encouraging young people, the evening wrapped up with a session from a group of six amazing young musicians. Driver had spotted them busking outside the Roundhouse in London and invited them along. New Roots band CC Smugglers gave a spontaneous performance in their infectious style of Americana-folk-blues-country to the delight of young and old in the audience. Brilliant!

Pete Starkey
I-Connect007
September 2013

Guidelines for Creating a Lead-Free Control Plan, ESA STM-281

October, 2012
Published by European Space Agency (ESA) Communications,
ISBN 978-92-9221-92319, ISSN 0379-4067

The European Space Agency (ESA) and other Agencies require that processes for the assembly of spacecraft electronics use tin-lead and indium-lead alloys for general soldering and, occasionally, tin-silver eutectic for higher temperature soldering to terminal posts. This recently published *Guidelines for Creating a Lead-Free Control Plan*(LFCP) results from tasks given to members of a Working Group (WG) comprised of engineers from major European space industries. The LFCP guide can be used as a basis for project and company documentation that might form part of a contract to assure customers, such as ESA, that high-reliability electronic systems will continue to be "reliable, safe, producible, re-workable and repairable" according to the processes specified in the Cooperation for Space Standardization(ECSS) series relating to components, assembly methods and selection of materials for the manufacture of European spacecraft hardware.

The EU Directive on the Restriction of the use of Certain Hazardous Substances, better known as the RoHS Directive, bans the use of lead-containing alloys or glasses in electronics does also list some exemptions. For instance, the high lead containing solders used in high temperature applications are exempt. Also, certain industries related directly to military, aerospace, transportation and "space" are exempted.

The ECSS Standards, specifically forbid the use of pure tin and hence LFCPs should ensure that electronic assemblies will contain no pure-tin. The plans should also ensure that only the alloys prescribed in ECSS Q-ST-70-08 (manual soldering) and 70-38 (surface mount technology) are selected for electronic assembly work. The Government Electronics and Information Technology Information Association(GEIA)-Std-0005-2, level 3 also prohibits the use of lead-free tin finishes and requires that measures must be taken to verify compliance.

This ESA STR is written to assist persons in the space industry who may be programme managers, product assurance engineers, materials and process engineers, component engineers, procurement officers, ESA skills training school managers, inspectors and the personnel who assemble spacecraft electronics.

Pure tin finished parts and components are known to have a deleterious effect on the reliability of space electrical systems, particularly resulting from the growth of tin whiskers. Multi-million euro communication satellites have been rendered inoperable after very short orbital lives as a direct result of using devices having pure tin finishes. Most European contractual requirements for component procurement, printed circuit board procurement and component assembly are all based on tin-lead technology, where space quality components and assembly techniques have been individually assessed and qualified by more than one hundred companies and institutes employed in the European space industry,

This document reflects the views of the working group and briefly lists problems that could be associated with lead-free technology during the manufacture of spacecraft hardware, such as PCBs, component terminations, electronic housings, guide rails, corrosion-protection finishes and grounding points. Methods for determining the composition of component terminations are offered and it is emphasised that a vendor's *Certificate of Compliance* does not eliminate the need to analyse material finishes. Component terminations discovered to be supplied with pure tin finishes may (under specific contractual requirements) be reprocessed by chemically stripping the tin plating followed by re-coating with Sn-Pb solder using a solder dipping process. Thermal shock must be avoided when delicate components, and those with glass-to-metal seals, are being re-processed, so dipping to a prescribed distance from the component body or seal is essential. This will avoid damage such as cracked package seals and loss of hermeticity. Resilient devices with pure tin terminations may simply be solder dipped up to and even over the component body. It is essential that pure tin is totally removed, either chemically (so as to expose the termination's substrate), or by complete alloying with Sn-Pb. If not, whiskers may grow and cause short circuits between adjacent leads close to their component package. It is noted that every mitigation process will need to be verified/qualified before being accepted into spacecraft programmes.

Mitigation strategies for tin whisker risk reduction are described, but some are rather subjective and based on the results of limited experimental testing. It is clear that, as lead spacing is reduced, space-borne component packages operating under vacuum will have a greater risk of whisker bridging, short circuits and metal vapour arcing. However, to rely on conformal coatings as a risk mitigator may not be sufficient. Soft silicone coatings (favoured by the space industry as they have low-outgassing-under-vacuum and are reworked easily during component replacement operations) can be penetrated by tin whiskers. Hard epoxy-type coatings may prevent whisker penetration, but during thermal cycling in orbit they can easily cause solder joints to fatigue and fail owing to the high coefficient of thermal expansion (CTE) of the hard coating.

The publication ends with a checklist designed to ensure that a supplier or manufacturer has taken steps to exclude the delivery and/or assembly of pure tin products onto space hardware. For instance, it is essential that a person is designated to supervise lead-free policies; procurement officers need to understand about the potential problems associated with pure tin and whiskering; that tin, applied to cables by hot-dipping and wire drawing is not a whisker issue; and, at incoming inspection, some precautions are taken to avoid the acceptance of pure tin products by applying swab tests (that turn red in the presence of lead), XRF or EDS/EDAX analysis.

The document is now freely available on line and can be downloaded from;

http://esamultimedia.esa.int/multimedia/publications/STM-281

Dr Barrie Dunn
European Space Agency

Book Review by Martin Goosey

Polymer Electronics

Mark Geoghegan & Georges Hadziioannou
Published by Oxford University Press
Great Clarendon Street, Oxford, OX2 6DP, UK
ISBN: 978-0-199-953382-4 (hardback) and
978-0-199-953383-1 (paperback)
Published 2013

Polymer electronics has been developing over a number of years and the global market is now predicted to exceed $8 billion dollars by 2018. It is currently the basis of several important new technological developments including flexible electronics, novel types of displays, printed lighting and photovoltaic devices. The technology also has the potential to enable radical innovations in a whole range of electronic products that find widespread everyday use. Polymer electronics thus covers a broad range of subject matter and there is clearly a need for a work that presents the subject in a clear and concise manner to those who have broad interest or may be starting to work in the area. This book by Mark Geoghegan and Georges Hadziioannou has exactly the intention of addressing these needs and it is published as part of the Oxford Master Series in Condensed Matter Physics. Books in this series are aimed at the final year undergraduate / initial post graduate level and have the intention of providing straightforward introductions to key subjects in physics.

This two hundred and fifty page book is divided into ten discrete chapters and begins with an introduction and overview of polymer electronics, covering history and applications along with the challenges that will influence broader exploitation. There is then a chapter covering the theory that gives rise to semiconducting behaviour and how it applies to polymers; it begins with an overview of conductivity and the free electron model, which can be used to predict conductivity in many different materials. It then covers , band theory and energy bands in polymers, with an introduction to doping and the influence it has on both inorganic and organic semicondcutors.

The doping of polyacteylene with iodine was first investigated in the 1970s and since then a wide range of other materials have subsequently been investigated. Well known examples include polyaniline, polythiophene, polypyrrole and poly(p-phenylene vinylene), but more recently there has also been growing interest in carbon nanotubes, graphene, buckminsterfullerene and many other novel materials. Chapter three of this book is entitled 'Beyond polyacteylene' and it gives a brief introduction to several examples from this diverse range of materials that are of potential interest in polymer electronics.

The preparation of a high efficiency green light-emitting polymer based light emitting diodes in the 1990s generated a whole new wave of interest in polymer electronics and one of the key areas receiving attention in recent years has been associated with the use of these new materials in display applications. It is not surprising, therefore, that a chapter of this work is dedicated to 'Optoelectronic properties' and chapter four covers the main subject areas of interest including photoconduction, photoluminescence, electroluminescence and the structure of a basic light emitting device.

Charge transport is fundamental to the fabrication of viable transistors and opto-electronic devices and understanding the factors that influence electron and hole transport mechanisms in polymers is key to the successful selection of materials for polymer electronics applications. Chapter five focuses on 'Charge transport' and covers band transport, hopping, and a number of other key factors including injection and the nature of the electrodes that are so important when constructing functional devices.

The next two chapters alternate between the chemistry and physics of conducting polymers. In chapter six on 'Synthesis and macromolecular design', the book moves more towards the chemistry side of polymer electronics with coverage of polymerisation and a discussion of polymer solubility, doping and band gap control in the context of macromolecular design. This is then followed by details of the synthesis of a number of key conducting polymers such as polyaniline. There is also mention of the electrochemical synthesis of poly (3,4-ethylene dioxythiophene), which has found widespread application due to its high stability and optical transparency in the conducting state. Chapter seven then covers 'The physics of polymers', although this is achieved by also considering their structure and crystallinity.

Chapter eight considers 'Surfaces and interfaces' and begins with a discussion of interfacial energy before moving on to a consideration of polymers at surfaces, which is key to achieving the required performance and functionality from polymer electronic devices such as light emitting diodes or solar cells. Methods of depositing films are then described. These include the conventional approaches such as dip coating, spin coating and doctor blading, along with techniques that enable layer by layer deposition. The last part of the chapter is dedicated to surface analysis and covers methods that can be used to provide chemical structure or topographical information.

The first eight chapters of the book have focussed more on the fundamental properties, processing and characterisation of the novel materials used in polymer electronics, but chapters nine and ten cover their actual use in electronic and optoelectronic devices. Chapter nine is dedicated to 'Polymer transistors' while chapter ten is on 'Optoelectronic devices'. Polymer transistors have very different characteristics to the conventional silicon-based devices that are found in most electronics and, while they are unlikely to ever compete on speed and the levels of integration seen with silicon, they are ideal for applications where silicon devices are unsuitable. Typical examples of potential applications for polymer transistors would be in large area and flexible displays, as well is in RFID tags. This chapter gives a good overview of the thin film field effect transistors that are made from organic materials, rather than silicon and its inorganic analogues. The basics of the field effect transistor and the key important properties are described, along with details of how they can be optimised. The chapter concludes with an introduction to logic circuits. Organic light emitting devices have many attractive features including their good processability and low costs.

Chapter ten provides information on a range of optoelectronics devices; not just organic light emitting diodes but also light emitting transistors and photovoltaics.

At the end of most chapters there are number of exercises aimed at testing the reader on their understanding of the particular subject matter covered. Answers to these problems are given in one of the four appendices to the main body of the work; the other three covering descriptions of 'Schottky barriers', 'dispersity in step-growth polymerisation' and the 'regular solution theory'. Instead of providing a list of references at the end of each chapter, the book concludes with a bibliography that provides recommended further reading material.

In summary, Polymer Electronics provides an excellent introduction and overview of all of the key aspects of this new and important area of electronics. It is pitched at a level which provides sufficient detail for those who are likely to find themselves working on the subject, but it is also at a level where those with a more general interest will also find the book not overly complex and off-putting. The book presents a thorough introductory discussion of both the physics and chemistry of polymer electronics and should appeal to all those with an interest in this exciting new field.

Martin Goosey
September 2013

Polymer Electronics

Mark Geoghegan & Georges Hadziioannou

Published by Oxford University Press
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Published 2013

Review of

IeMRC 8th Annual Conference

Loughborough, UK,
25th September 2013
by Pete Starkey

The early morning mist gave way to a clear, bright autumn day as delegates gathered in the Sir Dennis Rooke Building for the 8th Annual Conference of the Innovative Electronics Manufacturing Research Centre at Loughborough University in the UK.


Dr Darren Cadman

Research Coordinator Dr Darren Cadman introduced an intensive programme of eleven presentations, grouped into four sessions :-

Accelerating Innovation,
Flexible Electronics,
Sustainability and
Nanoelectronics.

Accelerating Innovation

The opening presentation came from Dr Huw Davies, Lead Technologist with the Technology Strategy Board, the UK's innovation agency whose goal is to accelerate economic growth by stimulating and supporting business-led innovation and offering funding to help businesses develop new products and services and to bring them closer to market.


Dr Huw Davies

He gave an overview of his specialist area of electronics, sensors and photonics, considered by the TSB to be key enabling technologies, and referred to the recently published ESCO report – Electronics Systems: Challenges and Opportunities – a strategy document created for the Department of Business, Innovation and Skills, which detailed how the electronic systems industry could expand by 55% between now and 2020 to contribute £120 billion to the UK economy and create an additional 150,000 highly-skilled jobs.

One of the main challenges for the UK electronics sector was the prohibitive cost of product development and manufacturing, especially for early-stage companies, and Dr Davies used Paul Graham's "Start-up Curve" to illustrate the process of taking a concept to commercial realisation. Phases labelled "Trough of Sorrow", "Crash of Ineptitude" and "Wiggles of False Hope" constituted the "Valley of Death" which the TSB aimed to help companies to cross with a whole range of business support and funding tools, designed to meet specific needs of companies, sectors and technologies.

The Valley of Death was central to the following presentation.


Prof. Andy West

In his enormously energetic and entertaining style, Andy West, Professor of Intelligent Systems at Loughborough, told a story about getting into it and floundering around trying to get out of it. His topic was embedded product and process monitoring across the electronics supply chain, and the big question was "Can we get it right first time?" in the context of the migration of UK electronics towards supplying low-volume high-complex manufacturing solutions to a global market.

With his first example, he demonstrated how a combination of RFID and various sensors had been used to help improve the performance of Olympic swimmers by monitoring, measuring and recording the physical parameters of the process of swimming, then analysing the results to determine how the process could be performed more efficiently. The principle of getting information from sensors to gather data on how a product performed had enormous scope, and could enable designs to be optimised to ensure that a product performed effectively in the environment it was required to work in.

Standing in front of a complex Ishikawa cause-effect analysis diagram, he discussed how knowledge could be identified, derived and extracted from all the possible causes, then, using experimental models, simulation models and physical models, built into software to predict where problems might be encountered.

But how to find help and funding for the research? Professor West showed a long list of completed and current TSB and EPSRC projects in which his team had been involved, and briefly described two embedded RFID projects, one related to bare-board testing of PCBs, linking the RFID with the test results and one being conducted in partnership with MTC in Coventry where the system was being incorporated into a complete SMT assembly line. There was massive interest from the automotive industry who saw the principle as a route to better traceability, more robustness and right-first-time performance.

Flexible Electronics

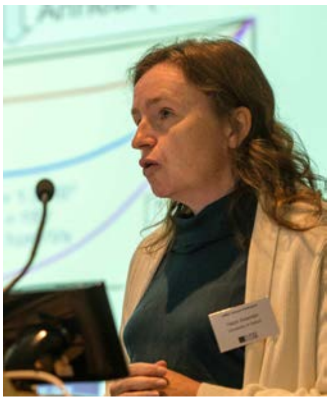
Dr Martin Walkinshaw

Once more into the Valley of Death – not Tennyson’s Light Brigade but Dr Martin Walkinshaw from the Centre for Process Innovation as he opened the session on flexible electronics. CPI is an independent public/private partnership, whose Printable Electronics Centre focuses on design, development and prototyping for the emerging printable electronics industry. CPI’s mission is to work with clients to bring new printable electronics products and processes to market quickly and efficiently, by offering facilities and expertise that help reduce the level of R&D risk and capital investment, while speeding up time to market – assisting them to cross the same Valley of Death that previous presenters had confronted: the innovation challenges in the mid technology-readiness-level and manufacturing-readiness-level development stages. "Research is the transformation of money into knowledge. Innovation is the transformation of knowledge into money".

Dr Walkinshaw listed current innovation challenges in printable electronics: scale up to large area, roll to roll processing, uniformity, integration with conventional electronics, barrier and encapsulation, and cost of manufacturing. A key technology area was the atomic layer deposition of ultra-barriers for flexible electronics applications, which was an enabler for organic thin film transistors for flexible displays, solid state lighting and photovoltaics, and integrated smart systems and sensors.

He gave updates on the LACE project: large-area coating for organic LEDs including developments in large-area single pixel solid-state lighting, organic photovoltaic technology for architectural glass, integrated smart systems developments, including ink formulation and characterisation, printed connections for novel lighting application, printed antenna for flexible circuits and printed electronics in toys and games.

Other projects in which CPI were partners were Intellico: intelligent embedded components for enhanced supply chain observability and traceability, and Diginova: innovation for digital fabrication. He reviewed activities in the development of high-mobility organic semiconductors for displays, and challenges in roll-to-roll coating of these materials by ink-jet and slot-die techniques.



Dr Hazel Assander

Roll-to-roll processing was the subject of the following presentation, by Dr Hazel Assander from University of Oxford, but in this case the operation was carried out under vacuum. Dr Assander reported latest developments in the IeMRC flagship project aimed at demonstrating the ability to fabricate all-evaporated transistors in a roll-to-roll web process environment, exploiting technology that is used in the packaging industry. Main issues were to establish process parameters for building and testing transistors, to design circuits tailored for the properties achievable by this manufacturing route, to develop suitable organic semiconductor and polymer gate insulator materials and patterning processes to yield robust final devices. Good progress had been made in integrating the process stages, and in the optimisation of techniques for high-resolution pattern metallisation, gate insulator deposition, patterning of organic insulator and semiconductor layers and modification of the insulator surface. Dinaphthothienothiophene (DNTT) had been evaluated as an alternative to pentacene and had given improvements in environmental stability.

Yield improvements and the reproducibility of transistor properties had provided the confidence to start building actual circuits; inverters, NAND and NOR gates and ring oscillators, which had been characterised and environmentally and mechanically tested

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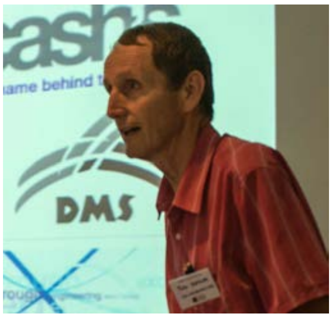
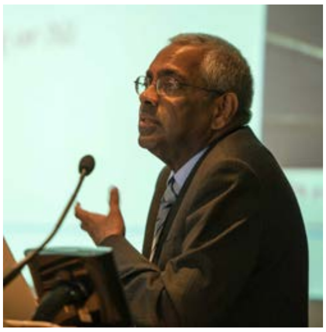


Dr Rob Seagar


Professor Tilak Dias

From film-based flexible electronics to fabric-based antennae for wearable applications, Dr Rob Seagar from Loughborough University and Professor Tilak Dias from Nottingham Trent University took turns to describe their work on high performance flexible fabric electronics for megahertz frequency communications and the results they had achieved.

Tests had been conducted with full fabric patches and dipoles made of copper wire or a proprietary metallised textile fibre and their high-frequency characteristics measured. Their performance made these antennae commercially viable, although some variability still needed to be addressed.

Work was currently focused on digital embroidery techniques, the selection of suitable electro-conductive yarns, the optimisation of machine conditions to create fabric antennae and the investigation of fabric based interconnection systems. The mechanical and electrical properties of wide range of different yarns had been studied, and their compatibility with embroidering machines determined. Overcoming friction had been one of the biggest challenges, but lubrication and modification of the yarn-guiding system had yielded some improvements. Parameters such as stitch direction and stitch density had significant effects on the durability of the fabric antennae during abrasion testing. Washing trials had shown little effect on durability. Meshed patch antennae were being investigated as a means of reducing material cost and reducing stiffness, and funding was currently being sought for continuation work.

Sustainability


Professor Margaret Bates

The third session was on the theme of sustainability. Professor Margaret Bates from the University of Northampton took time out of her international travel schedule, pausing en-route from India to Kenya to describe to the conference her work to improve the recycling of electronic waste in Africa.

She commented that E-waste, of which the UK currently produces 1million tonnes per annum, is increasing three times faster than other waste streams. World-wide, 41.5 million tonnes had been generated in 2011 and this was forecast to increase to 93.5 million tonnes in 2016. What started off as a re-use strategy to give developing regions the benefit of low-cost information technology by shipping functional or easily repairable computers as a means of fosterig sustainable development had now got out of proportion and it was estimated that by 2016-2018, the volume of obsolete PCs generated in developing regions would exceed that of developed regions and that by 2030 the developing countries would be discarding 400-700 million obsolete PCs per year compared to 200-300 million in developed countries.

Although the Basel Convention prohibited the shipping of hazardous waste to developing countries, Nigeria was a key destination for E-waste from UK, largely because Nigerians came to the UK to buy it, and there were links with organised crime. There was a huge trade in second-hand PCs because people could not afford to buy new, but a large proportion of the material currently imported was beyond repair and unless there was an effective end-of-life recycling solution would end up in landfill or on illegal open dumps.

Professor Bates had worked for several years with government and industry to provide education and training and to establish proper E-waste recycling facilities in Nigeria, Ghana and Tanzania to reduce their reliance on landfill for disposal,. Presently she was working with the Kenyan National Environment Management Authority to build the E-waste recycling capacity in that country.

Dr Andrew Ballantyne

Sustainability from a different angle – Dr Andrew Ballantyne reported work in progress at University of Leicester to develop greener, cleaner, cheaper sustainable soldering fluxes from novel ionic liquid solvents.

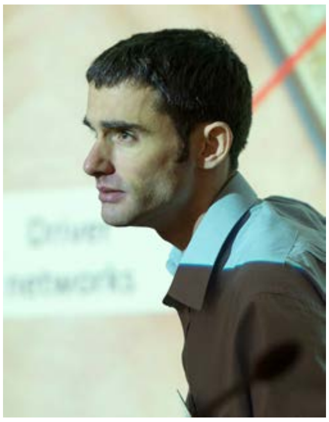
Ionic liquids were purely ionic materials with melting points below 100 C, which exhibited unusual solvent properties, low vapour pressure and good thermal stability.

Deep eutectic solvents were a class of ionic liquid composed of organic cations with halide anions and various complexing agents to make an anionic complexes, characterised by low cost, ease of manufacture, low sensitivity to water and high metal solubility, which had proven applications in metal finishing, plating, electropolishing and metals recovery.

The purpose of a soldering flux was to clean metal surfaces, prevent them from oxidising during the soldering process and maximise wetting interaction between substrate and solder.

But conventional fluxes tended to be toxic and corrosive, and there were supply chain issues with certain ingredients. By comparison, deep eutectic solvents were inexpensive, exhibited high solubility of metal oxides, together with low toxicity and environmental impact. Qualitative tests had indicated that they could be used as flux for soldering a variety of metals including copper, brass, cast iron and stainless steel.

IeMRC was supporting a project to assess the use of deep eutectic solvents as flux media for electronics assembly, to understand the surface chemistry, the influence of formulation and the analysis of degradation products. Studies of solder spread and interfacial properties on copper and electroless nickel immersion gold surfaces were showing encouraging results, which were in the process of being quantified by wetting balance measurements.



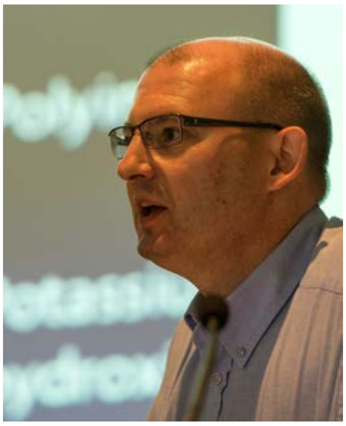
Daniel Rogers

Daniel Rogers, a PhD student from the University of Sheffield returned to the topic of recycling and sustainable end-of-life re-manufacture of electronics with a presentation on adapting ATX computer power supply units (PSUs) for use as maximum-power-point-tracking (MPPT) solar interfaces for battery charging. His point of reference was 2007, when EU countries disposed of 6.5 million tonnes of Waste Electrical and Electronic Equipment (WEEE). Traditionally WEEE processing has been focused on extraction of raw materials, and processing centres in Germany were achieving recovery rates ranging from 29% to 61% from ICT equipment. As an alternative to raw materials extraction, the Environmental Association for Universities and Colleges advocated the reuse of computer equipment in the developing countries in Africa.

Mr Rogers was engaged in a project to investigate the practical steps in recovering PSUs, to develop a generic MPPT converter tolerant to variable component choices and specifications, to present a business case for dismantling, recovery and reuse of components, and to evaluate the socio-economic viability of PSU reuse through interaction with ICT recyclers and photovoltaic providers. A partner in the project, Aspire-Sheffield provided employment and a supported working environment for vulnerable or marginalised people, and used the recycling of WEEE as a revenue and employment stream. Their staff had been trained to identify active power-factor-correction (PFC) PSUs.

The suggested end application was to provide a low-cost means of charging mobile phone batteries in in the poorest parts of the world using solar panels as the power source. The technical aim of the power converter was to maintain the solar panel at its maximum power point. ATX PSUs had been modified with a new controller feeding the boost and half bridge stages. With surplus output cables removed and new driver inputs, the PSUs now operated from a DC input at 12-25V. "Perturb and Observe" (P&O) methodology had been chosen as a preferred means of maintaining the maximum power point and solar simulator trials had indicated very high levels of conversion efficiency, confirming the feasibility of the system as an affordable photovoltaic converter.

Nanoelectronics



Prof. Marc Desmulliez

"Where Nature Meets Electronics" was the tag-line of the presentation by Professor Marc Desmulliez from Heriot-Watt University, which described a process for metallisation of non-conductive surfaces using chlorophyll.

Of the various routes available for achieving additive pattern metallisation, Heriot-Watt had an established history in light-directed additive metallisation for contact-less, high-resolution patterning.

Their process began by treating a polyimide substrate with potassium hydroxide to impregnate the surface with potassium ions, then immersion in a silver solution to ion-exchange potassium for silver before coating with a thin layer of a photo-activated reducing agent which would donate electrons to regions of the substrate selectively exposed to light and generate silver metal nanoparticles only on those sites. The substrate surface became a nanocomposite layer, with the metal nanoparticles mechanically interlocked within the modified polymer matrix, and 40-micron line-and-space resolution had been achieved.

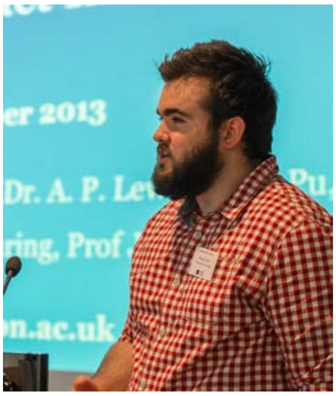
The photo-activated reducing agent originally used was a methoxy polyethylene glycol, which had the limitation of being very slow to expose, and an undesirable side effect of the long exposure was UV degradation of the substrate.

A more efficient alternative had been sought, and Professor Desmulliez' team looked to nature for a solution. The perceived potential advantages were that the process would be faster – nature is good at optimising process efficiency – and environmentally friendly. Spinach proved to be a good source of natural photoactive reducing agents, although the physics and chemistry of photosynthesis was extremely complex. The natural photosystems contained many light-absorbing proteins, including chlorophylls and carotenes. Using an extract of pulped spinach as the photo-activated agent in the imaging process reduced the exposure time from hours to seconds and gave remarkable uniformity of distribution of silver particles through the thickness of the surface layer, the mechanism of which had not yet been explained.

Dr David Hutt

The theme of the fourth conference session was nanotechnology, and it began with a presentation from Dr David Hutt of Loughborough University on the functionalisation of copper nanoparticles to enable metallisation in electronics manufacturing, a joint IeMRC project between Loughborough and Coventry Universities.

Electroless copper was widely used in printed circuit manufacture for the metallisation of via holes, and most proprietary processes depended upon a colloidal tin-palladium initiator, which was expensive and gave limited adhesion on some substrates, particularly glass. An alternative was proposed based upon commercially available copper nanoparticle powders. In order to aid dispersion, improve adhesion to surfaces and reduce the rate of oxidation, it was necessary to functionalise these particles. The suggested route was to coat them with a self-assembled organic monolayer approximately 2-3 nanometres thick, the typical diameter of the nanoparticles being about 25 nanometres. Ultrasound had been used to achieve good particle dispersion and the functional coating had improved both the stability of the dispersion, as measured by dynamic light scattering, and the adhesion of the nanoparticles and subsequently deposited electroless copper on FR4 laminate surfaces. Other substrates were presently being studied.



Michael Down

Final presentation of the day came from Michael Down, a PhD student at Southampton University, discussing a means of dramatically improving the lifetime and endurance of MEMS microswitches by applying vertically aligned multi walled carbon nanotubes as a compliant subsurface to electrical contact interfaces, and to investigate the effects of this subsurface on the electrical and physical performance of low force, low current MEMS microswitches.

Carbon nanotubes were grown on silicon chips sputter-coated with an aluminium oxide seed layer and an iron catalyst in a chemical vapour deposition furnace using ethylene as the carbon source. They were then sputter-coated with gold, creating rough, but compliant and conductive, surfaces.

Samples were tested by mounting them on a piezoelectric cantilever, and contacting them with a gold coated hemisphere at actuating frequencies up to 150hz, with an electrical load of 4V, an electrical current of 0 to 200mA and a contact force of 1mN.

Wear mechanisms and cycles-to-failure were observed, and lifetimes were found to be several orders of magnitude longer than those of solid-solid contacts under the same conditions.

A counter intuitive effect was that the number on bounces upon closing the switch increased with the presence of the compliant subsurface. And material transfer, which in regular devices was largely determined by the polarity of the contacts, transferred from the flat substrate to the ball regardless of the polarity and was rate dependent on current and frequency.

IeMRC Academic Director
Prof. Paul Conway

IeMRC Academic Director Professor Paul Conway made the closing remarks, summarised ongoing IeMRC activities and announced that a final call for proposals would be made shortly.
The 8th Annual Conference of the IeMRC was once again a technically intense but highly informative opportunity for delegates to learn about innovative and exploitable new technologies, and to network with their peers in industry and academia. It was a great credit to the IeMRC team for their smooth and efficient administration and organisation.

Pete Starkey,
I-Connect007,
September 2013

Pete is grateful to Vin Scothern for kindly allowing the use of his photographs

£250 prize offered for best young-person's paper.

The 2013 ICT Seminar on Hayling Island was themed on encouraging young people to join and develop careers in manufacturing industry.

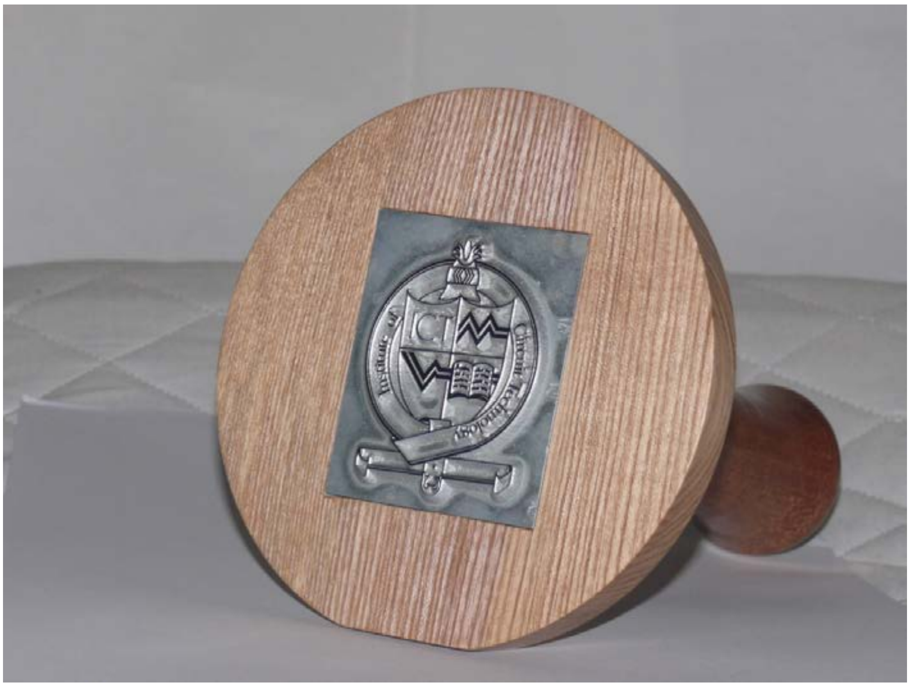
In his introduction, ICT Chairman Professor Martin Goosey remarked that the negative public perception of manufacturing had made it unattractive to young workers, but that government and industry leaders were finally acknowledging the worth of manufacturing industry to the UK economy, especially in high-value areas like electronics. Many companies were now making more effort to secure their future workforce and there was increasing interest in training young people.

Having re-affirmed the Institute's ongoing commitment to education and training Professor Goosey announced that, as an additional incentive, the ICT Council had voted to offer an award of £250 for the best young-person's paper of the year, to be published in the Journal.

Entries were invited on any subject relevant to PCB technology, please send to:-

Professor Martin Goosey
martingoosey@aol.com

Pete Starkey,
ICT Council,



The Great Seal

Organisation	*Address*	*Communication*
Anglia Circuits Ltd.	Burrel Road, St.Ives, Huntingdon PE27 3LB	01480 467 770 www.angliacircuits.com
Atotech UK Ltd.	William Street, West Bromwich. B70 0BE	01210 067 777 www.atotech.de
CCE Europe	Wharton Ind. Est., Nat Lane, Winsford CW7 3BS	01606 861 155 www.ccee.co.uk
ECS Circuits	Centrepoint Business Park Oak Road, Dublin 12, Ireland	++353-(01)1-4564855 sales@ecscircuits.com
Electra Polymers Ltd.	Roughway Mill, Dunks Green, Tonbridge TN11 9SG	01732 811 118 www.electrapolymers.com
The Eurotech Group	Salterton Industrial Estate, Salterton Road Exmouth EX8 4RZ	01395 280100 www.eurotech-group.co.uk
Falcon Group	Riverside Ind. Est. ,Littlehampton BN17 5DF	01903 725 365 www.falconpcbgroup.com
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Invotec Group Ltd	Hedging Lane, Dosthill , Tamworth B77 5HH	01827 263 000 www.invotecgroup.com
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Ventec Europe	1 Trojan Business Centre, Tachbrook Park Estate Leamington Spa CV34 6RH	01926 889 822
Zot Engineering Ltd	Inveresk Industrial Park Musselburgh, B19 EH21 7UQ	0131-653-6834 www.data@zot.co.uk

The Membership Secretary's notes - October 2013

The Great Seal

Bruce Routledge, our Journal editor and ex Membership Secretary had the metal seal made in the early days of the Institute and I had the ash and mahogany handle added in the Kelso workshop. The metal seal was made using a process called Dow etching, where the part was placed on the roof of the etcher to eliminate puddling and reduce undercut. Castor oil was also added to the etchant to coat exposed edges and control the angle of undercut, both positively and negatively. Resist is still evident on most of the un-etched areas - not bad for a 40 year old.

Why are these items important?

We held a Seminar at the end of September with a theme of 'Encouraging young people into the Industry' and four twenty-some-things astounded us with a set of presentations, which both captivated and energised by faultless delivery, content and timing and it was a privilege to be part of an idea which exceeded all expectations.

When Bruce was making the seal in the Seventies, I was one of those twenty-some-things, making flexible circuits on a vertical etcher. We are all children of our own generation, but it helps to be part of an organisation which helps to draw the Industry together and that is one of the main benefits of belonging to the Institute. We are an unbroken line of twenty-some-things stretching from today back to the Seventies and providing a point of contact for everyone involved in the PCB and related Industries.