Journal of the
Institute of Circuit Technology

Vol.8 No.3 Summer 2015 Issue

2015 Events

3rd March *Tuesday* — **ICT Northern Seminar and AGM** at Chimney House Hotel, Sandbach
www.instct.org
bill.wilkie@InstCT.org

13th -16th April *Tuesday - Friday* — **ICT Annual Foundation Course** at Loughborough University
bill.wilkie@InstCT.org

3rd June *Wednesday* — **ICT Annual Symposium** at Black Country Museum
bill.wilkie@InstCT.org

22/23rd September SMART Group *Tuesday Wednesday* European Conference & Exhibition at National Physical Laboratory (NPL)Teddington
See http://www.smartgroup.org/ai1ec_event/smart-e-webinar-promotion-day-september-event/?instance_id=475

22nd September *Tuesday* — **ICT Evening Seminar** at Newtown House Hotel, Hayling Island
The REINDUSTRIALISATION of EUROPE
bill.wilkie@InstCT.org

November — **ICT Northern Evening Seminar**
Date and details to follow
bill.wilkie@InstCT.org

2016 Events

13/14th April — EMPS-7th Electronic Materials and Processes for Space Workshop at Portsmouth University
http://emps.port.ac.uk/documents.html

Editorial

The growth of the modern electronics industry can, in many ways, be linked to the global adoption of the latest major 'must have' gadget, be it consumer or industry focused. Examples from the last 25 years include personal computers, mobile phones, lap tops, flat panel TVs and tablets. While these products, and many others, will doubtless keep the electronics industry occupied for the foreseeable future, there is another development emerging that may well have an even greater and broader influence on both industry and society as a whole. This development is the Internet of Things (IoT). The IoT is basically defined as the network of physical objects or 'things' that have both embedded electronics, software, sensors etc and connectivity to provide greater value and service by being able to exchange data with manufacturers, users and/or other connected devices. It is, essentially, the interconnection of all things through the incorporation of the appropriate electronics. Examples of the key specific focus areas for the IoT include smart cities, transport, buildings, industry, health and living.

This will present a major challenge for the PCB industry, especially as the demand for ever higher data transmission rates is often combined with the low operating voltages of portable and mobile devices. Many of the applications will require a high frequency capability. The 5G mobile phone system operates at 28 and 38 GHz, while short range wireless local area networks and wireless personal area networks are likely to be at 60 GHz (i.e. in the 57 - 66 GHz band). Add to this the increasing use of industrial and automotive radars which operate at up to 122 GHz and the potential demand for high speed solutions becomes apparent. Many of these applications will require very careful circuit design if signal integrity is to be maintained and losses minimised.

PCBs that can be used in these applications will need to have dielectric properties that are both homogenous and isotropic, while also exhibiting low loss. The materials used will also need to have low moisture absorption and dielectric constants that are stable with temperature. With increasing frequency, more of the signals will be transmitted in the surfaces of the conductors, meaning that there will be specific performance demands on the choice of solderable finishes used, as well as on conductor surface morphology. There will also be the added challenge of achieving electromagnetic interference (EMI) and electromagnetic compatibility (EMC) in an increasingly crowded and busy environment. The move to smaller features in PCBs will also present difficulties as, for example, vias are known to have poor signal transmission properties, especially as they become smaller, with higher aspect ratios, and where they are present in high density. The electromagnetic properties of vias will increasingly need to be optimised for these types of applications and design aspects such as the pitch between signal and return current vias will be increasingly important. At the practical level, this will not only require the expertise of circuit designers, it will also drive the development and introduction of the new materials that will be required for higher frequency operation, along with new simulation and measurement approaches.

It will not just be in improvements to conventional circuit boards where there will be an opportunity. There will also be an immense demand for embedded intelligence, which will be achieved through the use of RFID devices and a plethora of sensors and transducers and via a wide range of other novel electronic devices. In many cases, these will need to be thin and flexible, which will encourage the further development of many of the emerging technologies that have been increasingly promoted in recent years, such as printed electronics, flexible circuitry and 3D printing.

Although there are various emerging technology trends underway, it seems that there is every likelihood the biggest one could well be the Internet of Things/Everything. It is certainly going to provide major opportunities on a global scale, but it could also be very disruptive to the established methods of operation. If you are not already planning how you can be a part of this opportunity, maybe it is now time to give it some serious consideration. We are approaching a period when almost anything will be contactable by, and connectable to, anything else, at any time, no matter where it is.

Martin Goosey
20th June 2015

Membership *New members notified by the Membership Secretary*

10347 Neil Butler M.Inst.C.T.
10348 Michelle Le Brun A.Inst.C.T.
10349 Andrew McLeod A.Inst.C.T.
10350 Angus McGorman A.Inst.C.T.
10351 Michael Russell A.Inst.C.T.
10352 Justas Abramavicius A.Inst.C.T.
10353 Daniel Johnson A.Inst.C.T.
10354 Tom Hill A.Inst.C.T.
10355 Karl Shields A.Inst.C.T.
10356 Achref Ghanmi A.Inst.C.T.
10357 Ane Amilibia A.Inst.C.T.
10358 Josh Aspinwall A.Inst.C.T.
10359 Andrew Ross A.Inst.C.T.
10360 Alex Machin A.Inst.C.T.
10361 Kevin Stanistreet A.Inst.C.T.
10362 Anjali Krishnanunni A.Inst.C.T.
10363 Carlstien Castillo-McEvoy A.Inst.C.T.
10364 Thomas Devahif A.Inst.C.T.
10365 Guillaume Ansias A.Inst.C.T.
10366 Sebastien Havelange A.Inst.C.T.

Corrections & Clarifications

It is the policy of the Journal to correct errors in the next issue. Please send corrections to : -
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Review of a Visit to:-

Cemco in Waterlooville

by Peter Starkey

Engineering creativity - Cemco - the Art of.

Peter Starkey

Cemco - the art of engineering creativity

It's always a pleasure to visit Cemco in Waterlooville and see a UK equipment manufacturer continuing to operate successfully in a market area where most of its domestic competitors have ceased trading and the importers can source conventional wet processing equipment from low-cost manufacturing areas and offer it at discount prices.

The workshop was busy. Sales Director Paul Watson proudly pointed out three complete process lines - one each for inner layer and solder mask micro-etching and oxide replacement - all based on Cemco's Streamline fluid-dynamics technology, and explained that they were about to be dismantled and crated for export.

Elsewhere in the shop I could see a reel-to-reel web treatment system, a Quicksilver solder levelling machine and a post-drill hole cleaner.

Paul commented that although Cemco has been building and developing quality equipment for the PCB industry for more than 40 years, much of which had been used in the UK, 80% of Cemco's business was now in new technology and most of that was for export.

Today's expectation of more for less had forced Cemco's competitors to supply equipment manufactured in low cost manufacturing zones. Cemco had responded by providing "more *from* less" - a large increase in capacity and efficiency from a substantially smaller footprint through the use of their patented Streamline Fluid Engines in place of conventional flood and spray processing techniques .

I understood the basic principles of the Streamline fluid-dynamics from my conversations with Cemco Chairman Peter Lymn, one of the industry's leading lateral-thinking innovators. I have held Peter in the highest regard for many years as an engineer who has constantly challenged the traditional "we've always done it this way, and we always will" mind-set, and has offered creative and ingenious solutions to processing challenges. Peter is never shy of pulling the covers off a machine to reveal the secrets of its internal workings, and to go to great lengths to explain the logic behind the design.

The Streamline equipment range takes its name from the unique laminar-flow treatment modules that replace conventional flood and spray chambers and result in faster and more uniform reaction, reducing processing time and equipment footprint.

Each module comprises two plates closed at each side to form a narrow chamber. Fluid containment rollers, mounted at the entrance and exit of the chamber, push and pull both flexible and rigid materials through this chamber. There are no rollers within the chamber. Fluid is injected at the centre of each plate via continuous slots or knives, resulting in steady boundary layers balancing and guiding material in transit. The leading and trailing edges of the plates are shaped to take advantage of the Coander effect, the phenomenon in which a jet flow attaches itself to a nearby surface and remains attached even when the surface curves away from the initial jet direction, diverting the boundary layer diffusion point away from the panel entry and exit zones. This maintains the streamline flow and diverts fluid above the plates, preventing flooding and material deflection. Similar principles are applied in the rinsing and drying modules.

Another unique Cemco innovation was evident in their reel-to-reel web treatment system, destined for a high-volume printed electronics manufacturing application where the challenge was to transport a continuous web of thin polyester through a 60-metre serpentine path immersed in process solution, at speeds of up to 12 metres per minute with less than 800 grams of tension.

How was this achieved?

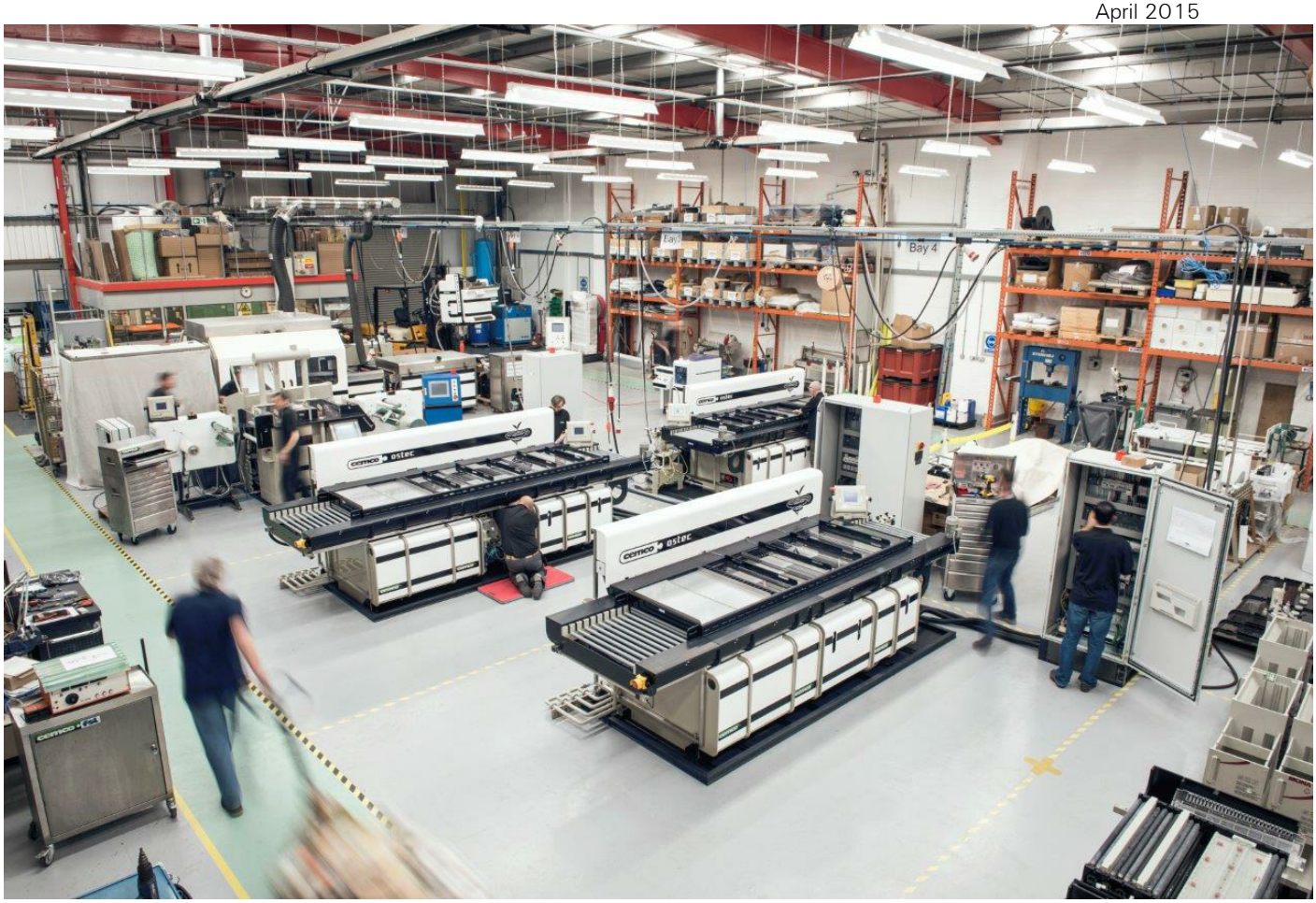
By fluid dynamics again: at each change of direction within the 2-metre long process tank, the web passed not over a mechanical roller but instead a fluidised bearing: a stationary guide bar through which process chemistry was jetted at high pressure through a pattern of fine holes, allowing the web to float on a liquid cushion - a true non-contact transport system.

Cemco's innovative approach to resolving process challenges, together with their in-depth engineering and fabrication skills, continues to set the company apart from its competitors.

And, standing in the background, another new Quicksilver - the industry-standard workhorse which established hot-air solder-levelling as a preferred selective solderable finish over 25 years ago, still going strong over 700 installations later, and now with a 10-year track record of success in lead-free processing: an icon of elegant functionality and durability.

I look forward to my next visit to the Waterlooville factory - I'll leave it for a couple of years then go back and check out how the art of engineering creativity has progressed in the meantime!

Pete Starkey
Institute of Circuit Technology.
April 2015



Review of :-

6th Electronic Materials and Processes for Space Workshop (EMPS-6) held on 15/16th April 2015 at DLR Oberpfaffenhofen, Germany

by Barrie Dunn, EMPS co-founder and Professor at Portsmouth University

The EMPS Workshops are a University of Portsmouth (School of Engineering) initiative which started in 2010 with EMPS-1. The Workshops are held at least once per year, typically at one of the six ESA-Approved Skills Training Schools. The Workshops are non-profit making and held to develop and promote the materials and manufacturing processes utilized for spacecraft applications.

Materials engineers and students are encouraged to attend. EMPS events are usually free of charge, but when participation is limited due to capacity constraints at any venue, priority is given to the workshop presenters, specialist engineers and scientists and students occupied in the fields of materials, manufacturing and the space industry.

The events are publicised on a University of Portsmouth website from which all past EMPS presentations can be freely downloaded : http://emps.port.ac.uk/documents.html

Past locations for EMPS events were at: the University of Portsmouth (2010); the Institut de Soudure, Paris (2011) and the Italian Welding Institute, Genoa (2012); the Danish Institute of Technology and Research - Hytek, Aalborg (2013); and ESA-Estec, Noordwijk, the Netherlands (2014).

EMPS-6 was held on the 15/16th April 2015 at the German Space Operations Centre (DLR), Oberpfaffenhofen, near Munich. The modern lecture hall was filled by more than 70 enthusiastic engineers, academics and students from 17 countries. 18 presentations were delivered during this 2-day event. Organisers included the ESA-skills training school managers Leo Schoeberle, IFE, and Karl Ring, ZVE; Dr Jussi Hokka, ESA-Estec; Martin Wickham, NPL; Dr Barrie Dunn and Dr Misha Filip, UoP.

European GPS satellite system Galileo.

Professor Dr. Felix Huber

The opening address was given by **Professor Dr. Felix Huber** – Director, Space Operations and Astronaut Training at the **DLR** site. Professor Huber described the work at DLR which covered space missions and the development of navigation systems such as the European GPS satellite system Galileo. The civilian Galileo programme is expected to include 30 satellites orbiting the earth at an altitude of 24,000 kms. This work has begun and already Galileo spacecraft are transmitting signals to the DLR-Command Center. An exciting development at DLR involves the successful construction of Robonauts to support humans in space. Although seemingly science fiction, these robots have been developed and are being considered to be sent into space in order to take on tasks considered far too dangerous for human astronauts.

During the workshop delegates were given a short insight into the DLR Communications and Navigation facility which resembled a mini Houston, with screens showing the location of orbiting European spacecraft as well as a dedicated operations room having direct contact with astronauts on board the International Space Station as it passes over Europe.

Nanoceramic coatings

Dr Giles Humpston

Dr Giles Humpston of Cambridge Nanotherm Ltd, UK, kicked off the workshop session related to *Circuit Technologies*. Nanotherm was founded in 2010 and produces Nanoceramic coatings on various aluminium alloys. These coatings are dense and have a high breakdown voltage being ideal for electronic applications. The Nanoceramic layer can be made to vary in colour from ivory-white to black (dependent on the composition of the aluminium alloy: the darker coatings are made on copper-containing aluminium alloys such as AA2024, the white coatings are produced on purer grades of alloy). Inorganic PCBs can be manufactured from the ceramic-coated aluminium by adhering copper foil to the top surface of the nanoceramic. Such "PCBs" have a thermal conductivity of 115 W per mK. Assembly of components to these "PCBs" (with pre-drilled holes) is similar to the component assembly of conventional epoxy- or polyimide-glass fibre PCBs. This fully inorganic substrate can operate to 350^{0}C, there is no outgassing-under-vacuum and with such a high thermal conductivity it is expected that this novel material will find many applications during the design of spacecraft electronics, combustion monitoring systems and craft heading to the inner planets, Mercury and Venus.

Reliable printed circuit boards for space missions.

Ilknur Baylakoglu

The following presentation was made by **Ilknur Baylakoglu** of the **Saturn Engineering and Training Consultancy**, Ankara, Turkey. She stressed the need for reliable printed circuit boards for space missions. The manufacture of these conventional PCBs can involve about 180 individual process steps. Modern spacecraft PCBs are becoming smaller with increasing component density; new components are introduced early, possibly without sufficient reliability testing - this combination is a potential "driver for failure". The European space industries ECSS standards covering PCBs, such as the design rules, choice of materials and the qualification of manufacturing lines were described. Detailed examples were given of PCB failure modes, particularly those involving plated through vias (PTVs). Ms Baylakoglu characterised the base laminates in terms of glass transition temperature, mechanical properties and other moduli. This well focused presentation concluded with a series of photomicrographs showing the need for contamination-free production lines in order to obviate the growth of conductive anodic filaments and other electrical short circuit occurrences.

Use of passive electronics for low risk satellite payloads.

Dave Davitt

Dave Davitt from **COMDEV, Canada**, a global company manufacturing space hardware for communications, space science and remote sensing satellites, gave an interesting talk that focused on the use of passive electronics for low risk satellite payloads. He described coaxial and stripline circuits for microwave devices and explained the difficulties faced for the electrical signal transition from these circuits to adjacent hardware. The RF VIA approach developed by COMDEV was outlined, together with the need for matched impedance. The circuit laminating difficulties often encountered were explained. Also, a series of manufacturing defects were highlighted by means of metallographic sections and recommended alternative processing methods were provided. An inhomogeneous stripline interface transition was detailed as a novel approach for designs incorporating a transition from alternate impedance circuits to standard 50 Ohm impedance interfaces. This transition included a good degree of stress relief in the axial direction and this novel ISIT interface technology has been qualified for space use.

Embedding ultra-thin chip packages into rigid, and flexible PCB's.

Dr Jan Vanfleteren

The following two presentations were made by **Dr Jan Vanfleteren** from the IMEC Centre for Microsystems Technology, **Gent University**, Belgium. He reported on the manufacturing processes developed at IMEC for embedding ultra-thin chip packages into the thickness of both

rigid, and flexible printed circuit boards. Here, bare commercial semi-conductor dies are thinned down to a thickness of between 20 and 30 microns without losing their functionality. These chips are then embedded in spin-on polyamide material and, using thin-film technology and lithography, the fine pitch chip contact pads are fanned out to a more coarse pitch which is compatible for alignment and contacting with conventional PCBs. These IMAC packages have a thickness below 100 microns and they are mechanically flexible. The full description of the processes were described and physical samples were demonstrated to be completely bendable as they were passed around for assessment by the workshop participants.

Elastic and rigid 2.5D free-form circuits.

Dr Jan Vanfleteren

Dr Vanfleteren's second presentation was equally fascinating; it covered elastic and rigid 2.5D free-form circuits. The copper conductors on these flexible circuits were designed rather like springs so that they could elongate between 60% and 100% without failure. These substrates are made from elastic polymers (e.g. silicone rubbers or polyurethanes). Again, remarkable samples of (wearable) "blue light therapy" *devises* were passed around the audience. These *stretchable* electrical connections are thought to have many interesting features for space applications. Due to their flexibility such circuits could be incorporated as interconnections between highly bendable parts such as on solar arrays and even astronauts' spacesuits.

Nanosilver Die Attach and Other Emerging Technologies for Power Electronics

Dr Klas Brinkfeldt

The next session concerned *Processes and Re-processing* and was started by **Dr Klas Brinkfeldt** of **Swera/IVF**, Molndal, Sweden entitled "Nanosilver Die Attach and Other Emerging Technologies for Power Electronics". Dr Brinkfeldt explained his sintered silver particle material and demonstrated its use in a manufacturing process for low volume, high performance applications – particularly for the attachment of dies in power electronic units. Present common failure mechanisms in power electronic assemblies were illustrated using scanning electron fractographs (wire bond failures, delamination of substrate materials, and the cracking and fatigue of solder alloys, as well as burn-out failure mechanisms). The use of sintered silver nanoparticles in an organic matrix was seen for a die attach application to be of similar, or better, reliability than conventional solder attach processing. Thermal cycling of these die-attach configurations between -40^{O}C and +125^{O}C gave excellent results and, for power cycles between +45^{O}C and +175^{O}C, for the same silver sintered die attachments, up to 160 million power cycles can be envisaged from Coffin-Manson modelling. By using the same environmental testing cycles, present-day solder interconnections would fail at about 40,000 cycles. For real-life applications it was acknowledged that some precautions must be taken in order to avoid silver migration and resulting short circuiting – suitable coatings do exist and would need to be applied to these devices. Also, Dr Brinkfeld considered that the silver sintering process steps could be optimized, and should include a physical pressure cycle that would further enhance the adhesion between mating surfaces. The thermal management of compact, small scale power electronic systems can be improved and this will lead to extending their lifetimes: achievable by cooling component devices on both sides and by the selection of SiC-based substrates with high thermal conductivity. This presentation concluded with examples of SiC-based inverters for electric vehicles and the use of additive manufacturing heat sinks, all developed at Swera/IVF.

Re-processing of leadless semiconductor packages and column grid array (CGA) packages

Mark Walmsley

The re-processing of leadless semiconductor packages and column grid array (CGA) packages are part of the core business capabilities of **Micross Components Ltd** (Crewe, UK). **Mark Walmsley** discussed how lead-free terminations on a very wide range of component packages can be reprocessed at their Crewe facility into tin-lead technologies.

The use of Sn-Pb terminations and Sn-Pb solder interconnections are known to have a higher reliability for military avionics, space, nuclear power and other critical applications –industries producing such hardware are exempt from the EU RoHS directives related to lead-free electronics. A new material/process for Micross involves the practice of using non-collapsible stand-offs incorporated within the solder interconnections of area grid array packages. These have been shown by environmental testing to be extremely reliable for both ceramic and plastic packages mounted onto a variety of PCB laminates. Where column grid arrays are concerned, Micross have transferred a "column last attached solder process" from IBM in the USA to their facility in Crewe. The so-called CLASP columns consist of 10/90 Sn/Pb columns with eutectic Sn/Pb end fillets; they have been approved by US users and will be "qualified" using UK processed packages.

Converting Pb-free Ball Grid Arrays into tin-lead by "robotic hot solder dipping"

Don Tyler

Don Tyler of **Corfin Industries**, Salem, NH, USA, continued the theme of re-processing by describing his company's facility for converting Pb-free Ball Grid Arrays into tin-lead by "robotic hot solder dipping". The use of lead-free terminations with tin-lead solder alloys results in weakened solder joints. This so-called "mixed technology" is unreliable and Corfin Industries have been de-balling Pb-free BGAs using robotic systems for many years. The Pb-free spheres are removed over a solder wave in combination with forced hot air. The devices are then de-fluxed, cleaned and dried before re-balling in a programmable convection oven. Area grid array packages have been re-balled up to 3 times without appreciable loss of nickel or copper from their pads by dissolution into the liquid solder. Quality controls include scanning acoustic microscopy, cleanliness testing and solderability testing to IPC standards. Examples of all the processing steps were described and illustrated by means of a video film and photomicrographs of metallographic cross-sections.

Gaining ESA qualification for surface mount technologies to be used for spacecraft.

Fernando Perez Gracia

Fernando Perez Gracia (**CRISA, Airbus Defence and Space**), Tres Cantos, Spain delivered a challenging, if not controversial, talk concerning the complexity of gaining ESA qualification for surface mount technologies to be used for spacecraft. He discussed whisker mitigation methods and the possible use of Level 2C solder assembly philosophy per GEIA-STD-0005-2, where lead-free tin finishes are permitted under certain well defined circumstances.

Solid-liquid inter-diffusion bonding for MEMS sensor integration.

Antti Rautiainen

Antti Rautiainen of **Aalto University** Finland has spent some time during his doctoral candidacy at ESA studying solid-liquid inter-diffusion bonding for MEMS sensor integration. This technique is based on the formation of intermetallic compounds between high and low melting point alloys. So-called SLID bonding offers high re-melting temperature interconnections with low processing temperatures and small footprints. Antti compared other conventional metal bonding processes with SLID. Both in terms of manufacturing routs and resultant microstructures - mainly for Cu-Sn and Au-Sn final bond structures. He discussed reliability in terms of strength and environmental testing. The samples produced showed some voiding at the progressing Cu_3Sn intermetallic interfaces. Further work will be conducted at Aalto University to

understand the reliability of hermetically sealed MEMS devices, together with the measurement of accurate leak rates.

Growth of conductive anodic filaments (CAF) within multi-layer boards.

Ronald Schonholz

The final session on the second day related to the Failure Modes or potential failure modes related to spacecraft electronics. **Ronald Schonholz** from the **Isola-Group** in Germany reviewed the well-known failure mechanism caused by the growth of conductive anodic filaments (CAF) within multi-layer boards. This is particularly a problem for spacecraft electronics due to their progressive miniaturization. Spacecraft PCBs can be subjected to moisture during ground testing - also when assembled boards are thermal cycled from cold to hot environments they can be exposed to condensed water. The electro-chemistry related to CAF for various laminates was discussed, in particular the weave of laminate glass fibre fabrics was deemed to be very important. New fabrics used by Isola have a more even distribution of glass filaments and are better wetted by resin during manufacture. These are so-called "spread fibres" with Silan finishes (providing a better Si-O-Si-coupling agent to polymer) result in a far better chemically bonded interfaces between glass and resin. Examples of CAF failures were demonstrated by metallographic images for the old fibre systems.

*Electro-chemical migration (ECM) between tracks on PC*Bs.

Poul Juul

Following the CAF review, **Poul Juul** of the **Hytek Institute**, Aalborg, Denmark, demonstrated electro-chemical migration (ECM) between tracks on PCBs. Examples of ECM caused by flux residues were shown. Many examples of laminate failures were illustrated; their causes were said to be often related to insufficient bonding between resin and glass fibre, hollow fibres, poor drilling and void formation. Poul emphasised the urgent need to retain highly skilled persons in the European PCB manufacturing industry (process and chemical engineers, laboratory technicians and operators).

Cleaning aerospacemechanisms with hydrofluorethers

J.H. Serzisko

The company **Inventec**, part of the French Dehon Group, was represented by **J.H. Serzisko**. This company produces hydrofluorethers which are clear, colourless and low odour liquids, partially halogenated carbon bonds, with low boiling points. These liquid materials are used in specialised cleaning tanks for aerospace mechanisms, electronic assemblies, spacecraft mechanisms and for fire protection systems. These cleaning liquids meet all the legal requirements such as REACH and the cleaning equipment requires no local extraction.

Assessing reliability of cleaning flux residues from spacecraft electronics

Graham Naisbitt,

Continuing with the theme of cleaning for spacecraft electronics, **Graham Naisbitt**, Director of **GEN3 Systems**, Farnborough UK, reviewed the topic of flux residues and the need to clean such contaminants prior to conformal coating. All fluxes leave residues which might compromise electronic assembly performance. It is essential to know the electrochemistry of such fluxes and it is strongly recommended that the surface insulation resistance (SIR) of any residues that may be present after cleaning are fully understood. SIR and ROSE testing are the recommended methods for determining whether circuit reliability will be compromised by contaminants including the so-called "no-clean" flux residues. Other techniques such as ion chromatography may be effective at measuring the presence of ionic salts but the method is not suitable for assessing whether reliability will be compromised. SIR testing evaluates whether electrochemical failures may occur in the presence of humidity, ionic contamination and bias. Various ionic contamination test methods are available (ROSE and SEC). These determine the amount of salt (equivalent) remaining on both bare, and component-assembled printed circuit boards.

The tests involve a 75%/25% mix of IPA with de-ionised water. The conductivity of the mix solution is known, and once a contaminated test

PCB assembly is agitated in the solution a second reading computes the dissolved ionic contamination as micrograms/per sq cm NaCl equivalent. A new test method: Process Ionic Contamination Test (PICT) was discussed in detail, including the equipment and the criteria for specimens to pass or fail. The PICT test is described as an inexpensive fast and easy test to control an assembly process accurately.

Challenges and advantages of an independent laboratory as provider of expertise to the space and defense industries.

Cathy Barnes

Ms Cathy Barnes, quality manager at **Spur Electron Ltd**, Havant UK then described the challenges and advantages of an independent laboratory as provider of expertise to the space and defense industries. The services of Spur include engineering and component procurement; they have an advanced manufacturing capability and an extensive laboratory. One of the greatest challenges of an independent laboratory is how information gained from failure investigations can be used to the benefit of the space industry (due to non-disclosure agreements). However analyses and verification programmes conducted for ESA have revealed many problem areas related to component and solder joint failures that can be shared with the entire space community. Problems related to the design and assembly of electronic circuits have been relayed to ESA and Eurospace in order to enhance relevant standards in the ECSS - series. Cathy ended her talk by showing numerous unusual failures, some of which were caused by tin whisker growths.

Results of a tin whisker growth study using a standard accelerated environmental test following JESD22-A121A

Dimas J. Morilla

The results of a tin whisker growth study using a standard accelerated environmental test following JESD22-A121A was described by **Dimas J. Morilla** of **Alter Technology**, Seville, Spain. This is a JEDEC test designed to assess the susceptibility of commercial tin plated components for whisker growth. The numerous past failures caused by tin whiskers were related to satellites, heart pacemakers and the shutdown of nuclear power stations. The Alter test samples included surface mount devices having two tin-plated terminations (chips). These results will be published during 2015. However there is some controversy concerning the JEDEC standard (only whiskers greater than 40 microns are considered potentially harmful and whiskers shorter than 40 microns are acceptable). As this is a short term accelerated test it is not suitable for space electronics. Out of 3 lots of testing, the first lot showed 3 parts having one whisker each, with lengths of 99, 57 and 112 microns respectively. The second lot showed 2 parts with whiskers up to 122 microns length and the third lot showed 41 whiskers of up to 192 microns length. Reliability testing was considered essential whenever tin finishes are envisaged. For long-life electronics the JEDEC standard is probably not suitable. The best strategy, considered by Alter Technology, is to avoid using pure tin-plating on any component parts. Dimas also discussed mitigation strategies that included conformal coating, the use of a nickel barrier layer and component baking treatments. It should be noted that the test components did include a nickel barrier layer between substrate and tin-plating but this was found to be an ineffective mitigation method. Reference was also made to the *Guidelines for a Lead-free Control Plan* published by ESA.

Compilation of results of many whisker growth studies performed at National Physical Laboratory, UK

Martin Wickham

The final paper also concerned tin whisker growths and was given by **Martin Wickham** of the **National Physical Laboratory**, Teddington UK. Martin compiled the results of many whisker growth studies performed at NPL, and particularly the study of various families of conformal coatings applied to tin-plated plates, and their ability to prevent short circuits. All coatings are better than no coatings; whisker growth is greatest at edges where coatings may be thin - it was noted

that whiskers can grow at any time to cause electrically intermittent contacts. Other studies were made using "real assemblies" that included integrated circuits having tin-plated Olin194 lead frames where the leads were heat treated for 15 minutes at various temperatures up to 150^{O}C; some were reflowed at 230^{O}C. It was noticed that increasing the temperature of heat treatment (and also reflow) delayed the time for the first whisker to appear. These tests are continuing, but it is reported that the uncoated control samples have "shorted extensively", and all samples will be revisited/inspected biannually. Martin enquired whether additional companies might support these studies - particularly when considering the effect of vibration and forced air cooling on whiskers emanating from tin-plated component leads?

The Workshop Dinner was held at **Kloster Andechs**, a large property consisting of a beautiful hill-top chapel and an adjoining brewery, owned and run by an order of Benedictine monks. They provided our large group with a specially brewed beer and a simple, but excellent supper. Seating, during this warm sunny evening, was in a beer garden with a spectacular view over the surrounding Bavarian countryside.

Delegates from the EMPS-6 workshop who attended the tour and dinner at the Kloster Andechs, close to Munich".

For those interested to present their work, or attend, the next Workshop (EMPS-7) will be hosted by Bill Strachan and Dr Misha Filip at the University of Portsmouth, UK, on 13 – 14 April, 2016.

Details will be announced on the website:

Review of :-

Isola & Holders Technology Seminar

Worcester Rugby Football Club
Tuesday 16th September 2014

by John Ling

Angus Brunton

It was **Angus Brunton** who welcomed the many delegates to the joint technical seminar being held by Isola and Holders Technology in the imposing conference rooms at the Worcester Warriors RFC,

The aim was to introduce some new products from Isola, and some of the products sold in the UK by Holders Technology.

Angus reminded us that Isola have been making copper-clad laminate since 1956, when a few other holes were being drilled in the area around the Suez Canal. Whilst the Middle East has been steadily going backwards ever since, Isola have been going fast forward with an acquisition campaign and is a truly international company with the Far East covered from their offices in Hong Kong and five manufacturing plants in Asia, North America from their HQ in Chandler, Arizona, with three manufacturing plants in the USA, and Isola in Duren, Germany overseeing two in Europe, with the R&D back in Chandler.

High speed digital,Halogen free, Speciality, PCB Materials

Alun Morgan

Alun Morgan then explained the key technology focus areas – first up was high speed digital, operating up to 100GHz, which was presenting challenges to materials; then came Halogen free materials, required especially for base stations; automotive safety is demanding new materials, too, and CAF, and speciality areas.
With a reminder on how CCL is constructed, Alun said that the three components each play a critical role in the ability of manufacturers to modify the end product to suit the requirement of end use. There have been changes to the epoxy curing chemistry, making very robust structures, and for lead-free soldering the move from dicyandiamide ('dicy') to phenolic curing and beyond had been embraced with good results. The wonders of resin chemistry were described, and the colour changes that the resin system can impart, with dicy cured material not so good for CAF performance, so when a compromise in properties is sought, then it's a balance between mechanical and electrical ones.

The next generation of resin curing will not include dicy', nor phenolic, as was to be explained, but so far the test results are most encouraging, although there may be some additional cost.

Alun looked at the effect of structure on Tg, with very minor changes to the molecular structure having a profound effect on Tg, but with tolerance to higher temperatures greatly enhanced. With expansion as a stress force, cracking is the enemy of m/l boards with high layer counts, and here Isola have materials that will pass TC6 and TC7 (Bosch) thermal cycling tests. One gets there by modifying the filler content.

Losses, in their two forms were described, as was skin effect; copper surface profiles were shown, with copper foil micrographs and their effect on etching, and the subject of loss factors was covered in some detail, with a new generation of PCB substrate called I-Tera MT coming to the fore with a whole range of properties which are required for end use and processing.

Alun concluded with automotive radar development, or 'active safety' which is on the way to us all in new car design and development, and is becoming main-stream. Radar in cars is now common-place, and blind spot detection is also on the way. But the

growth in such components is growing rapidly, and Alun ended with a look at the multi-functional board with embedded components.

New PCB Materials

David Humby

David Humby presented a paper on what is driving Isola on to new materials. It is high-speed, lead-free, low loss, low Dk, Halogen free product, all as a result of discussion with customers, with the Scandinavians taking the lead with halogen free material demand; amongst their new materials are *I-Speed, I-Tera MT, GreenSpeed, 185HR,* with others under launch at the moment.
Alternative materials to PTFEs are now available to designers.

Products include :-

GigaSync, for high-speed application, which has very high thermal performance. Also, there are I-Speed, I-Speed IS, Tachyon, and IS680, a very low Dk material for RF and microwave applications.

I-Tera MT is a very versatile material, with applications in many fields; it has no filler, has a lower dissipation factor, long shelf-life, good cost benefit, and this is made in the USA, in 50" width, with square weave styles, and 2micron copper as standard.

TrraGreen is an ultra-low loss halogen-free option, targeted for backplanes, base station applications, cloud computing, with many good properties including thermal reliability and compatibility with lead-free specifications.

Tachyon is the next generation of ultra-low-loss laminates, low Dk, as close as you want to PTFE, with very good thermal performance, and easy drilling,

Astra MT is a low Dk 3.0 Dk, ideal for the RF/Microwave areas, including automotive radar and sensors; it is available in a limited range of thicknesses, with a good CTE.

Adhesion system - engineered for use between the press plates

Jürgen Knörchen

Jürgen Knörchen of Holders Technology in Germany wanted to talk about Pacomask. This is a patented, engineered adhesion system between mask and subsequently between the press plates to provide complete protection throughout the entire cycle of PCB lamination process.

The adhesion formulation assures a residue-free copper surface on copper clad laminates and separator plates after processing, it significantly improves handling of thinnest copper foils, it speeds the lay-up process and is suitable for all automated handling systems. The end result is a clear, clean, protected copper foil surface, free of epoxy dust, dirt or any other contamination. It has a tolerance of operating temperatures up to 195°C for up to 90 minutes, and the 3 mil film can be applied to copper sheets or rolls of 5 - 70µ

Insulation resistance - sudden loss. Test methodology

Alun Morgan

CAF – this is not an abbreviation of 'caffeine' but a phenomenon that keeps many people awake more effectively. **Alun Morgan** took us back to the 1970's when a sudden loss of insulation resistance was seen in circuit boards which had been subject to hostile operating conditions. Bell Laboratories took up the cudgel of investigating this, and found that the physical degradation of the glass/epoxy bond was permitting moisture absorbtion in conditions of high humidity and electrochemical corrosion followed. CAF is an electrochemical process, and requires three things – water – voltage bias, and a way for ions to move from the anode to the cathode.

High moisture, high voltages and high temperatures can all lead to CAF. Alun explained the test methodology which is not standardised at the moment. He illustrated the CAF resistance plot, with infantile failures, though to wear out failures, and examples where CAF had spread across between holes,

Dicy cured laminates proved to be the worst for CAF failure. With unreacted hardener being the culprit, but the advent of lead-free led to phenolic curing and the reduction of CAF failure.
Design, materials and process all are CAF elements – the sourcing of components, the number of appliances per part, the number of glass layers, etc and then there are laminate fabricator issues, such as the glass cloth, the resin formulation, the laminate thermal resistance, Factors affecting CAF resistance include gap, voltage, curing system, the board shop, orientation, glass weave, reflow, Tg, a mixture of design and materials. The need is to look at the effects that laminate materials, design, and the PCB manufacturing company processes, all of which can have an impact on CAF. A bad fabricator can make a good material bad, but good manufacturers cannot make a bad material good. Says it all, really.

Angus Brunton came back again with a couple of videos; the first was about their Global Analytical Service Laboratories, and he then introduced the IsoDesign service from Isola, a web-based system onto which one merely registers to obtain a design service for high speed digital design needs. This is a 24 hour on-line service.

Doosan Electro Materials

Detlev Kübler

Then **Detlev Kübler** the boss of Holders Germany to talk about Doosan Electro Materials. Doosan was established 118 years ago, and the Doosan Group is one of the top ten in Korea. Revenue has gone from $3.8 billion in 1998 to 23.6 by 2012, and this is based on growth by acquisition; they took over Circuit Foil in Luxembourg for example. Currently they are now No.3 in in packaging material supply to the memory market. Heavy copper clad material capacity has done well, and their flexible CCL has risen from a modest 490 sq. metres per month to 1 billion per month this year. They offer flexible copper clad laminate, including prepreg, coverlays, and have a single-step copper clad laminating line, against the competitor's 3-stage coating system, but with their double sided material they follow more conventional lines.

Mr Kübler described the transition loss properties of the flex ccl range, and he looked at the polyimide range of flex circuitry materials, and here the Doosan range is superior, with better peel strength, transparency and soldering after moisture absorbtion. Also Doosan offer RA copper. It is available in both single and double sided formats.

Glass fabric production and developments

Alun Morgan

Reading from the First Book of Laminations, **Alun Morgan** came to enlighten us about glass fabric production and developments. We got to handle a lump of resin, a bundle of yarns, and we were informed about such things as 'high tensile strength', 'dimensional stability' and 'high thermal resistance' etc. The glass fibres are known as e-glass, made from various metal oxides which are fired at some 3500^{O}F. Yarns have differing diameters, 5-9 microns in diameter, (human hair is 100 microns, just as a guide). Finishing and treating the yarns was described, it's a complex process, with an enormous range of style, thread diameters, and the permutations of warping and wefting seemed endless. There is a relationship between dielectric constant and yarn content, and the features now of a board can correspond with the features of the fibres, so the selection of thread count is important. A square weave is favoured for digital designs. This was a very detailed presentation on glass, fibres, and how these fibres play such an important part in determining the suitability of a laminate for a particular function.

PCB's for Aero Engine Controls.

Ian Fox

The last speaker of the day was **Ian Fox** of Controls and Data Services at Rolls-Royce. His company manufacture aero engine controls. Harsh environments is what they know about – with very high temperatures or very low ones, with high humidity, or low humidity, salt, dust, NOx and SOx. And, of course, vibration.
Aero engine controls sit right on the engine casing, and operate under very high temperatures. It is when operating temperatures are above 150°C that Mil-Specs come into play. Above 200°C and above 300°C Silicone carbide is used but that's expensive. In the field of solder alloys, eutectic SnPb is not good for operations at 150°C +, so they can modify alloys to suit. ENIG as a finish is fine, and above 150°C a polyimide PCB is required. Assembly can be machine soldered using conventional reflow. High Pb content alloy is used with temperatures of between 175°C and 225°C, an AuSn alloy is fine but processing is difficult and has a very steep liquidus line. For all practical purposes 225°C is the upper operational temperature limit for laminate base designs.

Ian listed the factors involved with the environmental protection of assemblies; post assembly cleaning is vital, and a conformal coat is needed to prevent oxidation and corrosion.

Hermetic microelectronics is the way forward, said Ian. Co-fired ceramic packages with integral substrate are either HTCC or LTCC, the HTCC has high thermal conductivity but at higher cost. The Low Temperature Co-fired Ceramic is more cost effective. For service temperatures of above 250°C die attachment works well, with cyanate ester adhesives, and Ag sinter materials for bonding. A hermetic package can be sealed with soldering, either by ultrasonic soldering, or liquid phase sintering. Aluminium wire bonding is fine below 250°C but above that full mono-metallic bonding is required.

The package atmosphere is critical to reliability, and what makes it secure is avoiding outgassing, so that H_2O is absent. This can be determined by a Residual Gas Analysis (RGA).

Ian concluded with a mention of Transient Liquid Phase Sintering, a Physics of Failure approach carried out by CALCE at the University of Maryland. The process uses Sn-rich alloy with Cu and SN parties mixed with flux and used to print the SMT devices and then sintered, and this gives a very solid and secure joint. The predominant intermetallic is Cu_6Sn_5 with a melting point of 415°C. This survived 500 cycles of shock test 1500G with no cracking and 2500 G with no separation.

This was a timely and well-considered seminar that was of obvious appeal to the technical management of the major companies in the UK PCB industry, and in true Isola style it was all done very well.

John Ling
October 2014

Review of :-

Institute of Circuit Technology 41st Annual Symposium

Black Country Living Museum, Dudley, UK, 3rd June 2015

by Peter Starkey

ICT Technical Director Bill Wilkie excels in locating interesting and unusual venues for the Institute of Circuit Technology Annual Symposium. For the 2015 event, the 41st he chose the Black Country Living Museum, an open-air museum of rebuilt historic buildings in Dudley in the West Midlands of England, home of the original Industrial Revolution.

From the smelting of iron with coal and the mechanisation of production with steam power, through the second industrial revolution that introduced mass production with electric power, followed by the digital revolution using electronics and information technology to automate production, we are now entering a fourth industrial revolution with development of the Internet of Things, a concept in which printed circuit boards are unseen but fundamentally essential components.

Welcoming a full house of delegates, Bill Wilkie opened the proceedings by acknowledging the enormous contribution over five years in office of retiring ICT Chairman Professor Martin Goosey, and introducing newly elected chairman Dr Andy Cobley.

Printed Supercapacitors

Dr Darren Southee

The first technical presentation came from **Dr Darren Southee**, formerly of Brunel University and currently Programme Director of Product Design and Technology at Loughborough University. Speaking from a background of 15 years' experience of printing electronic devices using unmodified printing presses, he described recent work supported by IeMRC at Loughborough aimed at broadening the integration of printed power sources with electronic systems, determining the feasibility of making rechargeable energy storage devices using mass produced printed electrodes, and producing a demonstrator.

His team had characterised electrodes produced by offset lithographic printing and new examples produced by flexographic printing using commercially available inks, and investigated the scope to combine them with various electrolytes to construct a range of supercapacitors. A supercapacitor needed high-surface-area electrode material, its resistance needed to be as low as possible to achieve high power and its energy storage was strongly affected by the electrolyte's electrochemical stability window. Trials with the new electrodes in 6-molar potassium hydroxide with a filter paper separator had given realistic electrical results, but there were issues regarding sealing and electrode wetting.

A solid-state version had been developed, by coating each electrode with a PVA gel and allowing it to dry, then gluing the two electrodes together using the same gel and allowing the assembly to partially dry before sealing. No additional separator was required.

A stack of supercapacitors charged to 2.4 volts had been shown capable of powering a 1.6 volt LED for around 90 seconds. In a second demonstration, the printed electrodes were modified by adding an activated carbon layer and an ionic liquid was used as the electrolyte. The two electrodes were separated using filter paper and two supercapacitors were connected in series. In this combination, the supercapacitors could be charged to 6 volts, with a capacitance of around 0.5 Farad, and could light a wind-up torch for over a minute.

Global electronics production

Francesca Stern

Independent business consultant and ICT council member **Francesca Stern** gave her outlook on the UK PCB and electronics industry.

Her figures indicated that the value of global electronics production, excluding components, grew from $1.4 trillion in 2013 to $1.5 trillion in 2014, the main growth coming from Asia, with low single-digit growth in Europe and North America and a 5% decline in Japan. Of a 2013 European total of $154 billion, the UK share was about $13 billion, major sectors being instrumentation, radar and navigation and communications.

Looking at UK PCB production, in pounds sterling to avoid distortion by exchange rate fluctuations, there had been a slight decline from £139 million in 2012 through £136 million in 2013 to £130 million in 2014, with the main market sectors being industrial and instrumentation 36%, military and government 21%, communications 12% and civil aerospace 10%.

Net imports of PCBs into the UK had risen from £41 million in 2012, through £54 million in 2103 to £75 million in 2014. She believed that growth in PCB production in the UK would overall be zero in 2015, although it would appear as low single digit growth because of the shrinking number of fabricators. All regions had peaked on their current growth cycles and she expected the next surge to be in 2017-18.

Fire Retardancy

Professor Martin Goosey

Bill Wilkie presenting an inscribed Quaich to Martin Goosey in Commemoration of the 35th Anniversary of the Annual Foundation Course

Because of other commitments, Alun Morgan, Chairman of the European Institute of Printed Circuits, was unable to attend the symposium and his paper on fire retardancy was presented by **Professor Martin Goosey**, who put his personal interpretation on certain points.

He explained that flame retardants were chemicals which, when added to materials during or after manufacture, inhibited or suppressed the combustion process during heating, decomposition, ignition or flame spread. The presence of flame retardants in otherwise combustible materials had the effect either of preventing the fire from developing altogether or of slowing down the propagation of the fire and delaying the time to flashover so that people could escape.

Annually in the EU there were more than 4,500 fatalities resulting from fires, accounting for 2% of all fatal injuries, and if occupants of a domestic dwelling fitted with working fire alarms were asleep upstairs when a fire started on the ground floor, they would have only about three minutes to escape.

Professor Goosey described the different classes of flame retardants and explained the physics and chemistry of how they worked. With specific reference to the halogenated flame retardant used in printed circuit laminates, the starting material was tetrabromobisphenol-A (TBBPA), which was chemically incorporated into epoxy resin during the manufacturing process. It was only when the resin was burned that bromine compounds were released by chemical breakdown, and inhibited the combustion process.

Unfortunately, there were widespread misconceptions about "halogens", and their perceived toxicity. In fact, halogens such as chlorine and iodine were essential to life, and so far as the end-user was concerned, a halogenated PCB material was no more than a cross-linked polymer that would not burn! The toxicology of TBBPA had been exhaustively studied. No evidence of risk to human health had been observed and there was no clear scientific justification for restricting the use of halogenated flame retardants. TBBPA was one of the first substances to have been registered under the REACH regulations, and was not listed as a "substance of very high concern" Neither was it listed as a restricted material under RoHS. However, the fact remained that

major multinational OEMs such as Apple and Dell were committed to eliminating brominated flame retardants and PVC plastics form their products. Non-halogenated alternative reactive flame retardants for epoxy resin included the phosphorus compound dihydro-oxa-phosphaphenanthrene-oxide (DOPO), aluminium trihydrate and aluminium monohydrate (Boehmite). Halogen-free laminates tended to be more expensive and more difficult to drill. However, they generally had lower thermal expansion, longer T-260 and T-288 times and higher Td temperatures, so might be better suited for multiple reflow processes and able to withstand higher reflow temperatures.

EPSRC Centre for Doctoral Training in Embedded Intelligence (CDT-EI)

Dr Donna Palmer

Dr Donna Palmer introduced the new EPSRC Centre for Doctoral Training in Embedded Intelligence (CDT-EI) at Loughborough University, of which she was the manager.

The centre, jointly sponsored by the Engineering and Physical Sciences Research Council, industry and the university, with funding of £13.6 million, was the first of its kind in Europe and focused on high priority areas such as autonomous complex manufactured products and systems, functional materials with high performance systems, data-to-knowledge solutions such as digital healthcare and digitally connected citizens, and engineering for industry, life and health.

Research in embedded intelligence addressed the challenges posed by the technical needs and requirements of end-users. Challenge areas included design for embedded intelligence, manufacturing of embedded or on-bedded devices, packaging and interconnection, software for data collection, and hard-soft integrative technologies, all converging through applications engineering. CDT students were funded for four years and the programme included technical and transferrable skills training as well as a substantial research element. The centre brought together diverse areas of expertise to train engineers and scientists with the skills, knowledge and confidence to tackle evolving issues and future challenges, and provided a supportive and exciting environment for students, creating new working cultures, building relationships between teams within the universities and forging lasting links with industry.

ICT Chairman

Dr Andy Cobley

MESMOPROC
Maskless metal patterning of non-conductive materials project

ICT Chairman **Dr Andy Cobley**, Reader in Sonochemistry and Materials at Coventry University and Director of the Functional Materials Applied Research Group, reviewed three research projects supported by the ICT.

The Eco-Innovation project **MESMOPROC** combined electrochemical reactor engineering with innovative ultrasound agitation to enable selective metallisation of microscale devices, components and printed circuit boards whilst eliminating repetitive photolithography. The conventional photolithographic method of patterning metal onto a substrate was a long, multiple step process, requiring many chemicals and a clean-room environment, and the mask could be used once only before it had to be stripped off. Electrochemical maskless patterning technology used a low metal concentration electrolyte and very small anode to cathode spacing. The 'mask' was placed on the anode, and ultrasound was used for agitation. The laboratory-scale reactor used in the initial stages of the project had been scaled up, plating trials were currently in progress at a PCB fabricator in the Czech Republic and a high-tech electroplating company in France, and the process was being demonstrated to potential customers and licensees.

A project for maskless metal patterning of non-conductive materials by electrochemical deposition in an external magnetic field was receiving pump-prime funding from Coventry University. The objective was to produce a disruptive, sustainable and cost effective technology for the metallic patterning of non-conductive materials by selective

electroless plating using template of magnetised iron rods mounted behind the substrate to attract metal ions.

e-MINDS
investigating electrochemical processing methodologies and corrosion protection

e-MINDS was investigating electrochemical processing methodologies and corrosion protection for device and systems miniaturization, through a COST action, COST being an inter-governmental scheme to open the European research area to international cooperation in science and technology. Dr Cobley explained that COST encouraged industry participation, and advised how small-medium enterprises could get involved.

Lunch was a less-than-formal event, which involved a walk to the museum's High Street and queueing for traditional fish and chips, cooked in authentic beef dripping by Hobbs and Son, served in newspaper with salt and vinegar and consumed while standing in the street!

Chip wrappers ecologically disposed of and greasy fingers washed clean, delegates returned to the conference room for the afternoon session, which began with an authoritative guide to the selection of PCB materials for LED lighting applications by **Les Round**, Technical Sales Manager at Spirit Circuits.

Selection of PCB materials for LED lighting applications

Les Round

The PCB was an integral part of a modern LED luminaire, providing a convenient base for assembly and subsequent fixing of LEDs into the luminaire, thermal management of the LEDs, and an aid to power and light efficiency.

LED applications fell into three main categories: low wattage / low density, mid power and high power, each of which required a substrate that balanced cost against performance.

A typical low power / low wattage application was in ceiling-tile lights, accounting for large numbers of large-area single-sided PCBs on which there was a relatively low thermal demand. Low cost, flatness and high reflectance were fundamental requirements and these could be met by CEM1 material, which cost less than equivalent single-sided FR4 and had better flatness, although it needed to be selected carefully to ensure reflow compatibility. The finished surface required high reflectivity to maximise luminaire efficiency. This had opened up a market for specially formulated white solder resists and Round described test methods developed at Spirit for qualifying reflectivity

For mid- to high-power applications, the main requirement of the PCB was effective thermal management in order to improve efficiency and longevity. A wide range of IMS materials was available to meet most thermal demands. Materials could be selected based on cost versus performance, although customers sometimes specified particular proprietary grades. Spirit had evaluated more than 70 commercially available IMS material using their own testing procedures, and had produced a league table of thermal performance. A simulated down-lighter test was used to compare high-specification IMS, traditional IMS, branded Chinese IMS and unbranded Chinese IMS. Only the unbranded Chinese material gave unsatisfactory results, and Round advised caution in selecting this type of product from data sheet values alone, without doing practical testing. He strongly recommended that the materials and panel sizes were selected as early as possible in the design cycle, and that designers used their PCB suppliers' product knowledge to best match materials to the specific requirements of the application: thermal performance, flatness, solderable finish and solder resist.

FOD
Foreign Object Damage.

Ian Mayoh

Ventec Europe Technical Support Manager **Ian Mayoh**, explained "what the FOD was going on", FOD being Foreign Object Damage.

Having started by illustrating some extreme examples of aviation disasters, he focused on the growing awareness of foreign object damage in electronic devices, particularly in ultra-high-reliability applications, where critical failure could result in loss of life or have extreme cost implications.

In the case of multilayer laminates, particularly in cores less than 50 microns thick, the avoidance of FOD was becoming increasingly critical and he referred to recent proposals by the European Space Agency to add an appendix on laminate cleanliness to the IPC-4101-D specification.

Mayoh went on to explain the steps that Ventec had taken to establish a clean, quality-driven culture at all stages of their AS9100C-accredited integrated supply chain, from raw materials, resin processing and prepreg treating, layup and lamination, all the way through their fabrication and distribution operations. The company's fundamental policy was to manufacture quality into their products, rather than to inspect defects out, and as result of their investments and procedures they were now able to mass-produce dielectric layers of 30 microns and below to enable customers to build HDI constructions with full confidence in the cleanliness of the material.

STOWURC
Sustainable Treatment of Waste Using Recycled Chitosans.

Dr Emma Goosey

Final speaker of the day was **Dr Emma Goosey** from MTG Research, with an update on the STOWURC project - Sustainable Treatment of Waste Using Recycled Chitosans.

The requirement to remove low levels of metal pollutants such as copper and nickel from PCB manufacturing effluent could be achieved using ion exchange resins, but an alternative was to use waste natural products and it had been observed that chitin, present in crab shells, could absorb these metals.

Disposal of crab shell waste from the food industry was expensive and subject to various legislation, so to use the waste from one industry to treat waste from another industry and to recover potentially valuable metals was an attractive proposition.

Dr Goosey described how crab shells were prepared for use by first crushing and demineralising, then treating with alkali to convert chitin to chitosan, which was a more efficient absorbant, by de-acetylation. The resulting material had been shown to give consistent fast uptake of copper and a high rate of recovery from actual PCB manufacturing effluent. Ultimately, it was found that the copper could be desorbed into sulphuric acid to give an electroplating solution from which metallic copper could be recovered galvanically, and the metal-free chitosan could then be reused.

The Institute of Circuit Technology continues to grow its membership, and the Annual Symposium is a major occasion that attracts most of the leading names and faces of the UK PCB industry. This year's event was not only a platform for exchange of knowledge and ideas but another great opportunity for building networks and collaborative relationships.

Pete Starkey
I-Connect007
June 2015

Corporate Members of The Institute of Circuit Technology July 2015

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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	0121 606 7777 www.atotech.com
CCE Europe	Wharton Ind. Est., Nat Lane, Winsford CW7 3BS	01606 861 155 www.ccee.co.uk
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Falcon Group	Riverside Ind. Est. ,Littlehampton BN17 5DF	01903 725 365 www.falconpcbgroup.com
Faraday Printed Circuits Ltd	15-19 Faraday Close, Pattinson North Ind. Est., Washington. NE38 8QJ	01914 153 350 www.faraday-circuits.co.uk
Graphic plc	Down End, Lords Meadow Ind. Est., Crediton EX17 1HN	01363 774 874 www.graphic.plc.uk
GSPK (TCL Group)	Knaresborough Technology Park, Manse Lane Knaresborough HG5 8LF	01423 798 740 www.gspkcircuits.ltd.uk
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PMD (UK) Ltd.	Broad Lane, Coventry CV5 7AY	02476 466 691 sales@pmdgroup.co.uk
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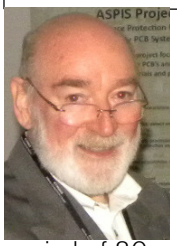

The Membership Secretary's notes - July 2015

This year we held our Annual Symposium at the Black Country Museum in Dudley, and exactly seven years ago to the day, we held it at the Tweed Horizon Conference Centre in St Boswells, Scottish Borders. That event was set up for us by Mike Osmond, whose company Intrasys Design operates from the centre and Mike was also able to offer a facility tour at the end of the Symposium. Inrasys Design Ltd was established by a group of senior designers who have between them more than 190 years of expertise in the PCB industry. The team has worked together for many years through different evolutions, developing extensive skills over a period of 30 years, in all aspects of PCB layout from concept to product build.

Mike Osmond

Mike delivered the Design for Manufacture lecture for many years at the NUKCG Basic Course at the Heriot Watt Campus and continued to travel to the Midlands, when we moved the course to Loughborough in 2005 as the Annual Foundation Course in PCB Design and Manufacture. Pressure of business meant that Mike passed the lecture mantle over to Martin Cotton, but we owe Mike a debt of gratitude for his dedicated support over many years. We visited the Tweed Horizon Centre once again and presented Mike with an inscribed Quaich to commemorate the 35th Anniversary of the Course.

We were also able to surprise ex-Chairman Martin Goosey at the Annual Symposium this year, by presenting him with an inscribed Quaich to mark the 35th anniversary of the Foundation Course. Martin presented the Lead Free Assembly lecture for many years and was always on hand as Chairman to hand out the Associate Membership Certificates at the end of the course and we thank him for his long standing contribution to the Foundation Course.

Institute of Circuit Technology

Evening Seminar

Tuesday 22nd September
at Newton House Hotel, Hayling Island

The REINDUSTRIALISATION of EUROPE

Interim list of Papers

ROMANIA - Joining the EU and the supply chain opportunities.
Repatriating PCB fabrication from Asia to Europe – ie Romania
Sculptured Circuits and SMI Surface Mount Interconnects

A the close of the seminar, a Romanian Quartet will be performing some classical music while we eat

Further details will be posted shortly

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