Journal of the
Institute of Circuit Technology
Vol.8 No.4 Autumn 2015 Issue

2015 Events

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

24th November *Tuesday* **ICT Northern Evening Seminar** at St. Georges Hotel, Darlington bill.wilkie@InstCT.org

2016 Events

1st March *Tuesday* **ICT Evening Seminar & AGM** at the Hilton Puckrup Hall Hotel, Tewkesbury. bill.wilkie@InstCT.org

11th-14th April *Monday - Thursday* **ICT Annual Foundation Course** at Loughborough University bill.wilkie@InstCT.org

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

1stJune *Wednesday* **ICT Annual Symposium** at M Shed, Bristol bill.wilkie@InstCT.org

Editorial

The provision of education and training has always been one of the major objectives of The Institute of Circuit Technology since it was established in 1974 and, for a number of years, John Brooks ran a residential ICT Basic Course at Bournemouth Technical College, this was transferred to Oxford University on the appointment of Pat Kirby as ICT Organiser. *(at about this time the Printed Circuit Group of Institute of Metal Finishing was also running courses of Evening Lectures)* The Northern UK Circuit Group founded in 1980, also ran its own two week "Basic Course in Printed Circuit Technology" up in the Borders region of Scotland where like, the ICT course, the lectures were presented by suppliers and PCB manufacturers, The attendees were also drawn from both suppliers and manufacturers to and in the PCB industry.. The two courses ran in parallel for years until the ICT course was halted as a result of Pat Kirby's untimely death.

I was privileged to attend the NUKCG course in 1982 as a supplier. Several of the other attendees on that course are still active in the PCB industry today. I was also honoured to be asked to present lectures on "Inks for use in the PCB Industry" on the ICT course in Oxford and still have the hand-drawn OHP slides that I used – no PowerPoint back in those days!

Although the ICT course in Oxford stopped, the NUKCG course continued unabated until 2005 when it was moved to Loughborough University and promoted jointly by the ICT and NUKCG until 2007 when the NUKCG was wound up.

The course is now promoted by the ICT and run by the ICT Organiser Bill Wilkie as the "ICT/NUKCG Foundation Course" and has, of necessity, been shortened from the original 2 week course with an exam at the end, to a 4 day course with no exam. This reflects the difficulties of the companies releasing their attendees for such a long time. Nevertheless, the quality of the education material and training freely provided by the lecturers remains extremely high and this is reflected in the number and variety of backgrounds of the delegates.

Recent courses have had between 20 to 30 delegates, nearly all young people, new to the industry, some from Suppliers and some from Manufacturers, mostly from the UK but with a few from overseas. The Foundation course provides them all with a good, basic understanding and overview of the different processes and materials used in the manufacture of PCBs. My own experience of presenting on the course is that the delegates find the course both interesting and enjoyable and engage fully with the presenters, asking thoughtful questions during and at the end of the lecture. Feedback from the delegates is almost universally good and confirms the benefit they receive from attending the course.

Not only that but relationships are built which, as my own experience can testify, can last many years and can only be to the good of the industry as a whole. The next course will take place in early 2016 (date to be confirmed) and I would, without reservation, recommend it for all new entrants to the PCB industry, as a unique and important block in their education and training programme.

Chris Wall
ICT Treasurer

Membership *New members notified by the Membership Secretary*

10367 Clive Wall M.Inst.C.T.
10368 Gareth Greig M.Inst.C.T.
10369 Mike Devine M.Inst.C.T.
10370 Frederick Martin F.Inst.C.T.
10371 Nigel Davies M.Inst.C.T.
10372 Robert Hunter M.Inst.C.T.
10373 David Boardman M.Inst.C.T.
10374 Andrew Weddell M.Inst.C.T.
10375 Jonathan Calver M.Inst.C.T.
10376 Peter Kirwan M.Inst.C.T.

Corrections & Clarifications

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

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Review of :-

The Reindustrialisation of Europe
Institute of Circuit Technology Seminar

Hayling Island, Tuesday 22nd September 2015

by Pete Starkey

Re industrialisation

Steve Driver

With an inquisitive mind and a head for challenges, besides the ability to think outside the box and the courage to dare to be different and strive to be first, Spirit Circuits MD **Steve Driver** can be relied upon to grab the attention of an audience of PCB professionals. As keynote speaker at the Institute of Circuit Technology Hayling Island Seminar, he lived up to his reputation with a motivational presentation, the two themes of which exemplified his latest entrepreneurial venture.

Driver's primary theme was the Re industrialisation of Europe, specifically the repatriation of PCB fabrication from Asia to Europe. Taking his LED substrates business as the example, he remarked that the typical customer "wanted them cheap and wanted them quick! He had for several years been successfully using Chinese sources for his production quantities, but freight charges were an increasingly large proportion of the bought-in cost. Why not source the boards closer to home? Why not *make* them closer to home, but in a lower-cost area than the UK?

With the help of his local chamber of commerce, and specifically through an initiative known as BRIDGE providing practical in-country support to maximise trade opportunities in eastern Europe, he had formed strong links with their counterpart chamber of commerce in the county of Dolj in Romania and after a year of due diligence had purchased a site in the city of Craiova with the aim to have a new PCB factory operational during 2017. The attraction of Romania went far beyond low cost of labour - excellent infrastructure and logistics were already in place, English was widely spoken and the standard of education was excellent - Driver had already signed a memorandum of understanding with the local university. And European funding was available to encourage the establishment of manufacturing industry.

What imaging technology did Driver plan to employ in his new factory? "The future is digital! And we're going to have the first fully digital factory - in Europe anyway - the Americans got there first!" referring to the newly opened PCB facility at Whelen Engineering in Chester, Connecticut, and commending the attributes of the ink-jet primary and secondary imaging equipment manufactured by Dutch company Mutracx. Whelen were an OEM who, having previously sourced their PCBs in China, found that they could make substantial cost savings by re-shoring and bringing manufacturing in-house, under their own control. Driver predicted that there would be a resurgence of captive-shop PCB manufacture.

Digital ink-jet imaging

Andre Bodegom

Expanding on the "future is digital" theme, and speaking from a background of over 15 years' development experience of digital ink-jet imaging applications in PCB manufacture, **Andre Bodegom**, Managing Director of Adeon Technologies in the Netherlands, described two complementary systems, the Adeon JetRite legend printer and the Camtek Gryphon solder mask deposition system.

"Before I became a dumb salesman, I was a dumb engineer...." Was his self-effacing introduction as he went on to explain how the JetRite system had been progressively improved and refined by close collaboration with users, to develop a robust and reliable production-friendly machine which combined versatility and ease of operation and maintenance with low cost of ownership. Besides the obvious advantages of inkjet technology over screen printing or photolithography, the machine offered automatic print-

head cleaning before each print, automatic three-point alignment with automatic compensation for board translation, rotation and scaling, and automatic panel height and print-head adjustment. The machine was ready to print within 30 seconds from standby and every job, every setting and every event was logged and timestamped. On-the-fly UV tack curing enabled immediate second-side printing and a typical print cycle was 75 seconds for a 21" x 15" panel at 720dpi with 14 picolitre drop size. "One speed setting - Fast. One quality setting - High!" was the principle.

Cooperation with Agfa and Xaar on ink and print-head development had enabled improvements in JetRite's ability to overcome the challenges of layer-by-layer 3D build-up and "climbing over" copper features as high as 200 microns. Print-head life had been greatly extended, and could now well exceed two years. And in response to customer demand for on-the-fly two-colour printing, the system could be configured with four heads, two for each colour, with a choice of black, white and yellow. Bodegom re-emphasised that the enhancement of system performance and capability relied upon continuous dialogue and collaboration with users and suppliers.

The quest for ink-jet solder mask had been long and arduous. Many claims been made in the past and many hopes raised, only to culminate in failure and disappointment. Camtek's Gryphon digital inkjet solder mask deposition system represented several years of combined equipment and material development, and was claimed to be the world's first successful solution. It overcame a whole series of traditional process technology limitations, particularly registration, pad clearance, solder dam definition and robustness, and freedom from resist in holes, and offered the process advantages of high yield, faster production, less manpower requirement and small footprint, besides being a "green" no-waste procedure. And, of course, these all contributed to cost savings. The system used real-time alignment and built-in AOI to match the image to the actual panel, and the print-head recognised and followed the 3D topography of the PCB surface. The ink was immediately tack-dried with a built-in UV curing system. Described as a "one-stop-shop" for solder mask and legend deposition, Gryphon had the capability to print solder mask and legend consecutively from a single alignment, with consequent reduction in total process cycle time. From Camtek's point of view, there were clear benefits in being in control of their own ink development, manufacture and quality assurance, with the ability to optimise their formulations for printability and physical properties whilst responding quickly to meet the needs of their customers. Their inks met the requirements of IPC-SM-840E and IPC-4781, and were qualified to UL94-V0.

Sculptured circuits

Peter Dobromylski

A division of Spirit Crcuits PCB Solutions Group is Lyncolec, a NADCAP AC7119 and AS9100 accredited manufacturer of flexible and flex-rigid circuits. Sculptured circuits are a differentiated form of flexible circuits with conductors of variable thickness able to carry heavy currents, provide physical robustness and enable unsupported fingers to be produced. Lyncolec's **Peter Dobromylski** took the opportunity to discuss their characteristics and applications. He explained that the manufacturing process began with a 250 micron copper sheet on which the conductor image was printed directly using photoresist. Chemical milling techniques were used to remove unwanted copper and to selectively reduce the thickness in conductor areas where flexibility was required, but to leave the original thickness where rigidity or high current carrying capacity was needed. Precisely located apertures of any shape or size could be placed at any position. The technology enabled the thickness of the copper conductors to vary at any point on the circuit, and selective application of the supporting dielectric enabled the production of integral exposed fingers which could be used directly as connector pins, either straight or

post-formed. The dielectric was generally polyimide, but polyester or polyethylene naphthalate (PEN) might be specified depending on thermal performance requirements

Dobromylski discussed design rules and tolerances, and handed round samples of custom interconnects for applications ranging from motor sport to missiles, demonstrating how sculptured circuits could provide a cost effective solution to complex interconnection problems whilst simplifying assembly and increasing reliability.

Surface mounted interconnects (SMIs) were an ingenious spin-off of the sculptured circuit principle. Effectively small jumper circuits, available in a range of standard patterns but made to specific design if required, they were packaged on tape reels for use on pick-and-place machines. Placed as a surface-mount component across a routed slot in a panelised rigid circuit, an SMI became a flexible bridge between rigid areas once the assembly was broken out of the panel - a low-cost flex-rigid circuit!

BRIDGE *(British Romanian International Development Gateway Exchange)*

Calin Huma

Steve Driver returned to introduce **Calin Huma**, CEO of BRIDGE (British Romanian International Development Gateway Exchange), who had been instrumental in introducing him to business and commercial opportunities in Romania. Huma, who had grown up in Romania, but had studied and worked in the UK for many years, described how the country had developed in the years following the execution of Ceausescu and the end of the communist regime in 1989. "Before 1989, all we knew about capitalism was what we had seen in American cowboy movies!" With freedom came responsibility: there had been considerable difficulty in forming a government and constitution, democratising institutions, devolving power and adjusting to a free market economy with poor material resources. But major engineering companies like Rolls Royce and BAE Systems had set up manufacturing operations in Romania and there was a rapidly developing industry in aerospace, naval and automotive engineering. And the Romanian people had great respect and admiration for the British culture, and were keen to integrate. "Forget what you read in the press, we are not all bad apples!" Since 2007 a member of the EU, Romania now had the highest economic growth rate in Europe, a central location and a well-established infrastructure. So it offered great opportunities.

Thanking Calin Huma for his inspirational presentation, **Steve Driver** asked "Why should I share my experiences and business plans at an event like this, when my competitors are present? One reason is that I want to encourage not just them, but our supply base, to follow us into Romania. By the way, who moved my cheese?"

Driver concluded the proceedings by revealing that Calin Huma was not only an international facilitator but also an acclaimed composer of classical music, whose symphony "Carpatica" was shortly to be premiered in London by the Philharmonic Chamber Orchestra. And in typical Driver style, he had invited a Romanian string quartet to provide a musical round-off to the evening.

The ICT Hayling Island Seminar has become a premier event in the Institute's technical programme, and a great meeting-place and networking opportunity for the UK PCB industry and European visitors.
And Steve Driver will unfailingly deliver an out-of-the-ordinary experience.

What may next year's event hold in store.....?

Pete Starkey
I-Connect007
September 2015

ICT Seminar Cabaret

Delegates listening to the Romanian String Quartet

Update of Progress on :-

The ICT's Research and Development Projects

by :-

Martin Goosey – Institute of Circuit Technology
with major contributions from
Emma Goosey – MTG Research Ltd (STOWURC)
Andy Ballantyne – University of Leicester (MACFEST)
Stuart Dalrymple – C-Tech Innovation Ltd (REPRIME 2)

Prof. Martin Goosey

For the last five years, the **ICT** has been an active partner in a number of collaborative research and development projects, both at the UK and European levels. The Institute's first engagement in this type of activity was in the European FP7 ASPIS project, which investigated various aspects of nickel gold solderable finishes. This was a complex project that studied the reliability of these finishes from a basic mechanistic perspective, while also developing prognostic approaches to early reliability issue detection and new high performance metal deposition processes.

The project was successful in a number of key areas, especially around the fundamental understanding of 'black pad' formation and in the demonstration of new, non-aqueous coating processes. However, it also highlighted that such complex projects were difficult for the ICT, with its limited resource availability, to support.

As a consequence, the ICT has continued to engage in collaborative R&D projects, but in a more modest and manageable way, by contributing to the dissemination activities of two multi-partner UK Centric R&D programmes. In this way, the ICT receives grant funding for its role in the projects and it is also able to bring the results and outputs to its members via evening seminars, the ICT website and this journal.

The ICT is currently engaged as the dissemination partner in two **Innovate UK** supported projects and these are known as STOWURC and MACFEST. STOWURC is a two year project that concludes at the end of November this year, while the MACFEST project started in January and runs until the end of December 2016.

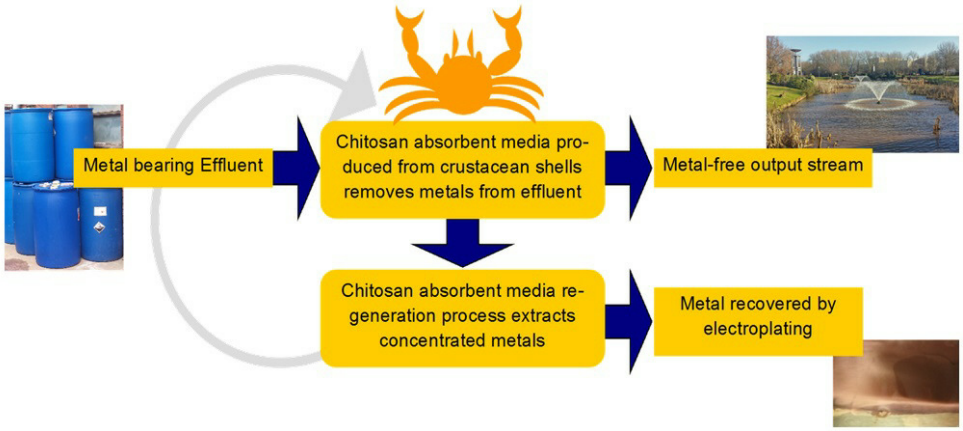
STOWURC
(Sustainable Treatment Of Waste Using Recycled Chitosan)

STOWURC is short for Sustainable Treatment Of Waste Using Recycled Chitosan and it has regularly been called the 'crabs' project. The project concept has a focus on the use of a waste product from the seafood industry, in this case crab shells, to treat waste generated by the printed circuit board and metal finishing industries.

Specifically, the project is using chitin, which is a key component of crab shells and its close analogue, chitosan, to capture metals such as copper from production effluent. Both chitin and chitosan are well known for their abilities to capture a wide range of metals and the project is developing optimised materials and processes aimed at the recovery of copper from PCB manufacturing waste.

Crab shells can naturally absorb metals from a solution, for example, crab shells that have been ground to increase their surface area can typically remove up to 40% of the copper found in PCB manufacturing effluent. However, this natural material's metal absorbency efficiency increases with chemical treatment and purification of the natural polymers found in the shells (chitin and chitosan). Unfortunately, at each stage of material refinement, an additional cost is incurred and so there is trade-off/balance that needs to be achieved between efficiency and cost, in order to optimise the materials and processes that can make them both applicable and economically attractive for use in the PCB and metal finishing industries.

Currently, effluent from manufacturing sites is typically treated with ion exchange resins and other synthetic absorbent materials. Replacing these materials with the crab-shell derived biomaterials, or by using the crab biomaterial before the synthetic materials, can reduce costs and, in the second case, significantly extend their lifetimes. Use of the biomaterial is relatively simple; shells can simply be ground to an optimum particle size and packed into columns as a loose particulate in a similar manner to an ion exchange resin. This type of application can reduce waste treatment costs and enable copper to be recovered via subsequent electro winning or refining methods.



The basic STOWURC concept for using crab shells to treat manufacturing effluent

As the STOWURC project progresses towards its successful conclusion, a pilot plant unit is being installed at **Invotec** in Tamworth and, at the time of writing, initial industrial scale trials are about to begin.

The pilot plant will be used to reduce copper concentrations directly from copper-rich effluent derived from the plating lines at Invotec. Based on the results of the work to date, it is expected that copper levels will be reduced to below 5% of the inflow concentration. A promotional demonstration event is due to be held at Invotec Tamworth in December, at which the grant funding body, Innovate UK, will attend.

Additionally, the project work has also recently been extended to tailor the crab shell derived biosorbent materials for use in spill pillows and emergency kits. The application of crab biosorbents as spill media, allows for fast and easy retention of hazardous materials present in spillages. The bags are even reusable after the copper is recovered. The project consortium has also been looking into other applications for these biosorbents, both in the UK and further afield, including applications with other metals and in other industries beyond the PCB and metal finishing sectors.

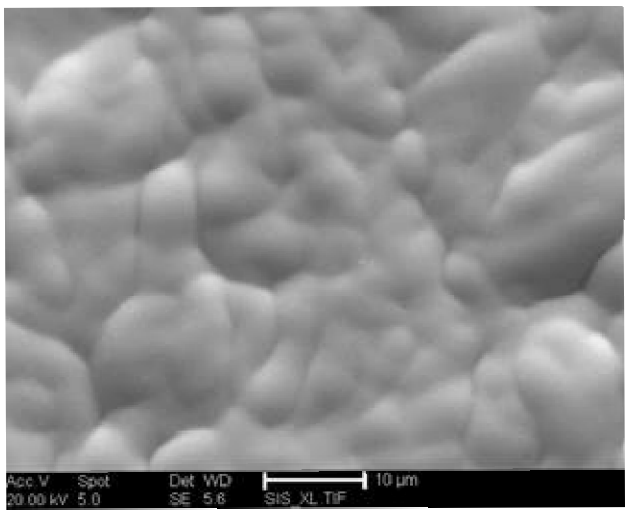
MACFEST

The second R&D project in which the ICT is engaged, MACFEST, is now in the fourth quarter of what is also a two year project, so it is nearing the halfway stage. It is seeking to build on one particular successful aspect of the ASPIS project mentioned above, which was deposition of novel metal coatings from non-aqueous media, using tailored ionic liquids, rather than water to form the deposition solutions.

By using such ionic liquids, it has previously been shown that the properties of metal coatings deposited from ionic liquids could be markedly different from those deposited using traditional aqueous deposition routes. The different grain structures and deposit morphologies were found to have a beneficial impact on subsequent coating solderability, performance and reliability.

With the key objective of developing a more sustainable and low hazard nickel/palladium/gold film plating methodology, the Innovate UK supported MACFEST project is currently progressing ahead of schedule. It

has thus far seen the development of a novel immersion palladium coating onto electroless nickel that satisfies the thickness requirements of the IPC-4556 standard. In addition, it has been demonstrated that the deposition of an immersion gold coating onto these surfaces is also possible and work is ongoing to finalise this process.



SEM of an immersion palladium coating on electrolessly deposited nickel.

Having developed the novel plating methodology, the next step is validation of the resultant coating quality and its efficacy for use as part of a "universal finish" for both soldering and wire bonding joining technologies in the electronics industry. The performance will be evaluated through standardised testing methods, followed by production of PCBs on a production scale with inputs from **C-Tech Innovation Ltd** and **Merlin Circuit Technology Ltd.**

REPRIME 2

The ICT has also recently become involved in a third project known as REPRIME 2, which is being led by C-Tech Innovation Ltd. REPRIME 2 is studying the application of advanced ultrasonics to enable the replacement of 'explosive precursors and poisons' used in industrial metal plating processes.

Most of the project's technical work is being carried out by C-Tech, but the ICT**,** along with the **Surface Engineering Association**, is making a contribution in terms of identifying the process chemistries currently used by their respective sectors and providing market analysis information.

Most surface modification chemical treatments used in the PCB and surface engineering sectors, by their very nature, contain hazardous and oxidising chemicals. There is thus a major concern that these chemicals might be used maliciously with the intent to manufacture explosives or to formulate poisons that are harmful to the public. For example, cyanide-based plating solutions and high concentrations of hydrogen peroxide find significant use in these industries.

The use of cyanide and hydrogen peroxide is concentrated in a few industries: large polymer manufacturers, chemical manufacturers, and surface finishing companies.

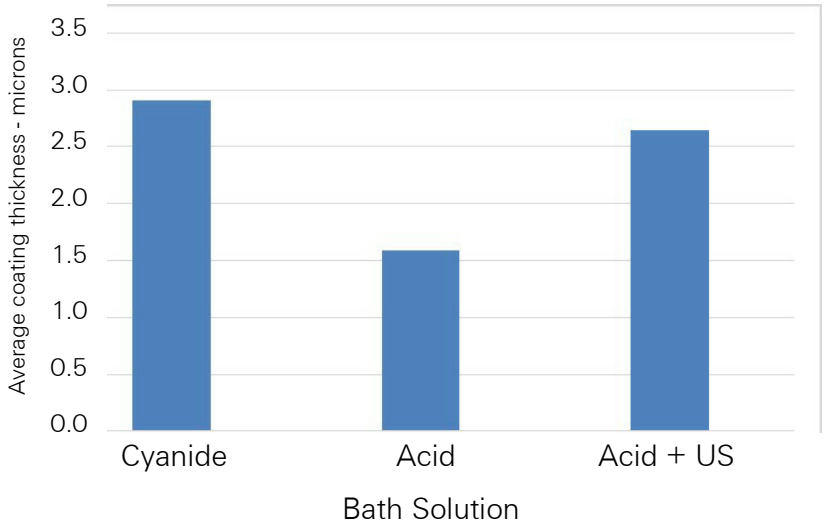
Surface finishing and PCB manufacturing is deemed to be a particular risk area, as the sites where these processes are run are often small, distributed and less secure than large chemical plants. Consequently, significant amounts of these potentially dangerous substances are found across the UK, with varying and sometimes limited control over their use, representing a significant risk. Ideally, these harmful materials could be replaced with more benign alternatives.

There has long been an interest in finding viable replacements for cyanide in metal plating applications, but there are significant barriers to implementation related to the quality of the coatings produced and related process operational requirements. The introduction of novel ultrasound technology can overcome some of these barriers, but it must be validated on full scale processes and over a range of plating systems before it will be accepted by industrial end users.

The introduction of ultrasound to current industrial protocols has already been demonstrated in the first phase of this REPRIME project to allow the removal of cyanide from metal plating processes, and significantly reduce the amount of hydrogen peroxide used. A small test plating line was set up featuring an ultrasound tank in which barrel plating, vat plating or PCB etching could be performed, (see the figure below).

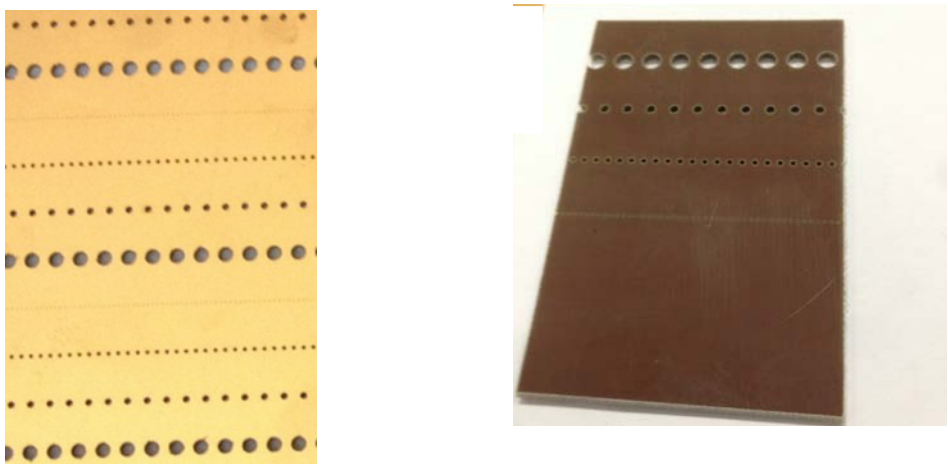
Ultrasound reactor showing the transducers (left) and barrel plating (right)

Results from zinc plating trials on fixings, showed that cyanide-free solutions could be improved in terms of the weight addition and the coverage consistency via the appropriate application of ultrasound. The technique particularly aids coverage when used on unusual shapes and when plating through holes which are typically problematic with cyanide free solutions.



Improved plating rate on hex-nuts in acid-based zinc plating solutions when ultrasound is applied.

Ultrasound was shown to reduce the levels of hydrogen peroxide required in etchant solutions used in PCB manufacturing. However, the biggest improvements were seen when considering bath life. Baths treated with a particular configuration of ultrasound could perform over significantly longer timescale without performance degradation. Therefore, bath chemistry can be replenished at a less frequent rate, reducing both chemical use and handling requirements.



PCB test materials untreated (left) and treated (right) with a hydrogen peroxide based etchant.

To go beyond the current process development and achieve impact in industry, the scope of the work must be increased to testing on an industrially relevant scale and to broaden the range of processes covered.

Work is currently focused on making cyanide-free technology more attractive on performance grounds to overcome barriers to implementation.

The overall aims of the project are as follows:-

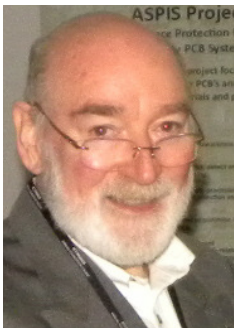
- Demonstration of Zinc plating at a scale relevant to industrial systems.
- Ensure technology can be easily used with existing equipment.
- Extend plating trials to other cyanide plating systems such as copper, gold and silver to cover the bulk of the industrial processes.
- Carry out hydrogen peroxide etching on a full PCB manufacturing scale and for prolonged bath life trials.
- Work with industry bodies, i.e. the SEA (Surface Engineering Association) and ICT (Institute of Circuit Technology) to engage and inform industry.

There is huge potential for this technology to make a positive impact to the reduction of dangerous chemicals with over 1,000 factories in the UK operating surface finishing or PCB manufacturing processes. The outputs from these industries are cross sectorial, including vast markets within the automotive, aerospace and electronics sectors. It is hoped that through this research work, a viable technical solution can be applied through this industry. This work has been made possible due to funding received from The Home Office.

The ICT's current engagement in these three projects, as well as the earlier ASPIS project, has been beneficial in a number of ways. It has enabled the Institute to play its part in advanced research and development activities that would otherwise not have been possible. This has generated new information for the benefit of its members while also helping to confirm the Institutes status as the learned body representing the UK PCB industry. Finally, engagement in these projects has generated a small but valuable revenue stream to the Institute that has helped to support these activities. It is to be hoped that the Institutes engagement in this type of activity will continue for the foreseeable future and I would be pleased to hear from members if they have any ideas or suggestions for new projects of this type.

Martin Goosey
1st October 2015

The Membership Secretary's notes - October 2015



Bill Wilkie

The ICT/NUKCG Foundation Course

The origin of the present course goes back to a meeting held at the Hewlett Packard facility in South Queensferry in the autumn of 1979. This facility was advanced even for the seventies, with all the facilities, including the tank farm, in the basement and they didn't bother with anything as mundane as a solder mask, having gold all over as their corporate finish!

The meeting was well attended by over 100 delegates, including me, and proposed the start-up of a Northern Circuit Group – from Manchester upwards to align with the more London centric existing organisations. Anyone could become a member, and the Group initially had three tenets – organise seminars, set up a training course and run an annual dinner dance.

Jeff Paterson, who was the technical manager at Bepi Electronics, was in charge of setting up and running – The Basic Course in PCB Technology - at the Borders College in Galashiels. The syllabus was given to the group by Brian Pledger, who was running a similar course at Slough College of further Education. Prestwick Circuits supplied the secretary (Peter Carmichael) and the donkey work and advertising fell to Brian Murrin.

The course was run over two weeks and was based on the same principle as today of inviting industry experts to give presentations. The course had a get-together dinner and also latterly, a multichoice question at the end, with a Fifty Pound book token as first prize. Each delegate was given a copy of John Scarlett's book (an Introduction to Printed Circuit Board Technology), which was quite an expensive giveaway, even when bought in bulk.

Jeff left in 1985 to join PAL in Hong Kong (eventually becoming MD) and I was given the task of organising the event – as a local. As we were all volunteers, the course could not be covered by one person, and although I was required to attend the start-up and closing down of the course (and the get-together dinner) other members of the committee looked in on the course during the two weeks.

No internet in those days, and all communication was by letter and I spent many a happy Sunday stuffing 20 or so paper copies of each presentation into gold blocked folders. It was during this period that the course was re-located from the Borders College (becoming a bit down at heel) to the local Heriot Watt University Campus, utilising the Halls of residence instead of the local hotels. We also spent considerable time and effort in producing a distance-learning course using the same syllabus, but it had a very poor take-up. The course worked in close cooperation with the local apprentice scheme, although as a national scheme, they were more electrical and mechanical based than the electronics industry supported by the Basic Course.

In 1990, with the course running for 10 years, my job function changed and Lawson Lightfoot took over for the next 14 years through good times and bad.

By 2004, Industry changes had devastated the Northern PCB Industry and the Northern UK Circuit Group had been much truncated. Ian Hood, the then Chairman showed rare vision and showed that sometimes you need to give something away to see it survive – he closed the NUKCG and handed the course over to the Institute of Circuit Technology, who had cooperated in a start up at a more central location - Loughborough University. NUKCG remains as part of the title of the course to show its origins.

Feedback sheets showed what the industry wanted, and we shortened the course to five and then four days, organised a full-time coordinator and a first day at Invotec Circuits Group to give us sufficient time for a facility tour, re-introduced a get-together dinner and added and removed subjects as required.

The course is well supported by a wide variety of companies in the UK and we owe a debt of gratitude to the companies who supply lecturers and the companies who send delegates, with the Institute maintaining one of its founding principles in providing forums and venues for the advancement of training and technology in the pcb and related Industries.

Test yourself on the following NATIONAL JOINT EXAMINATION BOARD - PRINTED CIRCUIT TECHNOLOGY - BASIC COURSE exam from 1988:

NATIONAL JOINT EXAMINATION BOARD

PRINTED CIRCUIT TECHNOLOGY BASIC COURSE

EXAMINATION

JUNE 1988

3 HOURS ALLOWED

INSTRUCTIONS. TO CANDIDATES
PLEASE READ CAREFULLY

1. 5ix (6) questions only are to be attempted'
2. The compulsory question, Question 1, must be attempted.
3. A mini.mum of two (2) questions f rom section B must be attempted.
4. A minimum of two (2) questions from section C must be attempted"
5. Where possible, answers should be illustrated with neat labelled sketches in "good proportion.
6. Each question must be commenced on a separate sheet of Paper.
7. The first sheet of each question must show clearly the candidate number and question Number.
8. All sheets of paper for each question must be fastened carefully to each other before being submitted to the invigilator for subsequent marking.
9. Time allowed 3 hours

SECTION A

QUESTION 1

A.. List the process steps necessary to manufacture a multilayer board capable of meeting the requirements of a military user. *7 MARKS*
Detailed information for each step is not required.

B. Define or explain the following terms: -A3
1) Carbon treatment
2) Beta backscatter
3) Solder resist
4) Eutectic
5) BS 9000 *5 MARKS*

C. Distinguish between the terms Process Control and Quality Control' *3 MARKS*

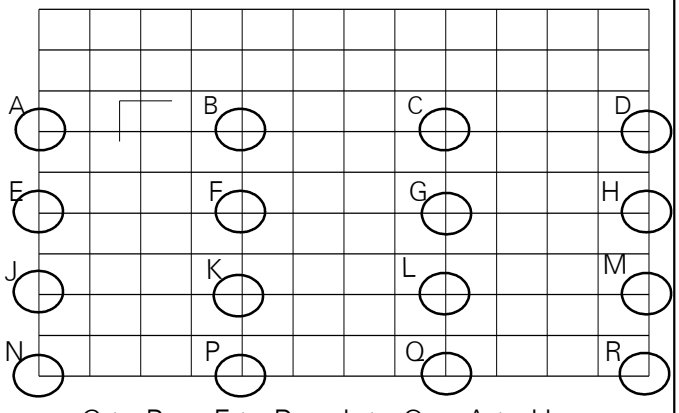
D. Why are the following important in Printed Circuit Board manufacturing?
1) Orientation of photographic emulsion
2) Collimation of light sources
3) Flatness
4) Thermal co-efficient of expansion
5) Copper Phosphorus anodes' *5 MARKS*

SECTION B

QUESTION 2

A. Name the four main objectives that should be achieved when designing a Printed Circuit Layout, and comment on each of these. *10 MARKS*

B. Design a connection layout for a single sided PCB using the diagram and information below



G to P, F to R, L to Q, A to H

The grid is .050" and only those may be used.
Ignore line width and pad diameter *6 MARKS*

QUESTION 3

A. Describe briefly what. is meant by the following laminate types:
1) FR2
2) FR3
3) FR4
4) CEM-1 *6 MARKS*

B. Detail the process used for the manufacture of electro deposited copper foil
Use a sketch to show important details.
4 MARKS

C. State key features considered when selecting the following
laminate types and typical application:
1) Synthetic resin bonded Paper
2) Epoxy resin bonded glass
3) Polyimide resin bonded glass
6 MARKS

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QUESTION 4

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A. Describe why the following are important to the efficient cutting action of a P.C.B. drill bit.
1) Symmetrical drill point geometry and rotational concentricity.
2) Narrow web-thickness and a short length of chisel edge.
3) Spirally ground and highly polished flutes.
4) Back tapered cutting diameters and narrow cylindrical margin lands. *8 MARK,S*

B, Identify the four main hole quality defects which can be generated during drilling, giving reasons for their formation. *4 MARK,S*

C. Discuss the general effect on drill point operating temperature of the following:
1) An increase in drill rotational speed.
2) An increase in drill in-feed (advance per revolution).
3) Greater dwell time at maximum stroke.
4) The use of blunt drills. *4 MARK,S*

QUESTION 5

A. List, in sequence, the five basic process steps when using a dry film photo resist.
5 MARKS

B. Name the process steps and parameters to be investigated for poor resist adhesion.
5 MARKS

C. List the main causes of the presence of dry film resist residues being present on non-exposed areas following development.
6 MARKS

(Please note in our copy of this historic document there is NO QUESTION 6 or 7.)

QUESTION 8

A. High undercut in PTH boards is undesirable. Give reasons for this. *4 MARKS*

B. What are the factors to be considered when choosing etchants used in the manufacture of:-
1) Print and etch boards
2) Plated through .hole boards
8 MARKS

C. Describe the desirable aspects of an etchant for PTE use. *4 MARKS*

QUESTION 9

A. Tin/lead can be applied to PCB's in a number of ways.
1) Name the three methods most widely used industrially. Underline the most versatile method.
2) Discounting any fabrication considerations, describe the purpose or function of the tln/lead finish- *6 MARKS*

B. In all the methods which employ heat, a special liquid chemical is used also.
1) What Is the general name given to a chemical of this type?
2) What is its primary function?
3) How is It subsequently removed? *4 MARKS*

C. In short statements, describe the significant metallurgical differences between a fused and unfused coating. Describe the benefits to be obtained `by fusing/reflowlng. Are there any disadvantages?
6 MARKS

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