Journal of the Institute of Circuit Technology

Contents

vol.3 no.1 January 2010

2009 Events

24th September	*Southern Golf Day and PCB Dinner, Wiltshire Golf Club*
6th October	*14.00 ICT Council Meeting - Comfort Inn, Arundel* *17.00 Evening Seminar, - Supported by Lamar Group*
3rd November	*17.00 Evening Seminar, Devonport Hotel, Darlington*

2010 Events

28th - 29th January	*EIPC Winter Conference - Toulouse*
3rd Febuary	13.30 ICT Council Meeting 17.00 ICT AGM - followed by Evening Seminar, Norfolk Hotel, Arundel The event is supported by Isola Group, CCI Eurolam, Ventec Europe and Taconic
10th Febuary	*09.30 IeMRC Packaging and Interconnection for Electronics and Sensors past,present and future.Tel:01223 899000 Riverside Offices, Granta Park, Cambridge.*
2nd March	17.00 Evening Seminar, Devonport Hotel, Darlington
9th -10th March	*National Electronics Week SA Sandton Convention Centre,Johannesburg*
12th April - 15th April	Annual Foundation Course , Loughborough University
18th - 19th May	*National Electronics Week UK Hall 1 Birmingham NEC*
8th June	36th Annual Symposium Bracebridge Suite, National Motorcycle Museum at Solihull

Editorial

This issue has appendices of three additional .pdf files which are the basis of a comprehensive Index of all the Technical Information that has appeared in the first three issues of the *Journal*. Your comments are sought about the form it takes and how you would like it to be improved, before the laborious task of completing the Index up to the latest issue is attempted.

And now to repeat myself

We are now at the beginning of 2010, and have just completed a year that has seen our Membership increase by at least 15%, and during which we held, four highly successful Evening Seminars, an extremely pleasant 35th Anniversary Annual Symposium at Bletchley Park, and the popular Annual Foundation Course at Loughborough University. We have launched our vastly improved Web Site, and published four issues of our *Journal*.

On Wednesday 3rd February 2010, we will be holding our AGM at the Norfolk Hotel in Arundel followed by an Evening Seminar.

The 2009 Council are very keen to see the Institute and our Industry grow even more strongly in the coming years. Turning the AGM into a Major Event, rather than an occasion for reporting past progress, will we hope enable New and Old Members to contribute New Ideas and Enthusiasm for our advancement.

Please make a note in your personal diary of :-

ICT AGM on Wednesday 3rd February 2010 at 5.00 PM Norfolk Hotel, Arundel.

(Please note the revised date of the AGM and Evening Seminar.)

AND BE THERE !

Bruce Routledge
2009 Council Member

Council Members 2009 Steve Payne (*Chairman*), Martin Goosey (*Deputy Chairman*), John Walker (*Secretary*)
Chris Wall (*Treasurer*), William Wilkie (*Membership Secretary & Events*), Bruce Routledge (the *Journal*),
Andy Cobley, Peter Starkey, Francesca Stern, Bob Willis, Richard Wood - Roe

Opportunities on the ICT Council

At the forthcoming 2009 Annual General Meeting of the Institute to be held on Wednesday 3rd February 2010 at the Norfolk Arms, Arundel, an opportunity will arise to propose new members to the ICT Council.

The Institute of Circuit Technology, which has been established for over 30 years, is probably the only body which solely represents the Technical Aspects of Printed Circuit Manufacturing, Research and Development. If you are interested in serving on the its Council and currently hold a Senior Position in the Printed Circuit and Allied Industries you will be very welcome.

Should you wish to proceed , and if you are an Activist, please contact the ICT Secretary whose Email Address is :- bcsbasingstoke@btinternet.com no later than the 31st January 2010 with the names of your Proposer and Seconder, both of whom must currently be Fellows of the Institute.

John Walker Hon. Sec. ICT

Membership

New members notified by the Membership Secretary

Associate Member (A.Inst.C.T.)

10152 Bao Xainzhu

Member (M.Inst.C.T.)

10153 David Potter
10154 David Spruce
10155 David Fitzgerald
10156 David Hunton

Corrections and Clarifications

It is the policy of the Journal to correct errors in its next issue.
Please send corrections to : -
E-mail : bruce.rout@tiscali.co.uk

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Technical News

Len Pillinger F.Inst.C.T.

RoHS v2.0 and WEEE v2.0 – An update

In December 2008, the European Commission published proposals for 'recasting' (effectively revising) both the RoHS Directive and the WEEE Directive. On the11th December 2009,I attended a Stakeholders' Meeting hosted by the Department for Business Innovation and Skills (BIS) which has previously been known as both DTI and BERR. The three speakers from BIS were Steve Andrews, Debbie Huntington (WEEE) and Ilan Nichol (RoHS).

The object was to brief industry and other stakeholders of the progress with the recasting of the RoHS and WEEE Directives. The current versions of these Directives include a mandate for revision. The recasting has therefore not been provoked by 'green' lobbying or perceptions of the performance of the two Directives.

The points below include 'likely outcomes' detailed by the BIS representatives, but 'horse trading' in Brussels by Member State delegates may mean some non-preferred outcomes. There is a lot of talking to be done between now and final publication, so what follows below can only be an indication of current thinking.

RoHS v2.0

Several meetings to discuss RoHS have been held during the year, particularly under the Swedish presidency, with Jill Evans MEP (Plaid Cymru and aligned in the EU Parliament with the 'Greens') acting as 'reporter'. You may judge her views and interests at www.jillevans.net.

Jill Evans has published a report on the recast Directive which BIS regard as proposing further radical changes. BIS are confident that these will be significantly pared down. There is an accompanying 'Socio-Economic Report' which fails to mention the word 'industry'; you may wish to draw your own conclusion! These reports are buried deep within the European Parliament website at

www.europarl.europa.eu/oeil/FindByProcnum.do?lang=en&procnum=COD/2008/0240.

It was stated that a total of 75 amendments to original proposal have been tabled. Jill Evans' report appears to introduce a proposal for the future restriction of PVC and other halogenated polymers to a halogen threshold of 900ppm (0.09%). Given that polymers are outside the scope of REACh, it suggests that the electronics sector could suffer substance restrictions that other industries will avoid. Moreover, whilst not having studied chemistry much beyond GCE O-level (in 1971!!), I am not aware of an analytical technique that will resolve to this low level.

The current RoHS Directive takes its scope of products from the WEEE Directive. This is likely to be reversed. Both Directives will have a new number meaning that paperwork and electronic media will require updating at some point.

Categories 8 and 9 (medical, and monitoring and control equipment) will be brought into the scope. No new substances to be immediately introduced in RoHS v2 other than the known 3 new phthalates and 1 brominated flame retardant which will be introduced according the REACh timetable. The interaction between RoHS and REACh is much debated with any outcome still possible.

The four new substances proposed for restriction are:

Hexabromocyclododecane (HBCDD)
Bis (2-ethylhexyl) phthalate (DEHP)
Butyl benzyl phthalate (BBP)
Dibutylphthalate (DBP)

Current and future RoHS exemptions are to have a 4 year validity. BIS disagrees with such 'sunset clauses' which ignore the availability of substitute technologies.

As detailed in a previous ICT Newsletter; RoHS is to become a CE marking Directive and subject to stronger market surveillance.CE marking for RoHS compliance is to be self-declaration; analogous to the EMC and Low Voltage Directives with "no formal rôle for Notified Bodies". There was support in the meeting for CE marking to be applied to the whole electronics supply chain. This would mean that all components and materials needing to be CE marked or at least accompanied by a formal Declaration of Conformity. Before I had the opportunity to voice an objection, BIS made it clear that CE marking was for equipment and unlikely to be applied earlier in the supply chain.

There is a proposal to introduce an 11th category in 2014 to cover "all other electrical equipment". This would presumably include transportation and other currently excluded areas. BIS disagrees with this proposal.

WEEE v2.0

Whilst RoHS has more impact on ICT members than WEEE, the following may be worth noting:

Manufacturers offering products for sale in all EU Member States currently have to register with statutory bodies in those 27 Member States, and presumably pay 27 registration fees. Harmonised registration will be introduced by the recast WEEE Directive.

Collection / recovery targets are to be increased from 4kg per household to 65%POTM (placed on the market in previous 2 years) UK currently achieves 7kg per household which is equivalent to 39%POTM. Recovery, reuse and recycling are already mandated to increase by 5% by 2011.

A recovery, reuse and recycling target for medical devices of 75% is to be introduced. No exemption is currently being considered for in vitro and / or contaminated devices! The electro-medical sector will be lobbying for a change of policy.

There will be extended producer responsibility for collection from households. New regulations are to be introduced to monitor illegal WEEE shipments.

Timescales

The formal first reading of the two proposals in the EU Parliament is scheduled for the end of 2010. It is likely that the new Directives will be implemented in mid-2012.

There will be public consultations issued by BIS. These are announced at www.berr.gov.uk/consultations/index.html giving industry an opportunity to voice opinions on draft legislation. The 'green' lobby are certain to comment and industry needs to do likewise to ensure a balanced outcome.

Len Pillinger F.Inst.C.T.

16th December 2009

Book Review

Printed Circuits Handbook
- Sixth Edition

Edited by Clyde F Coombs Jr

McGraw and Hill, New York

For anyone who has an interest in Printed Circuit Board technology, either as an academic or someone working in the industry, the name of Clyde Coombs will already be well known. 'Coombs' is the word that many people use when referring to what has become the PCB industry's information bible. More correctly known as the 'Printed Circuits Handbook', this work has been in production for more than thirty years and it is the current sixth edition that is the subject of this review. Although the work's editor in chief is indeed Clyde Coombs, the preparation of this large and highly detailed manuscript has also involved a huge input from a large team of international experts. To give some idea of the scale of the work involved, there are over 40 named authors that have contributed in some way to the book's 67 chapters. This latest version attempts to bring the technology right up to date and includes a range of new topics including the key, and highly topical, subject of lead-free. There are new sections on lead-free PCB design and manufacturing techniques, lead-free materials and lead-free reliability modelling. Considering, the range of problems and issues that can be encountered when moving to lead-free, these sections are a welcome addition that will prove to be very useful. Given the growth in the use of high density interconnection (HDI) approaches, the book also now includes a section on HDI best practices. The rapid evolution and introduction of new technologies into the PCB industry means that new editions of standard works such as this one are increasingly needed if they are to convey up-to-date information to their readers. This is a fact acknowledged by the editor in the preface to the book, where he states that over 75% of the chapters have either been revised or are new to this edition. The sixth edition therefore contains the most new information since the first edition appeared in 1967.

The book is conveniently divided into a number of key sections (called parts) and begins with a single chapter section on 'Lead-free Legislation'. There then follow four chapters in a section covering 'Printed Circuit Technology Drivers', while the following section is on 'Materials' and has no less than seven chapters covering all aspects relating to base laminate materials. Section four is on 'Engineering Design' and this has nine chapters giving details on a wide range of topics including the PCB design process, electrical and mechanical design parameters, PCB design for thermal performance and information formatting and exchange. This section concludes with a chapter on embedded components, a topic that is, and continues to be, increasingly important as performance demands from both assembled electronics and their interconnects become more and more challenging.

Section five is another relatively short one, with two chapters being devoted to 'High Density Interconnection'. This is balanced by the following section on 'Fabrication' which has twelve chapters covering all aspects of the manufacturing process, including all of the well defined stages such as imaging, electroplating, direct plate, solderable finishes, solder, etching, drilling, machining and routing.

At this point it is worth noting that, despite the huge amount of information that has already been provided, the half-way point in the book has only just been passed and there are still another 30 chapters remaining! Section seven is devoted to 'Bare Board Testing' and its four chapters cover testing objectives and definitions, methods and equipment with a final chapter devoted to special testing methods for HDI bare boards. Two chapters on 'Board Assembly' then follow in section eight and these cover assembly processes and conformal coating. After this, the book moves on into the very important area relating to soldering and there are two sections, comprising seven chapters, that have a focus on 'Solderability Technology' and 'Soldering Materials and Processes', respectively. Within these two sections there are chapters covering most of the relevant subject matter from soldering fundamentals to repair and rework. Between these there is ample coverage of soldering materials and both conventional and lead-free alloys are covered, as well as fluxes, soldering techniques and incoming inspection methods. There is a little overlap here as there are two separate chapters covering fluxes: they could probably have been combined into a single chapter but in allocating two chapters it has been possible to provide additional and complementary detail. On reaching section eleven and chapters 49 and 50, the subject matter moves from soldering to 'Non-solder Interconnections', with the chapter headings being 'press fit interconnection' and 'land grid array interconnect'.

What might be expected to be the final three sections of the book cover the very important subjects of 'Quality', 'Reliability' and 'Environmental Issues'. Section Twelve on 'Quality' has five chapters covering another wide range of subject matter from acceptability and assembly inspection to design for testing and loaded board testing. The next section is on 'Reliability' and has four chapters. Its first chapter is interestingly, and some might say appropriately, devoted to the relatively new reliability issue known as Conductive Anodic Filament formation. This important failure mechanism has become more apparent with the move to lead-free assembly and it is good to see the subject given prominent and detailed coverage. The other three chapters in this section cover reliability aspects including component to board reliability and the impact of lead-free solders. Section fourteen has single chapter covering 'Process Waste Minimization and Treatment'. This is a subject area that has also gained much more importance in recent years, especially with the increasly stringent legislation that is impacting producers in various parts of the world, especially Europe and the United States and it is one that may need expanding in future editions.

It is at this point that one might expect the book to have reached it natural conclusion but, as an added bonus, there then follow six further chapters dedicated to the more specialised area of 'Flexible Circuits'. These final six chapters, which are almost equivalent to a book in their own right, give a detailed description of all aspects of the flexible circuit manufacturing process from materials and applications, through design and manufacturing, to quality assurance. There are also chapters on special considerations pertinent to flexible circuits and coverage of multilayer flex and rigid flex circuits. The book finally ends with an 'Appendix' giving a summary of key component, material, process and design standards, followed by a 'Glossary' of terms and a very detailed 'Index'.

In conclusion then, this book is the latest in a long line of Printed Circuit Handbooks that have served the PCB industry well for more than thirty years. With its unsurpassed level of detail and over 500 figures, tables and illustrations, this book provides the level of information that will satisfy the needs of even the most experienced PCB experts. The rapid pace of change in PCB technology means that new editions are increasingly required in order to be relevant for today's manufacturers and researchers. This latest version has been heavily updated with major revisions of existing chapters and perhaps more importantly with the addition of new chapters. The editor and his team are to be congratulated for producing another valuable tome that will undoubtedly benefit the great number of people around the world who share an interest in PCB technology.

Martin Goosey

October 2009

Institute of Circuit Technology Darlington Seminar, 3rd November 2009

Autumn in the Tees Valley, and a sharp change in the weather after a mild October had brought down the leaves in great drifts. Overlooking the river, the Devonport Hotel in the village of Middleton One Row, to the east of Darlington, County Durham in the north-east of England, was venue for the Institute of Circuit Technology's Darlington Evening Seminar on 3rd November 2009. An enthusiastic audience, and speakers from as far afield as Japan, Germany, Scotland and Cumbria gathered to share the latest knowledge on high-speed laminates and advanced conductor finishes.

First to speak was Andreas Gross from Umicore Galvanotechnic in Germany, with a presentation on multifunctional electroless nickel-palladium-gold finishes for soldering and wire-bonding applications. Comparing alternative processes based on either immersion palladium or electroless palladium as the barrier layer between nickel and gold, he demonstrated that even a very thin palladium layer was effective in maintaining solderability after ageing by preventing nickel diffusion to the surface.

Because of its neutral operating pH, electroless palladium chemistry was less corrosive of the nickel interface than its acidic immersion counterpart during the deposition process. However, except in conditions of extreme thermal stress, electroless nickel immersion palladium immersion gold was a cost-effective and easy-to-operate multifunctional finish which had been customer-approved for mass production in Europe.

Examining in detail the technology of the electroless palladium process, Hiroshi Otake from Uyemura in Japan described an innovation which had overcome some limitations of traditional chemistry and offered significant improvements in uniformity of deposition rate, bath stability and adhesion of palladium to nickel. Uyemura had developed an additive which stabilised the palladium chelate and substantially reduced the decline of deposition rate with time. Bath stability was improved, especially at extreme conditions of bath loading. A notable characteristic of the modified chemistry was its ability to promote good adhesion of the palladium deposit even if the electroless nickel surface had deliberately been allowed to oxidise between process stages.

George Wheadon, European technical service specialist for Park Electrochemical, gave the first of the two laminate presentations, introducing a newly developed low-loss material, branded Mercurywave 9350, which offered a cost-effective alternative to PTFE for radio frequency and microwave applications. Using fine-weave E-glass fabric and a 66% ratio of oxide-filled resin, loss tangent had been reduced to .004 at a dielectric constant of 3.5. No special facilities were required to process and fabricate the material. Dielectric characteristics were stable over a wide range of frequency, temperature and humidity and the material exhibited remarkable thermal properties – glass transition temperature above 200degC, very low coefficient of Z-axis thermal expansion and no delamination after 15 reflow cycles. The material was suitable for applications in base station equipment, automotive, satellite communications, military, and broadband antennae.

Jim Francey, Technical Service Manager with Taconic, reviewed trends in RF-microwave and high-speed digital technologies, with particular reference to their effects on printed circuit board processing requirements. Although optical techniques would ultimately take over from copper to meet high frequency data rate demands, copper-based systems would continue to be used for gigabit-speed transmission in millimetre wavebands, such as those specified by the Federal Communications Commission for E-band and now adopted in Europe and the rest of the world. Printed circuits were preferred over low-temperature co-fired ceramics for reasons of assembly economics, lower tooling costs and a global supply base, but the issue would remain of managing signal losses: conductor loss and dielectric loss. Skin effects could be minimised by using highly conductive finishes for copper, and Francey believed that the recently introduced autocatalytic silver immersion gold ASIG, with silver thickness of 0.5 micron and gold thickness 0.05 micron offered the best option for both solderability and wire bonding. Wire bondability became significant where monolithic microwave integrated circuits were flush-mounted in cavities machined into the PCB surface to minimise induction losses by keeping bond wires as short as possible. From the fabricator's standpoint, precision machining capability was essential. Similarly, imaging, etching and layer-to-layer registration became increasingly critical with increasing frequency. Low-loss materials were necessary in order to maintain signal integrity, and low-dielectric-constant laminates enabled reduced dielectric spacing for a given impedance. Signal integrity was degraded by woven glass, but the effect could be reduced by using finer weaves in combination with high resin content and fillers. Although thinner materials gave opportunities for tighter impedance control, this could be at the expense of compromising dimensional stability, requiring the printed circuit fabricator to maintain a high level of capability in dynamic process technologies such as laser direct imaging to compensate for material movement.

ICT Technical Director Bill Wilkie closed the formal proceedings, thanking the speakers for their contributions, the audience for their attention, and Holders Technology for supporting the event, and a buzz of informal technical discussion continued for a good while in the bar afterwards.

Pete Starkey - ICT Council
November 2009

IeMRC – CAFMaD
Workshop on Novel Electronic Materials

24th November 2009

Technium CAST, Bangor

The Innovative Electronics Manufacturing Research Centre's (IeMRC) final event in 2009 was held in collaboration with the Centre for Advanced Materials and Devices (CAFMaD) at Technium CAST in Bangor on the 24th November and the subject matter broadly covered the area of Novel Electronic Materials.

The workshop was opened by Gary Reed who introduced CAFMaD, which was one of four key research centres set up in Wales and which was based jointly in Aberystwyth and Bangor. Research areas covered by CAFMaD included organic conductors and molecular electronics, sensors and devices, extreme materials and characterisation and modelling.

Martin Goosey, Industrial Director of the Innovative Electronics Manufacturing Centre, then gave an introduction to the IeMRC and its current status.The IeMRC was currently preparing for the start of its second five year period of funding and it was in the middle of reviewing and selecting projects that would be funded from March 2010. The IeMRC's Vision Statement was presented and its engagement with the UK's electronics industry highlighted. Examples of materials related research that had been supported during the first five years of activity were highlighted. These were a project based at Birmingham University on high resolution, high sensitivity chemically amplified e-beam resists and the work carried out at Brunel University on printed electronic interconnects, devices and battery structures. Martin concluded by inviting attendees to engage with the IeMRC and highlighted the ways in which this could be possible.

The first technical presentation was given by Geoff Ashwell from CAFMaD, Bangor and it was entitled 'Single Molecule Electronics'. In this presentation Geoff detailed work on the synthesis of molecular wires and the control of their electrical properties via modification of molecular structure. The structure of the molecular wires was detailed and their synthesis could require an eleven stage process. The synthesis had been monitored using quartz microbalance and X-ray photo-electron spectroscopy techniques. The electrical properties of the molecules could be controlled by modifying their actual structures during their synthesis. Individual molecules could, for example, be changed from rectifying to non-rectifying by changing the end group terminations. Examples of the synthesis of a rectifying molecule were then described. Having synthesised the appropriate molecules, they could then be inserted into various device structures and one such example was described which was essentially a molecular necklace around a silicon nitride insulator layer. Work had been carried out in collaboration with QinetiQ, which had also developed various device structures where the molecules were deposited between silicon electrodes that were separated by a 7 nm silicon dioxide insulating layer. The molecule used in this later work had been synthesised by Durham University. Theoretical calculations of currents aligned well with the measured results. This in-situ synthesis method for molecular wires had given the highest recorded rectification ratio from a molecular wire and the research had enabled the first examples of molecules inserted into nano-gap silicon devices. Future work would be undertaken to develop the first single molecule devices.

Marc Desmullliez of Heriot Watt University then gave a talk entitled 'Enhanced Electrodeposition using Megasonic Agitation'. Marc began by describing the printed circuit board (PCB) market in Europe and discussed the current distribution of fabricators in different countries. Most of these were now smaller companies that did not have significant resources to support research and development. He then described the use of microvias in PCBs and the different approaches that were available for manufacturing them. The challenge was to be able to electroplate high aspect ratio blind microvias and the difficulties of depositing metal in blind vias were described.
The equations governing the deposition process were then detailed and some examples of the modelling data covering the deposition process were shown. The motivation for using acoustic streaming was then explained; the key objective was to decrease the thickness of the diffusion layer in order to increase the ionic concentration at the microvia surface. The acoustic streaming process was also illustrated; this had been built into a standard industrial plating line and had used Schloetter pulse plating chemistry. A range of designed experiments had been undertaken and the results were shown. Pulse plating with or without megasonic agitation delivered good results in terms of uniformity, even up to a 6:1 aspect ratio. However, the use of megasonics allowed greater plating efficiencies and plating times could be reduced by up to 50%. Future work would be carried out to investigate the potential of megasonics for etching various types of substrates including silicon.
Martin Taylor of CAFMaD then gave a talk on 'Characterising Electronic Materials for Organic Electronics'. He began by discussing the motivation for moving to the use of organic electronic circuits and giving examples of MISFET and MIS capacitor structures and their use for characterising materials. A combination of AC and DC measurements was essential if the behaviour of organic electronic devices was to be fully understood. The characterisation method known as admittance spectroscopy was described. Results obtained were shown and the effects of temperature on AC response were detailed. Examples of C-V plots for doping density in MIS capacitors were also shown and the information they gave described. The presentation concluded with a description of a TSB supported project that was investigating the use of this technology to provide smart substrates for use in RFID applications. There was also a proposal under review with the IeMRC for a flagship project to take this work forward.

Following lunch, David Whalley from Loughborough University gave a presentation on his work related to 'Polymer Ball Interconnect Technology'. This work had a focus on sub-millimetre sized balls that could be used as solder ball replacements for ball grid array (BGA) applications. This was somewhat different for their more conventional applications in anisotropically conductive adhesives, where the particles were much smaller. The use of polymer balls in BGA applications could provide compliance that could extend the thermal fatigue life and give improved shock resistance. They also helped to control stand-off height and the concept was extendable to smaller device geometries. The approach was said to have been in the public domain since 1997 and there was a commercial product available from Sekisui called MicroPearl. Conpart in Norway were also working in this area. Conpart had a unique technique for giving exceptionally uniform particle size (C_v ~3%), which was know as the Ugelstad process. The major performance characteristics that needed to be considered were then discussed. Thermal conductivity of polymer cores was much lower than that of typical metals and thus the thermal resistance was significantly worse. The polymers used were also not electrically conductive and thus attention had to be paid to the metallic coating. This had been studied using 2D FEA modelling. High frequency performance had also been studied and this had not been found to be significantly adversely affected. Soft solders were known to be subject to electromigration, particularly at high temperatures and modelling work had been carried out on current densities likely to be encountered when using the polymer ball approach. The results suggested that the maximum currents allowable would be smaller for polymer balls compared to solder balls. However, by optimising the design of the pad and ball interfaces, significant improvements could be achieved. Data was also shown which confirmed positive improvements in thermo-mechanical fatigue performance. Impact and drop performance should also be enhanced by 30 to 50%, especially compared to the typical performance achieved with lead-free solders. There were still some questions to be answered, such as the optimum metallisation and how thick it should be on the polymer ball. It was also not yet clear whether there was a need to use underfill with the polymer balls. Further work involving the whole supply chain was required to take the work forward towards industrial implementation but the results to date had been extremely positive.

Andrew Evans from CAFMaD, Aberystwyth, then gave a presentation on 'Spectroscopy and Imaging of Optoelectronic Materials'. A unique facility had been established for monitoring and characterising organic molecular films. There were four areas of organic electronics research underway and these included organic photovoltaics and polymer films. There was also work on diamond electronics which was investigating high temperature diodes and transfer-doped FETs. Andrew then discussed approaches to the optimisation of device structures via a better understanding of the fundamental science. An example was then given of the use of X-rays to provide information about the properties of deposited films via the collection of emitted electrons, IR-UV and X-rays. Work was also reported on the properties of diamond organic interfaces, which included the deposition of fullerenes onto diamond. The work had resulted in the development of new transfer dopants for diamond transistors.

Mike Lebby, CEO of the Optoelectronics Industry Development Association (USA), gave the final presentation of the workshop and this was called 'Is this the era of green photonics?' Mike began by giving an overview of the use of optoelectronics in green technology such as renewable energy sources. Interestingly, Asia had 81% of the $356 billion global market in 2008 and the market was predicted to grow significantly in the future, with green applications taking an increasing share. Mike introduced the concept of moving from local area networks to personal area networks or even body area networks. Another big issue was the energy consumption of networks and this was something that was not really considered seriously today. As the networks grow, energy consumption would become increasingly important. Data was also shown to highlight the growth in use of photonic lighting and there were significant energy savings that could be made as this transition took place. Solar cells would continue to become more efficient and they would become greener to produce. Mike then went on to give a comprehensive review of new and evolving applications for photonics devices. There was also a growing need, therefore, for new foundries to produce the devices that would be needed to satisfy these applications.

The presentations from this workshop are available at the IeMRC website; www.iemrc.org. Further information on the activities of the IeMRC and CaFMaD can be found at the following addresses; www.iemrc.org and www.cafmad.ac.uk respectively.

Martin Goosey

November 2009

An Innovation in Horizontal Processing. (Part 2)

Ken Bishop C Eng MIET
Technical Director - Cemco-FSL

Len Flint
Senior Development Eng. - Cemco-FSL

The first paper on this subject covered the theory behind a novel non-contact laminar or streamline flow process chamber that results in a faster and more uniform chemical reaction than obtainable with conventional flood chambers. It also described a number of variations on this chamber to provide a solution to a complete horizontal chemical processing line that reduced the footprint and operating cost over conventional designs.

This second paper describes a practical implementation of the design. It further describes how the design has been developed to produce equipment capable of processing material in a variety of chemical applications.

Note: Many of the figures in this paper are from a 3D CAD design software package. They are coloured for clarity and do not represent the colours used in practice.

Fluid Engine

A basic Fluid Engine is made up of an upper and lower fluid head screwed together to make a complete, easily removed assembly (figure 1).

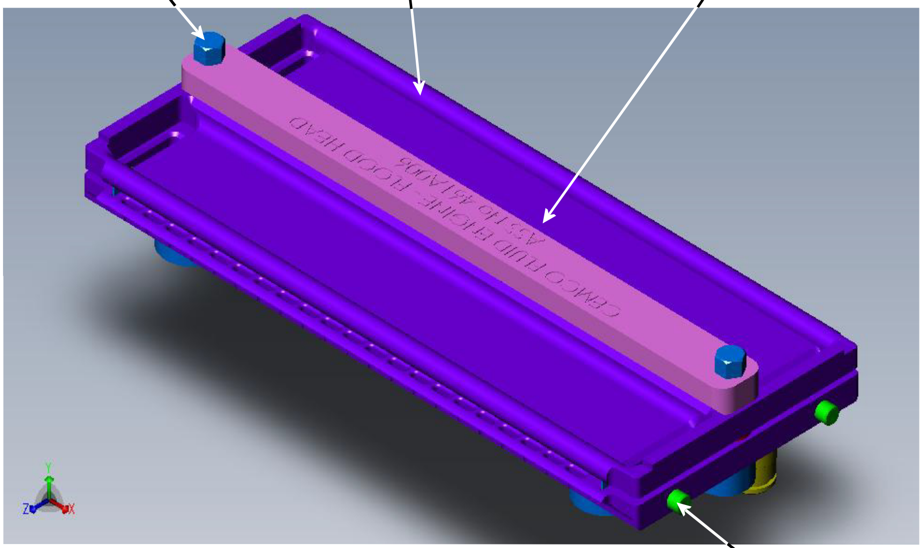


Fig 1. Fluid Engine assembly

Each head comprises a base plate machined from a solid piece of plastic and a plastic plenum welded to it. Both base plates have drainage slots to allow any fluid that accumulates on the top head to drain back into the chamber and then to the sump. The complete Fluid Engine assembly slots into the side frames of the conveyor using two location spigots fitted on a multiple of the conveyor pitch either side of the lower head.

A plastic strip screwed into the base plate creates the two fluid discharge slots. This strip can be easily removed for cleaning the heads. Strips fitted to either side of the base plate guide the fluid and stop it flowing over the sides of the head. This ensures laminar flow is constant over the whole width of the head. Fluid is fed into the lower head via a pipe connected to the lower plenum whereas the upper head is fed from pipes that pass through the lower head. The fluid feed is fitted with an "O" ring and is a push fit into the feed pipe from the process pump. This enables the Fluid Head to be easily removed and refitted manually. Figure 2 illustrates these design features.

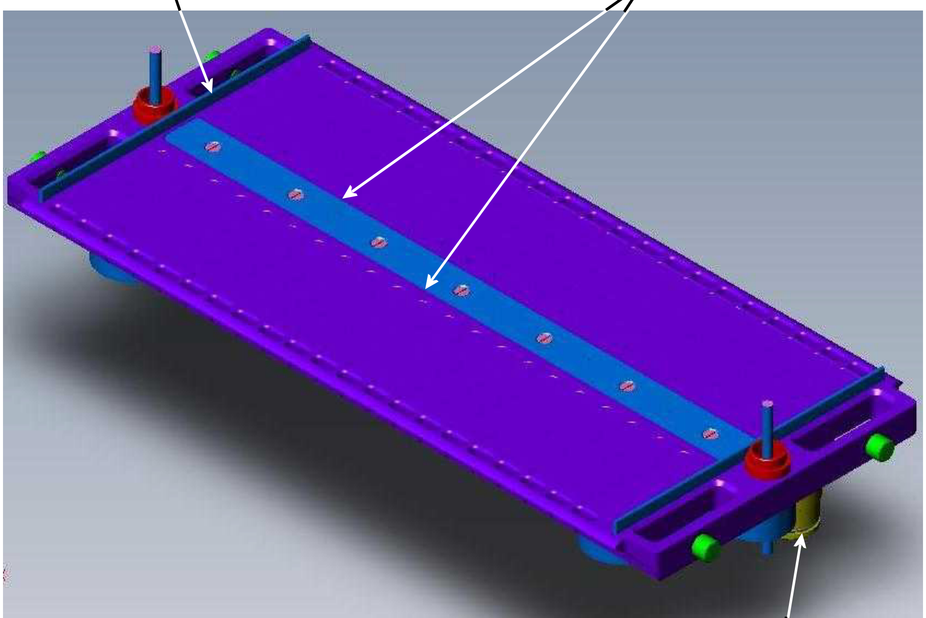


Fig 2. Lower Fluid Head

When a heated chemical is used with the Fluid Engine, the upper head is fitted with a pair of condenser plates (Figure 3). The hot chemical vapour condenses on the under side of these plates and runs back into the chamber. The plates are cooled to encourage condensation by drawing ambient air across the top utilising the fume extraction system. The assembly simply slots together and drops over the two nuts that hold the upper & lower heads together. There are no fixings and therefore the plates can be easily lifted off the fluid engine for cleaning.

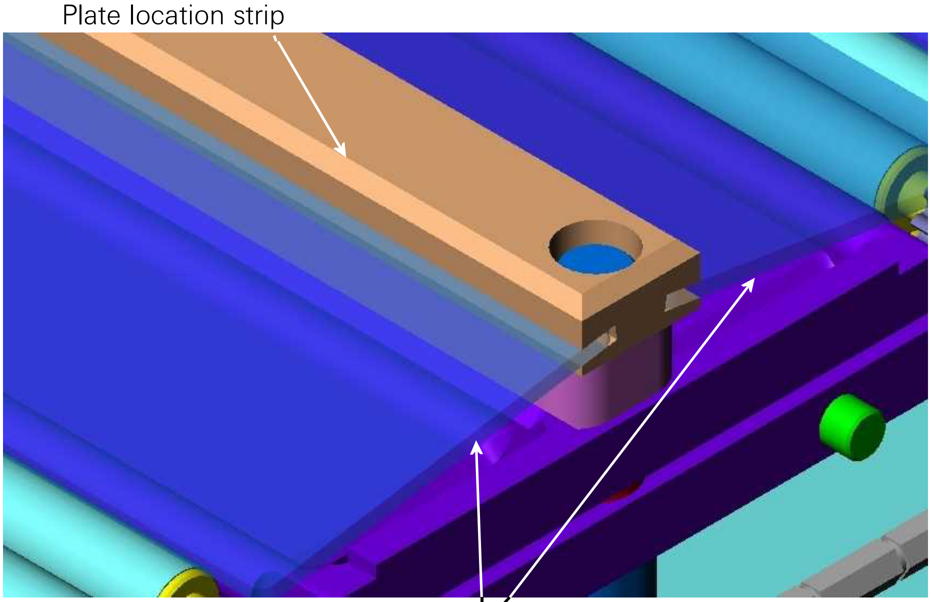


Fig. 3 Vapour condenser plates

Dual Feed Engine

The dual feed Fluid Engine is very similar in construction to the basic engine. The difference is in the way that the second fluid is delivered to the base plate and on to the discharge slots.

The base plate is exactly the same design but the liquid plenum is changed to enable the gas to pass through it and into the base plate. The plenum is machined so that a series of tubes pass directly through it. These tubes provide a path for the gas though the liquid plenum. The gas plenum is a hollowed out plastic block with a tapped hole for the gas feed fitting. The two plenums are welded together to give a fluid tight construction and then welded to the base plate. The liquid plenum is positioned such that the tubes align with every other hole in the base plate. The result is that gas and liquid exit the discharge slots from alternate holes spaced at approximately 7mm across the width of the panel being processed. By adjusting the pressure of the gas at the input port the mix of gas and liquid arriving at the panel can be controlled.

Figure 5 shows a cross section through a Dual Fluid Engine and shows the paths that the two fluids take to reach the discharge slots. The top head shows the liquid path while the lower head shows the gas path. A membrane is fitted between the two plenums that allows gas to pass through to the discharge slots but prevents liquid from flowing back to the gas plenum. The lower liquid plenum is larger than the upper as the liquid fed to both upper and lower discharge slots has to pass through the lower one.

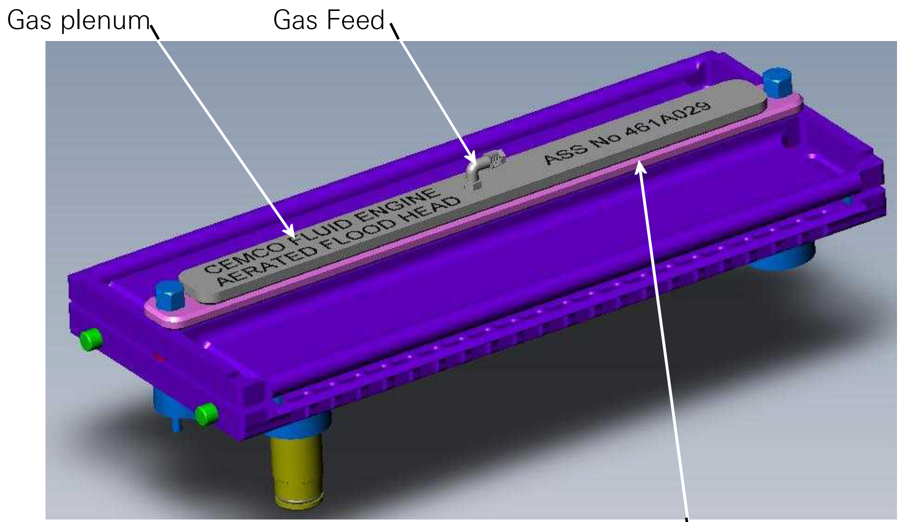


Fig. 4 Dual Feed Engine

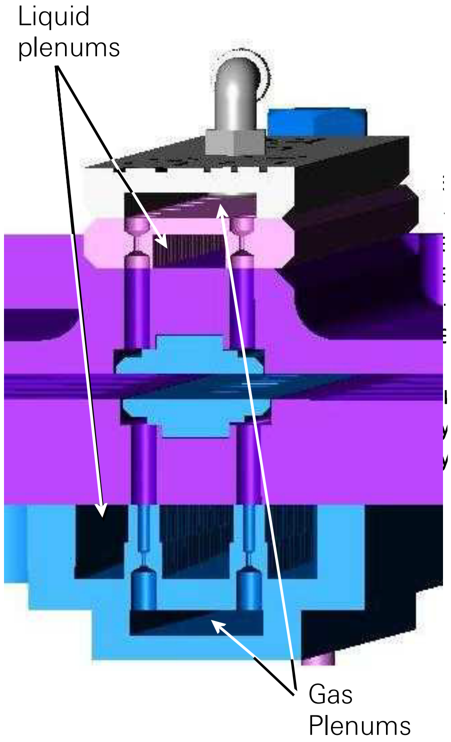


Fig.5 Fluid paths for Dual Fluid Engine

Fluid Knife

The fluid knife does not have to provide a long contact time between the fluid and the material and so is considerably narrower than the Fluid Engine. Both upper and lower heads consist of two plastic plates hollowed out to provide a plenum area. These plates are welded together to produce the complete head assembly. The weld line can be seen in figure 6 running across the length of the heads. The plates are machined to produce a fluid discharge slot running across the width. The plates are further fixed together using plastic screws to overcome the tendency of the plastic to bow over its length. This ensures that the discharge slot width remains constant producing an even flow of fluid. The leading edge of the lower knife has a series of slots machined in it shaped to allow the fluid to rapidly drain into the chamber. This allows the knife to be positioned extremely close to the input roller with the leading edge acting as a guide for thin material. A single location spigot is fitted either side of the lower head to position the knife assembly in the conveyor side frame.

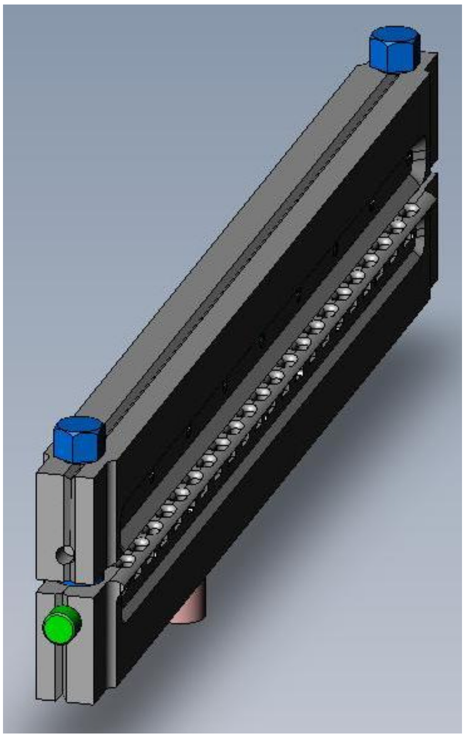


Fig. 6 Fluid knife assembly

Spray applications.

Although it has been found that most of the chemicals traditionally sprayed can be used to advantage in the fluid engine it has been anticipated that spray treatment may be required. To meet this requirement a module that can be fitted with either fluid engine or spray manifold has been developed.

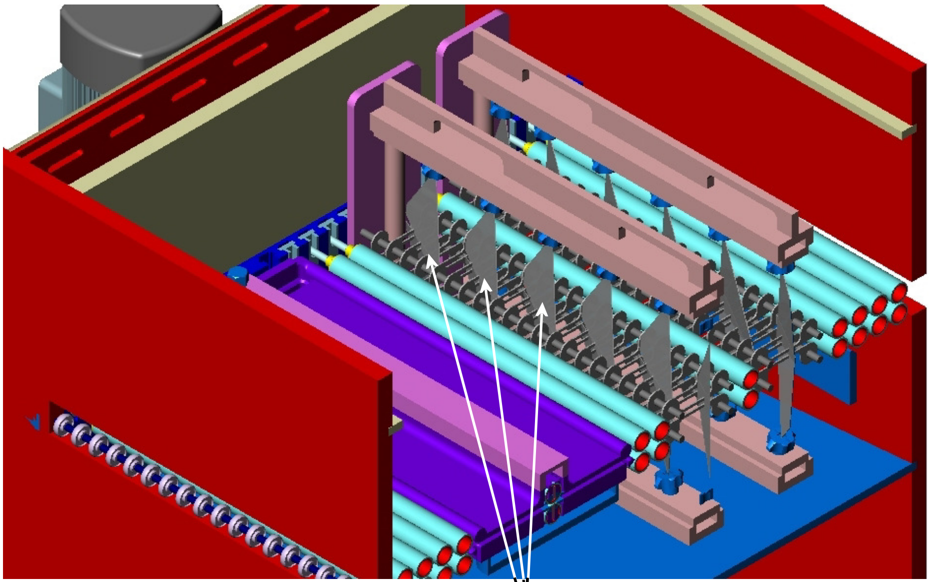


Fig.8 Spray applications

Jet Knife

Based on similar design concept as the fluid knife with two machined plastic plates welded together the Jet Knife has a series of holes tapped in the plenum. These tapped holes can accept standard moulded jets to provide high impingement forces on the panel.

Drain holes in the base of the lower head allow fluid to drain away rapidly to prevent it interfering with the spray pattern from the lower jets.

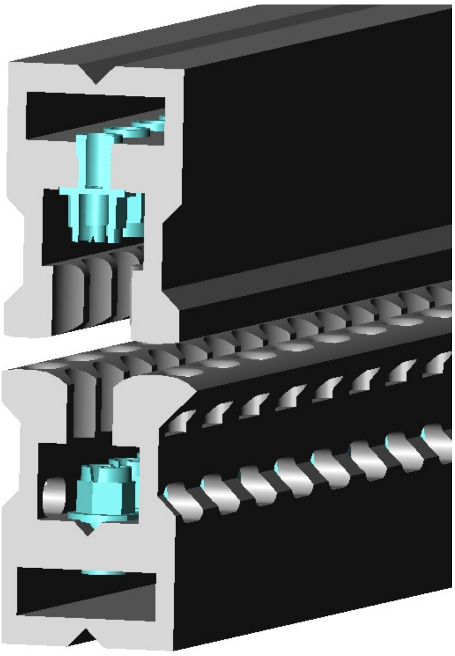


Fig. 7 Cross section through a Jet Knife

Figure 8 shows a typical process section combining Fluid Engine and Spray Modules. Both top entry Fluid Engine and Spray Module are ´plugged in´ to their supply manifold and are located in the conveyor side frames. Two single spray bar manifold assemblies fit the area occupied by one fluid engine and are interchangeable to facilitate testing and development. The design of the Spray Modules enables standard jets to be fitted providing the facility to generate a variety of spray patterns. Jets are spaced above and below the work to produce the desired fluid coverage. The jets shown in the figure are angled to provide coverage without interfering with fluid flow from adjacent jets.

Drying Knife

Material drying is achieved using a variation on the fluid knife design. Delivery of air to the discharge slots is the same as liquid delivery in the fluid knife. The path that the air takes however is different than that taken by liquids. Both top and bottom drying knives have extended input sections to help guide the panel into the air stream.

The lower knife is shaped to rapidly expand the air leaving the jet to produce a pressure difference between the top and bottom of the panel. This pressure difference sucks fluid from the holes in the panel and also helps to stabilise its position between the knives.

To avoid the problem of water left on the trailing edge of panels the knife jets are angled across the width of the conveyor. This causes the air to produce a "wiping" action across the panel driving excess water to the corner where it falls into the lower chamber and to drain.

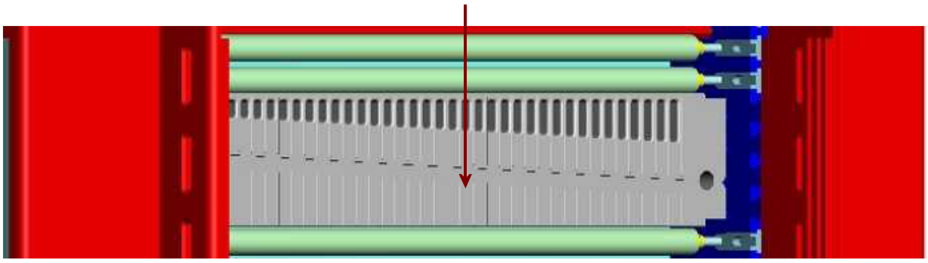


Figure 9 shows the lower air knife and illustrates its angular jet design.

Material transport

The conveyor system is housed in a series of wrap around plastic shells the number of shells being dictated by the length of the process. Running along the length of each shell are two side frames with slots cut at the conveyor pitch.

A slide in roller bearing block is fitted to every slot where a conveyor roller is located. The lower rollers are fitted with a bevel gear that picks up the drive from another bevel gear fitted to the common shaft that runs the length of the module. Each bevel gear set drives 2 upper and 2 lower rollers. A train of spur gears drive the slave roller and upper and lower spur gears provide positive drive to all rollers. Figure 10 shows how the drive is transferred from the main drive shaft to the rollers via the module drive shaft and the bevel gears.

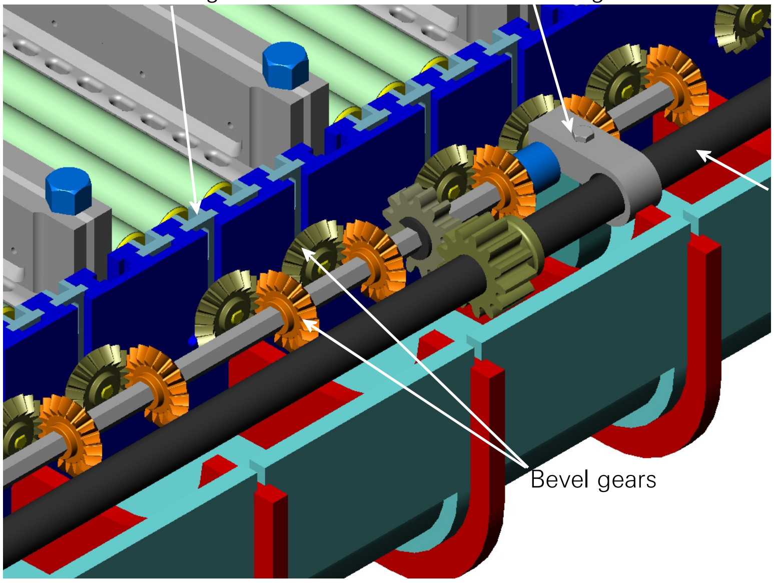


Fig. 10 Roller Drive System - Note: Upper rollers are removed for clarity.

One of the design objectives for the conveyor system was to provide the capability of transporting a variety of material with thickness from 0.005 to 5.0mm. The roller diameter has been selected such that the flex strength of 50-micron kapton is sufficient to overcome the capillary attraction of a wet roller and the gap between rollers is sufficient to prevent capillary attraction between them to reduce carry over. The spur gears that transfer the drive from the bottom to top rollers have a special tooth design to achieve positive drive with panels up to 5mm thick.

Figure 11 illustrates how the rollers are coupled via the spur gears on the drive side.The second top roller is driven from the other end of the lower roller immediately below it with spur gears mounted on the opposite end of the rollers.The rollers are fabricated from light, rigid hollow carbon fibre cores, to prevent deflection or damage when dropped, and alternative precision ground coatings are available to suit all chemicals. Drag out can be improved by increasing the weight of the upper rollers by inserting weights into the inner core.

Bearing blocks fixed directly to the side frames at either end of the module support the module drive shaft. Each module drive shaft picks up its drive from a spur gear on the main drive shaft. The separate drive shaft design enables a long drive train to be assembled without the possibility of potential drive shaft wind up. For longer lines or where composite lines running at multiple speeds are required the drive shaft can be split into two or more sections with a separate motor for each section of shaft. In these cases the motors can either be run from a common speed control where synchronous speeds are required or separate ones where different section speeds are needed.

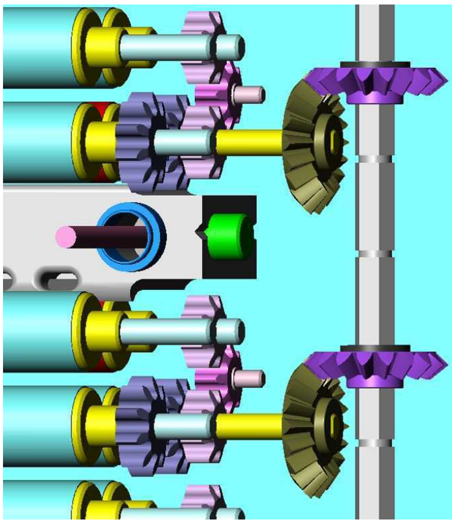


Fig.11 Transer of drive from driven rollers to other rollers.

Practical applications

Equipment using the Streamline techniques currently in use in, or being developed for, the PCB industry include surface conversion processes such as electroless silver and tin and surface treatment processes that conventionally demand spray application or significantly longer contact time. A low flow variant of the fluid engine has been developed for nano-coatings and is currently entering the third phase of evaluation. This and the application and capability of the fluid engine as an alternative to complex spray application for etching and similar processes will form the subjects of a further article.

By working with specialist manufactures and chemical suppliers Cemco has successfully implemented many aspects of the Streamline designs discussed in these two articles into equipment for use outside the PCB industry. These include electroless and electrolytic copper plating and surface treatments for RFID and Photo Voltaic and are currently being designed into aluminium web anodising equipment.

Many of the design concepts illustrated in this article have been protected under the following patents.

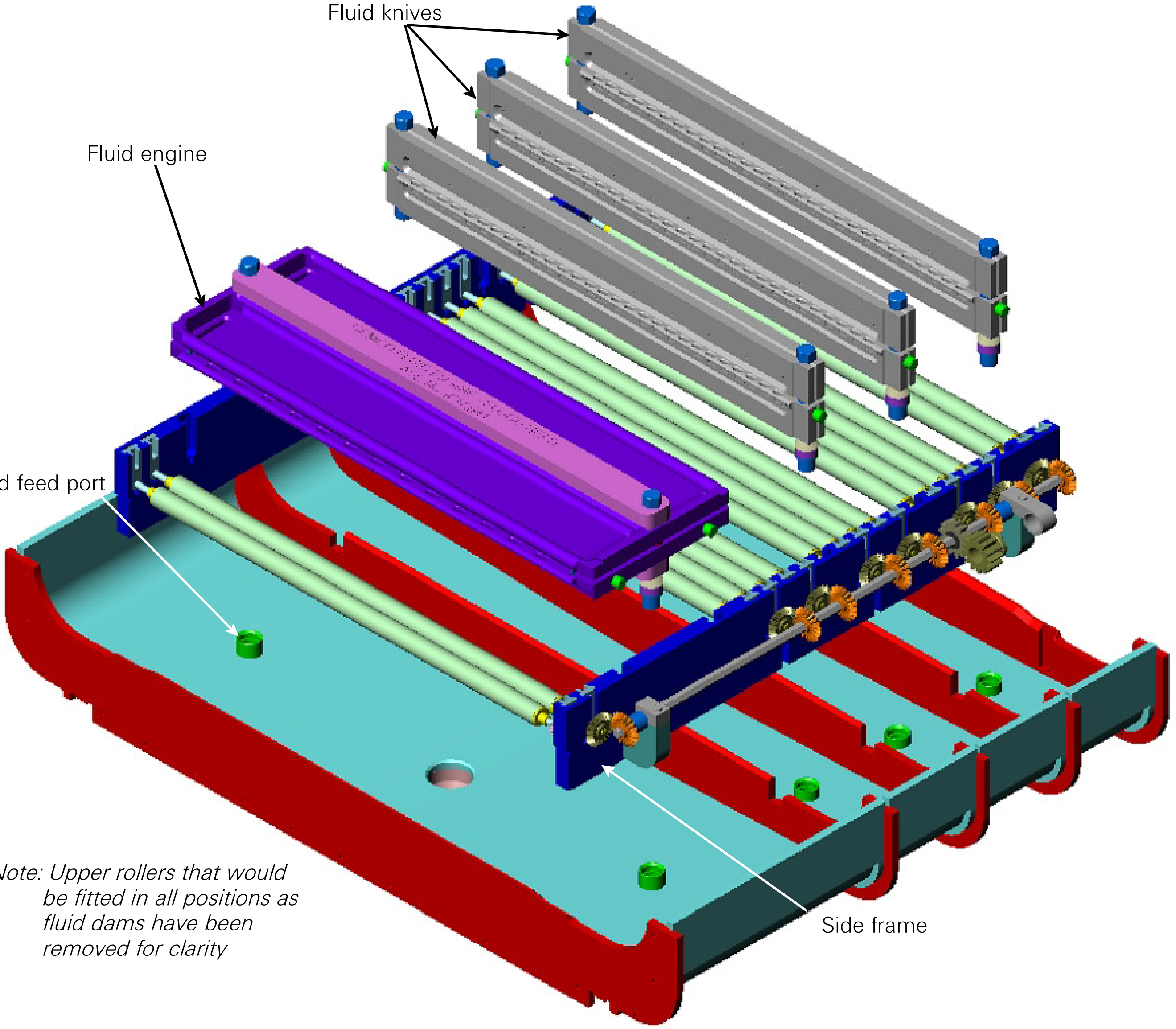
Pat No's. UK.2351458: GR.100 25 619 8: USA.6440215. USA.5155926
GB. 0827800: GR. 697 13 693.0-08; USA 5876499
Pat App No: PCT/GB2008/000062; WO2009/044124 A2.

Combining the processes

Figure 12 is an exploded view showing how a section of the Streamline process is built up and illustrates its modular construction and ease of maintenance.

This particular module shows a single Fluid Head chemical process followed by a triple water rinse section fitted with Fluid Knives.

The engines and knifes plug into feed ports built into the base of the conveyor chamber, one feeding the upper plenum and the other the lower plenum. The engines can be fed from horizontal or vertical pumps in either remote or integral sumps the former allowing wall mounting to further save space.



Note: Upper rollers that would be fitted in all positions as fluid dams have been removed for clarity

A typical complete line consists of multiple modules similar to figure 12 with combinations of Fluid Heads and Fluid Knives tailored to the complete process. The individual modules would be coupled together and driven from a single drive module.

A slave conveyor section is usually fitted to the output end of the line to allow processed panels to be removed. A panel feeder is available for fitting to the input conveyor section while a panel stacker can be included on the output conveyor.

Peter Lymn
Ken Bishop
Len Flint
Circuit Engineering Marketing Co.Ltd. (CEMCO)
December 2009 http://www.cemco.com

Institute of Circuit Technology

Arundel Evening Seminar

6th October 2009-10-07

There are traces of early Roman development in Arundel, West Sussex, on the south coast of England, although it developed mainly as a Saxon town, which was referred to in the Domesday Book in 1086. Today Arundel is a popular tourist destination famous for its castle and other historic buildings. Gaslight was first seen in the town in 1838 and electricity arrived during the 1930s. Since the 1970s, there has been a dynamic printed circuit board industry in the locality and although some familiar names have ceased trading during the last decade, there is always keen support for ICT's evening technical seminars.

Technical Director **Bill Wilkie** introduced a programme of three excellent presentations,on hole-plugging, high frequency materials and cost-effective panelisation, which were attentively received and which triggered some lively discussion both in the lecture room and in the bar afterwards

First presentation came from

Michael Herkommer, Taiyo Product Manager with Umicore Galvanotechnic, who gave a very clear insight into via-hole plugging with epoxy pastes. A range of processing techniques was available to permanently fill holes for subsequent multilayer build-up, and the three key steps were plating, plugging and planarisation. He described the principle of button-plating: selectively pattern plating vias and pads only before tenting and etching, to leave a button of reinforcing copper standing proud around each hole which would subsequently protect the knee of the hole at the planarisation stage, preventing dish-down and maintaining specification on finished copper thickness. For successful plugging, the barrel of the hole needed to be free of nodules, residues or moisture. Three plugging techniques were described: vacuum plugging, roller coating and screen printing, and their relative merits compared. Vacuum plugging gave technically the best results, but investment cost was high. Roller coating could achieve high throughput, but required materials with long pot-life because of its large reservoir capacity. Screen or stencil printing gave the opportunity for selective plugging, but aspect ratio capability was limited, and air entrapment was a possibility. After the work had been plugged and cured, there were three options for planarisation: horizontal planarising was good for thin panels but had limited ability to conform with surface topography, manual grinding was low-cost but operator-dependent, and sanding machines were good for high-layer-count work. Plugging materials were generally single-component epoxies, very viscous and difficult to de-bubble. Some were available pre-filled in de-aerated cartridges, ready to be slotted directly into vacuum-plugging machines. For reliable results, the materials needed to exhibit a combination of high glass transition temperature and low thermal expansion with good peel strength and crack resistance. Herkommer discussed failure mechanisms and showed several examples of what could go wrong if material properties and processing procedures were not optimised.

Geoff Layhe, Technical Manager of Lamar Group took the opportunity to describe in detail a new cost-effective, low dielectric constant, low loss laminate, manufactured by Panasonic and branded Megtron 4. The material was based on a functionalised polyphenylene oxide epoxy resin blend, with a dielectric constant of 3.7 at 10GHz and a loss factor of 0.005, considerably better than standard FR4, offering a cost-effective solution for high-frequency applications. Furthermore, with a glass transition temperature of 175degC and a decomposition temperature of 362degC, it was suitable for lead-free soldering processes. Layhe presented the results of conductive anodic filament resistance and interconnection stress testing, which indicated a high level of reliability, then discussed the practical aspects of bonding, drilling and de-smearing. The material could be processed through a similar route to FR4, although laminating temperature was higher. Because of its greater hardness and chemical resistance, increased drill wear and less weight loss at desmear were to be expected. A full range of laminate thicknesses and pre-preg styles was available.

Never afraid to provoke a little controversy, Sanmina-SCI's expert on PCB design, Martin Cotton, launched into the subject of panelisation from the viewpoint of the designer. He dismissed the term Design for Manufacture as implying a master-slave mentality, insisting that designers and manufacturers work together and listen to each other's arguments in order to

Martin Cotton

create a solution based on total cost of ownership. With lowest total cost as the objective, managers needed to allow PCB designers some scope to make real savings, not just run to a low-cost off-shore supplier. Panelisation was an important part of the whole value analysis scenario. Once the electronic function had stabilised and the material had been chosen, panelisation was the single most effective way of reducing cost.
A fundamental part of the design process, it needed to be treated as such and included up-front before the metalwork and plastics design had been frozen. As a real exercise in material utilisation, he suggested the audience consider how to panelise a leather hide for shoe production. Demonstrating the complexity of the value analysis procedure practised by a major EMS corporation like Sanmina-SCI, he explained that decisions had to be made for a combination of process, commercial and strategic reasons. Without going deep into the mathematics, Cotton used the concept of the Golden Rectangle to illustrate his vision of "geometric harmony" in panelisation – a PCB with no waste was in harmony, and harmony equated to lower cost. The A-series of paper sizes was an example of the relevance of harmonic proportions. He demonstrated a series of actual examples of good and bad panelisation and implored designers to design panels rather than PCBs to gain cost benefits at all stages of the value chain.

Another successful ICT seminar: technically informative and a valuable networking opportunity for the delegates. In his closing remarks, Bill Wilkie thanked all who attended, and Lamar Group for supporting the event.

Pete Starkey
October 2009

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Group Members of The Institute of Circuit Technology December 2009

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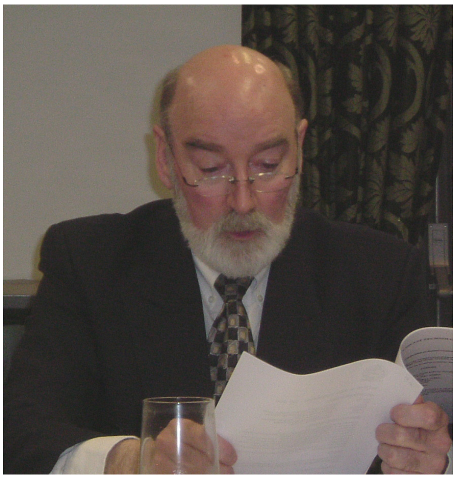

The Membership Secretary's notes December 2009

This quarter has seen unprecedented levels of activity in preparing the Institute for verification for our ASPIS programme under the European FP7 Framework

The ICT are the coordinators in a European consortium which has achieved outline approval on a proposal based around Electroless Nickel Gold, and will look at quality issues and the application of non-destructive test equipment as well as testing alternative surface treatments using normal and Ionic Liquids. Ionic liquids operate at a neutral pH and offer far less aggressive operating conditions.

This Quarter we have organised evening seminars at the Comfort Inn at Arundel and the Devonport Hotel at Darlington and are looking forward to our evening seminar and AGM at the Norfolk Arms Hotel in the centre of Arundel. This event is on the 3rd February and as part of our AGM, this event will be larger than usual with four presentations and tabletop displays, so we are hoping for a good turnout!

It only remains for me to thank all the members who have attended our events and helped out during the year and to wish you a Happy Christmas and a prosperous New Year

Bill Wilkie

Edited by Bruce Routledge on behalf of the
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One-day Seminar

Packaging and Interconnection for Electronics and Sensors -

Past, present and future

Wednesday 10th February 2010

Riverside Offices
Granda Park
Cambridge

PROGRAMME

09.30 Registration and Coffee

10.00 Welcome and Introduction
Roger Wise, TWI
Martin Goosey, IEMRC

10.15 Packaging of pyroelectric arrays for people-counting and thermal imaging applications,
Alan Butler, Jon Hall, Chris Carter and Martin Dickinson, Irisys

10.45 Packaging and interconnection technology for system-on-chip,
Peter Robinson, Cambridge Silicon Radio

11.15 Refreshment Break

11.35 Polymer wave guide optical interconnect manufacturing, *Prof David Selviah, University College, London*

12.05 MEMS packaging and 3D interconnection ,
Harrie Tilmans and Eric Beyne, IMEC

12.35 Lunch and Networking

13.20 Advanced PCB interconnection technology, *Martin Goosey, IEMRC*

13.50 Magnetics on Silicon - An enabling technology platform for power supply on chip, *Cian O'Mathuna, Tyndall*

14.20 Everything including the chip: DfM challenges and advanced packaging technologies, *Jonathan Edwards, ST Ericsson*

14.50 Refreshment Break

15.10 Medical device packaging, *Piers Tremlett and Henry Higgins, Zarlink Semiconductor*

15.40 Passive integration and system-in-package, *David Pedder, TWI*

16.10 Closing Remarks, *Roger Wise, Martin Goosey*

16.30 Champagne Reception
hosted by David Pedder

Details of programme subject to change without notice

Who should attend?

- Device designers
- Packaging and interconnection engineers and technology developers
- Manufacturing and device applications engineers in the electronics, photonics, displays and sensors industries

Fees

The fee for this seminar is £25 + VAT or £10 + VAT for students.

Closing date for registration - Monday 1 February 2010.

All fees are non-refundable.

Exhibition Space

Tabletop exhibition space will be available on a first come first served basis. The cost will be £200 + VAT. Please indicate your requirement on the registration form.

Venue

The event will take place in the Riverside Offices, Granta Park, Great Abington, Cambridge CB21 6AL.
Tel. 01223 899000.

Full location details will be provided when registering.

This event coincides with the retirement of Dr David Pedder

Enrol on-line at www.eventsforce.net/DPRS