# Journal of the Institute of Circuit Technology

Vol.9 No.1 Winter 2016 Issue


## 2015 Events

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

**Francesca Stern**
Independent consultant
providing
market research
analysis and forecasts
to the
electronics industry

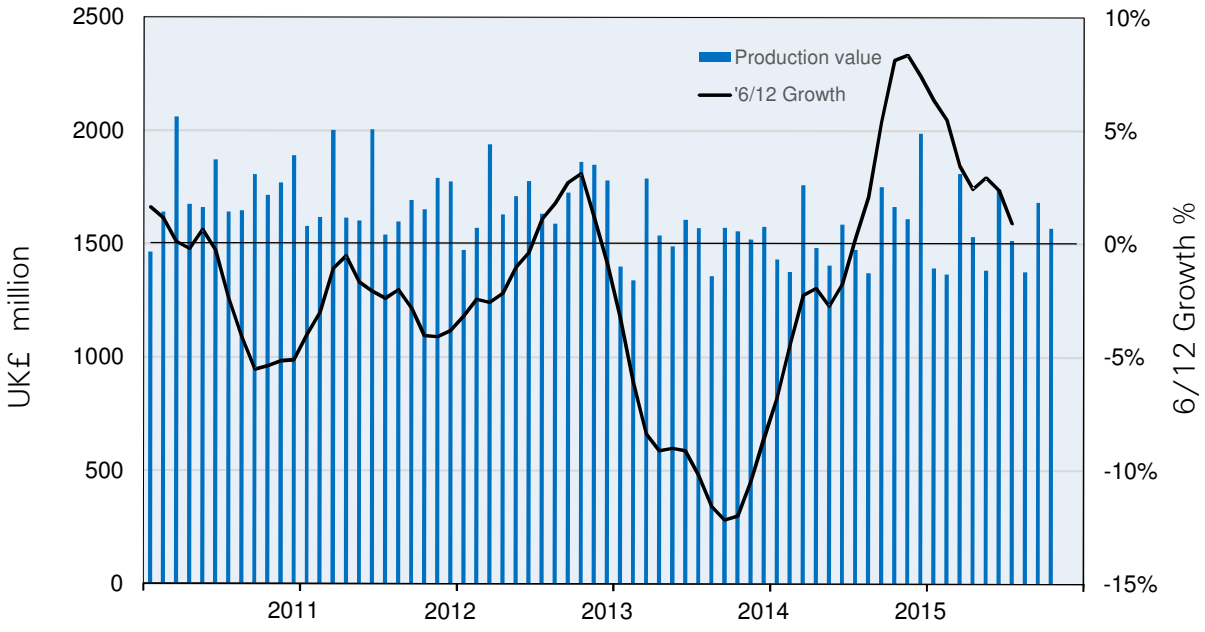
The continued existence of the UK printed circuit board industry is a credit to the character, resolve and resilience of the people who work in this industry. Since 1999 the reduction in electronics production in the UK, following the massive expansion of Asian capacity, has resulted in a decline in the number of domestic PCB fabricators from more than 160 to little more than 50, while the value of production has shrunk to one-third of what it had been. Meanwhile the value of net imports of PCBs into the UK now exceeds UK's PCB production output. For the surviving PCB companies, keeping up with printed circuit technology is crucial. This is particularly difficult, where for example, consumer-led technologies such as HDI, require a level of investment that is impossible for very small companies. However, the industry continues to be very innovative in many ways, with participation in a numerous research programmes including [1] ASPIS, [2] STOWURC, [3] MACFEST etc. that will improve technologies and process economies.

The struggle for the UK PCB industry is relentless and 2015 exits on a low key ending to a year that has been fairly lacklustre for the UK electronics industry with the consequential implications for the PCB fabricators serving it..

Note these changes in VALUE of UK Electronic Production :-

a) 2015 Q1 shrank 13% compared with 2014-Q4
b) 2015-Q1 almost unchanged with 2014-Q1
c) 2015-Q2 was an improvement (1.8%) on 2015-Q1
d) 2015-Q3 declined 1.7% compared with 2015-Q2
e) The total year on year decline in UK electronics output for the first ten months of 2015 is running at -2.5%. The domestic market which accounts for approximately half of the total, has declined most at -5%.

The chart below shows quarterly UK electronics production value overlaid with a smoothed growth curve. The trend is declining growth and the big questions are: when will this decline end and will it be a soft or hard landing before picking up again? The most recent data is not looking particularly hopeful.



Meanwhile the printed circuit board industry in the UK suffered a double whammy in 2015. The weakening UK market for PCBs was just part of the problem. Export licences, never quick or easy to obtain, proved a particular sticking point for several fabricators resulting in significant loss of orders (which went to French, German and Swiss fabricators).The value of PCB production in the UK has therefore suffered a further decline in 2015 which a preliminary estimate puts at -5%. This author notes that export of high value PCBs is an important element of the market for the larger UK fabricator and future growth will be dependent on an improved process for acquisition of export licences.

As we enter 2016, the outlook is similar to or a small improvement on 2015. European electronics production peaked on its current growth cycle in 2015 and low growth is expected in 2016 with the next peak around 2018/2019. North America will maintain low single digit growth over the next couple of years. Japan has peaked in its current growth cycle (remaining in negative growth throughout) while China is expected to bounce back slightly with single digit growth in 2016 if its current decline has bottomed out (and the data indicates that it has). The impact of all this on circuit board companies is low single digit growth in 2016 with the next round of growth peaking in 2017/18. Something to look forward to!

Happy New Year everyone

*Francesca Stern*

[1] STOWURC: Sustainable Treatment of Waste Using Recycled Chitosan
[2] ASPIS: Advanced Surface Protection for Improved reliability PCB Systems
[3] MACFEST: Manufacturing Advanced Coatings for Future Electronic Systems



## Membership

*New members notified by the Membership Secretary*

10377 Mark Vernon – Member

## 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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A Christmas Article

# Some Brief Thoughts on Circles and Squares

by

**Martin Goosey**

Martin Goosey

Many of you will recall being introduced to π at school and being told that the number obtained when twenty two was divided by seven was the key to determining the area or circumference of a circle from its radius or diameter. The value of π was normally given as 3.14 or, if you wanted to be more accurate, 3.142. Typically, for most of us, we took this at face value, used π when needed, and never considered any further aspects of its derivation, history or other facets of this fascinating transcendental number. Unbeknown to most people however, π pervades all aspects of life, impacting on just about everything we do, including drilling holes in PCBs. It is also something that, despite having being studied for almost four thousand years, still fascinates and challenges mathematicians to this day.

In the context of the circle, we are all familiar with the fact that the circumference of a circle is equal to its diameter multiplied by π and that the area is the radius squared multiplied by π

Thus, in a very simple way, we can for example, determine that a circle of 2.0 cm diameter has a circumference and area as follows;

The circumference of a 2.0 cm diameter circle is;

2.0 cm x 3.14 = 6.28 cm

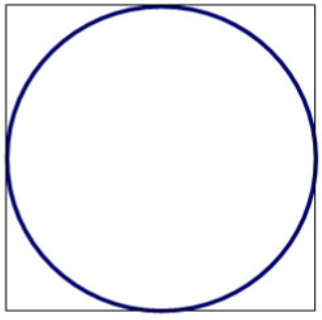
The area of a 2.0 cm diameter circle is:-

1.0 cm x 1.0 cm x 3.14 = 3.14 $cm^2$

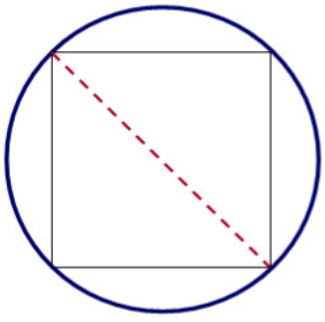
Both the above calculations used a value of π of 3.14 but that is not the exact value and it is simply an approximation that can be obtained by dividing 22 by 7. π is actually an irrational number, which means that it cannot be expressed as the ratio of two integers. The fact is that no-one knows the absolute value of π and, despite efforts to calculate it to many hundreds of decimal places, there is no definitive absolute value. This means that, although we can calculate the area or circumference of a circle with reasonable accuracy using values of π such as 3.14, the lack of an absolute value means that we can never totally accurately calculate the area of a circle, or its circumference.

Contrast this with a square, or rectangle, where it is simple to calculate the exact area, just by multiplying the height by the width. A square of side length 2.0 cm has an area of 4.0 $cm^2$; this is a value that can be determined with complete certainty and no error.

It is thus possible to say that, while we can determine the area of a square, we cannot be so certain about the area of a circle. Not surprisingly, therefore, there has been a lot of interest in the relationship between squares and circles and we even have the well known phrase, '*squaring the circle*', which is often used to represent an impossible task. If one draws a square that surrounds a circle and also a square that is inside the same circle, as shown below, it is clear that the area of the circle must fall between the areas of the two squares. This provides an initially simple, but increasingly complex, method for calculating the possible numerical outer limits of the value of π

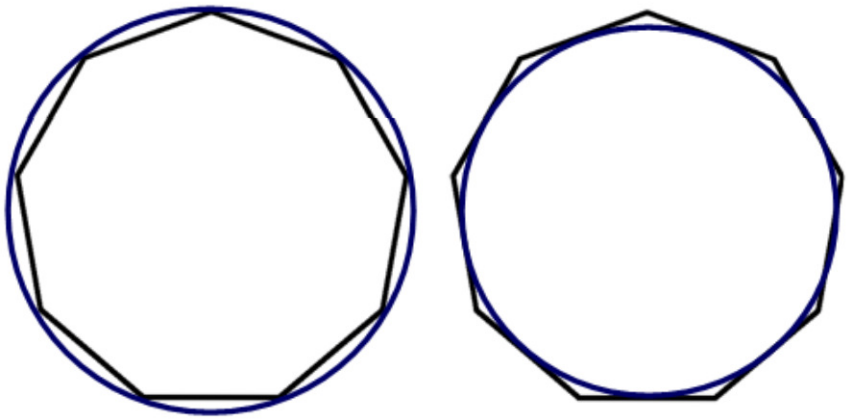


A circle circumscribed by a square



A square inscribed in a circle

f we assume that the circles above have a diameter of 2.0cm, then it follows that ealch side of the square on the left, i.e. the one with the square outside the circle, is also 2.0cm and thus the area of the square is 2.0cm x 2.0cm i.e. 4.0 $cm^2$. Calculating the area of the square on the right, i.e. the one with the square inside the circle, is slightly more difficult and involves drawing a diagonal, the dotted line in the figure on the right. The diagonal passes through the centre of the circle and is thus equal to the diameter, which in this case is 2.0 cm. Basic trigonometry tells us that the angles of the isosceles triangle formed from the two sides of the square and the diameter are 45°, 45° and 90°. The area of such a triangle can then be calculated using Pythagoras's theorem, which states that the square of the hypotenuse (the diameter) is equal to the sum of the square's of the other two sides. In this case, the square of the hypotenuse is 4.0 (2.0 x 2.0). It follows that each of the squares of the other two sides must both therefore be 2.0 and thus the side length is the square root of 2.0, i.e. 1.4142. Knowing that the length of the side of the square is 1.4142, the area is thus 1.4142 x 1.4142 i.e. 2.0 $cm^2$.
Thus, for the example with the squares above it can be stated that; 4.0 > $r^{2.}$ >2.0 and as the radius is 1.0 cm, the equation simplifies to 4.0 > >2.0.
So, it is can be seen that the value of $\pi$ lies between 2.0 and 4.0. This is not very accurate and of no real value, except that if the same approach is applied to polygons with increasing numbers of sides, the difference between the maximum and minimum values becomes smaller and smaller, as can be seen quite clearly for the nonagons shown above. (The actual area of a nonagon inscribed in a circle is approximately 92% of that of the circle's area). Ultimately, with an infinitely sided polygon (i.e. a circle), the two values coincide.



Nonaons inside and outside a circle showing the closer fit to the circle in terms of area

This type of approach for calculating an accurate value of $\pi$ goes back to the ancient Greeks and was a method employed by the mathematician Bryson of Heraclea in the period 450 to 390 BC. However, the calculations increase in complexity as the number of sides of the polygon used increase and this limited the level of accuracy to which $\pi$ could be calculated. Later, Archimedes also took a similar route for determining $\pi$ but, in this case, he focused on the perimeters of the inscribed and circumscribed polygons and developed a method that offered much simplified calculations. However, neither of these so called 'methods of exhaustion' could give the exact value of $\pi$, as they unfortunately require an infinitely sided polygon, and we again come to the conclusion that there is no absolute value of $\pi$. It was Archimedes who also showed that $\pi$ could not be obtained simply by dividing 22 by 7.

Ultimately, it is thus not possible to square the circle, ie to a square with the same area as a circle using a standard straight-edge and compass construction in a finite number of steps. The Greeks and many others were obsessed with trying to do this and people even thought there was an illness attached to trying to 'square a circle'; they called it Morbus Cyclometricus. Perhaps this is a good point at which to finish this short article.

Happy New Year to you all.

*Martin Goosey*

Review of :-

# ICT Darlington Seminar

24th November 2015

by **Pete Starkey**

Darlington in the north-east of England has become an established venue for the Institute of Circuit Technology's annual Northern Seminar, a not-to-be-missed opportunity for the UK's PCB technologists to keep abreast with current developments and to network and exchange ideas and experiences with their peers. Coordinated by ICT technical director Bill Wilkie, and generously supported by Merlin PCB Group, the programme consisted of papers on funded projects and project funding, and updates on chemical process technology.


**Anjali Krishnanunni**

With a presentation entitled Advanced PCB Manufacturing, **Anjali Krishnanunni,** project officer from **Coventry University working with Stevenage Circuits,** explained how Knowledge Transfer Partnerships (KTPs) supported by Innovate UK, the UK's innovation agency, assisted businesses to gain a competitive edge through better use of knowledge and technology, by promoting collaboration between academia and manufacturing industry

With reference to her "Pitch Perfect" project, she considered current and future issues in the PCB industry from the viewpoints of the designer, the fabricator and the assembler. Fine pitch component packaging demanded improved routability and higher interconnection density, using finer conductor geometries whilst keeping layer count to a minimum by cost-effective any-layer via-in-pad design rules. For maximising assembly yield, a critical factor was precision of solder paste application, and this was heavily influenced by the effect of PCB and solder mask topography on the consistency of contact between PCB feature and stencil. Established PCB fabrication techniques were approaching their capability limits and new methodologies were required.

Although at this stage of the project she was not at liberty to disclose practical details of process procedures, she explained that the objective of this KTP was to develop an ultra-high-density-interconnection fabrication technology compatible with a broad range of substrate materials, with low-cost interstitial vias and the potential for 25-micron lines and spaces, using low-impact surface modification techniques to minimise surface morphology. The technology would integrate straightforwardly with current process infrastructure, incurring minimal additional capital expenditure, and would be compliant with appropriate IPC standards.

**Nigel White**

From future developments concerning the minimisation of surface morphology to the current state-of-the-art in surface preparation chemistries: **Nigel White**, European product marketing manager at **Atotech**, declared tongue-in-cheek "You've just heard about using technology for making the surface smooth - now I'll discuss how to make it rough!" - although in his context the reference was to the chemical micro-roughening of copper to promote photoresist and solder mask adhesion. He described two proprietary chemistries, one based on sulphuric-peroxide and the other on cupric chloride.

Generic peroxide-sulphuric systems were well-established as adhesion-promoting micro-etches for dry film photoresist, and modern formulations offered improved stability and copper-carrying capacity

whilst providing controlled etching and uniform structures. However, they were highly sensitive to chloride contamination at levels as low as 3 ppm and there was an industry demand for chemistry with high chloride tolerance together with low process cost. Atotech's new product contained organic modifiers which gave optimised surface topography through preferential grain-boundary attack, with consistent results at chloride levels up to 40 ppm and copper loadings up to 40 g/l for an etch depth of 0.7 micron in a simple three-step process. Customers had observed yield improvements of 7%-10%.

Although mechanical cleaning had been the traditional pre-treatment technique for solder mask, chemical methods were now preferred and it was essential the pre-treatment was compatible with final finishing processes such as ENIG and immersion tin as well as maximising solder mask adhesion. Atotech had developed a formulation based on cupric chloride, which gave an optimum surface condition as measured by relative surface area increase at an etch depth of only 0.3 micron, with minimal copper removal although performance remained stable at copper loadings up to 40 g/l. The simple three-step process was compatible with horizontal equipment with titanium components and operated at low process temperatures, with cost savings over competitive products

In a second presentation, Nigel White turned his attention to direct metallisation technology.

Atotech's original direct plating system, based on tin-free colloidal palladium, had been launched 21 years ago and still fulfilled all specification requirements as a highly versatile and reliable process for all base materials including PTFE, with excellent acid-copper adhesion on surfaces with low roughness or low surface energy. But there was a market demand for an environmentally friendly and cost-effective direct metallisation process for MLB, HDI and flex/flex-rigid production, independent of the precious-metal price issues associated with palladium. He described Atotech's most recent generation of thiophene-based conductive polymer chemistry, which exhibited outstanding environmental benefits in addition to its technical attributes and low operating costs. The process was short and simple, with very low chemical and water consumption, and no hazardous materials such as formaldehyde or cyanide. It represented a mature technology, compatible with a wide range of base materials and delivering consistent high reliability, proven world-wide in mass production.

**Dr. Dominique Morrison**

Returning to the subject of the funding of research by government agencies, consultant **Dr. Dominique Morrison** clarified many of the perceived mysteries and obscurities surrounding the rules for qualification of projects for support and the procedures for preparing project proposals and gaining access to funding. Based on her many years of experience in senior research positions, and more recently as a project monitor, she gave an enlightening presentation entitled Research Funding for UK Small to Medium Enterprises. She explained the definition of an SME, basically a company with no more than 250 employees, turning over no more than 50 million euros, and the meaning of a Technology Readiness Level as a measure of the maturity of evolving research. Innovate UK, earlier referred to by Anjali Krishnanunni in connection with her KTP project, provided support for collaborative projects in the TRL range 3-6. The objective of the funding bodies was to help businesses to bring innovative products or services to market that would benefit the UK or Europe economically, socially or environmentally. Numerous types of funding were available for

individual or collaborative projects: she gave examples including Smart, Horizon 2020 and SME Instrument, and gave a step-by-step guide to the application procedure. A well organised plan was essential for success; the process was very competitive and the drafting of good proposal was not an easy task. Key elements of her advice were to consider initially whether the project offered a real solution to a business problem, was there a significant market opportunity and was it innovative? Then to prepare methodically before starting to write a realistic project plan, building a consortium and identifying a route to market, making sure the idea was innovative by conducting an IP search, and allowing plenty of time before the deadline. Expert help was available, and was to be recommended.

ICT technical director Bill Wilkie never fails to put together an outstanding programme, and the 2015 Darlington Seminar will go on record as yet another extremely successful, informative and enjoyable event.

**Pete Starkey**
I-Connect007
November 2015

**Pete Starkey**

## The Membership Secretary's notes - January 2016


It is always a pleasure to be able to hand over a Membership Certificate in person and Andy Cobley , ICT Chairman was able to do just that at the recent Darlington Seminar. Mark Vernon, our newest member is the founder and MD of VREO Innovations, an Optoelectronics company focusing on Video Technology and based in Tyne and Wear.

As we round up the ICT Membership Registry for 2015, we can confirm 32 new members and 4 reinstatements and ended the year with 355 individual members and 20 Corporate Members.

Our membership is drawn from over 100 companies with Fabricators and Suppliers representing the majority with 70%. Design houses are well represented at 10%, with the remainder being support companies to the Electronics Industry.

We have always been fortunate to have a strong support from many of the Universities in the UK and a number from assemblers and contract manufacturers.

Our level of support from the Industry has always been impressive and this year has been no exception with over 30 companies sponsoring us at various levels and due our grateful thanks.

Education remains the foundation stone of the Institute and this years' Foundation Course will be held between the 11th and 14th April at Loughborough University, using the well tried and tested principal of inviting Industry professionals to supply all the lecturers. The course has been running using the same format since 1980 and fees remain modest.

It only remains for me to wish all members a happy and prosperous New Year and to thank you for all the support you have given the Institute during 2015.

**Bill Wilkie**

Director, Membership Secretary & Organiser

### ICT MEMBERSHIP

| Year | 2010 | 2011 | 2012 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|
| Month | Dec | Dec | Jul | Dec | Dec | Dec | Dec |
| GRADE | | | | | | | |
| **A.M.Inst.C.T.** | 64 | 64 | 91 | 90 | 94 | 114 | 131 |
| **M.Inst.C.T.** | 108 | 119 | 122 | 133 | 142 | 128 | 140 |
| **Fellow** | 65 | 69 | 66 | 68 | 66 | 72 | 73 |
| **Hon. Fellow** | 10 | 10 | 10 | 11 | 11 | 13 | 11 |
| **Total of Members** | 247 | 262 | 289 | 302 | 313 | 327 | 355 |
| Increase | | 15 | 27 | 13 | 11 | 14 | 28 |

## Corporate Members of The Institute of Circuit Technology January 2016

| *Organisation* | *Address* | *Communication* |
|---|---|---|
| **Adeon Technologies BV** | Weidehek 26, 4824 AS Breda, The Netherlands | +31 (0) 76-5425059<br>www.adeon.nl |
| **ALR Services Ltd.** | Unit 9 Thame Business Park , Thame, Oxon OX9 3XA | 01844 217 487<br>www.alrpcbs.co.uk |
| **Anglia Circuits Ltd.** | Burrel Road, St.Ives, Huntingdon PE27 3LB | 01480 467 770<br>www.angliacircuits.com |
| **Atotech UK Ltd.** | William Street, West Bromwich. B70 0BE | 0121 606 7777<br>www.atotech.com |
| **CCE Europe** | Wharton Ind. Est., Nat Lane, Winsford CW7 3BS | 01606 861 155<br>www.ccee.co.uk |
| **ECS Circuits Ltd.** | Unit B7, Centrepoint Business Park, Oak Road, Dublin 12, Ireland | +353-(0)1-456 4855<br>www.ecscircuits.com |
| **Electra Polymers Ltd.** | Roughway Mill, Dunks Green, Tonbridge TN11 9SG | 01732 811 118<br>www.electrapolymers.com |
| **The Eurotech Group** | Salterton Industrial Estate, Salterton Road Exmouth EX8 4RZ | 01395 280 100<br>www.eurotech-group.co.uk |
| **Exception PCB Solutions** | Alexandra Way, Ashchurch Business Centre, T ewkesbury, Gloucestershire. GL20 8NB | 01684 292 448<br>wwwinfo@exceptionpcbsolutioncom |
| **Falcon Group** | Riverside Ind. Est. ,Littlehampton BN17 5DF | 01903 725 365<br>www.falconpcbgroup.com |
| **Faraday Printed Circuits Ltd** | 15-19 Faraday Close, Pattinson North Ind. Est., Washington. NE38 8QJ | 01914 153 350<br>www.faraday-circuits.co.uk |
| **Graphic plc** | Down End, Lords Meadow Ind. Est., Crediton EX17 1HN | 01363 774 874<br>www.graphic.plc.uk |
| **GSPK (TCL Group)** | Knaresborough Technology Park, Manse Lane Knaresborough HG5 8LF | 01423 798 740<br>www.gspkcircuits.ltd.uk |
| **Invotec Group Ltd** | Hedging Lane, Dosthill , Tamworth B77 5HH | 01827 263 000<br>www.invotecgroup.com |
| **PMD (UK) Ltd.** | Broad Lane, Coventry CV5 7AY | 02476 466 691<br>sales@pmdgroup.co.uk |
| **Rainbow Technology Systems** | 40 Kelvin Avenue, Hillington Park Glasgow G52 4LT | 01418 923 320<br>www.rainbow-technology.com |
| **Spirit Circuits** | 22-24 Aston Road, Waterlooville, Hampshire PO7 7XJ | 02392 243 000<br>info@spiritcircuits.com |
| **Stevenage Circuits Ltd** | Caxton Way, Stevenage. SG1 2DF | 01438 751 800<br>www.stevenagecircuits.co.uk |
| **Ventec Europe** | 1 Trojan Business Centre, Tachbrook Park Estate Leamington Spa CV34 6RH | 01926 889 822<br>www.ventec-europe.com |
| **Zot Engineering Ltd** | Inveresk Industrial Park Musselburgh, B19 EH21 7UQ | 0131-653-6834<br>www.data@zot.co.uk |


# Institute of Circuit Technology

## ICT Evening Seminar and AGM

at the

Puckrup Hall, Tewkesbury

**1st March 2016**

**AGM 16:30**
**Seminar Registration 17:00**
**Seminar - 17:30**

Interim list of Papers

**"Laser-induced forward transfer":**
***A novel laser-based deposition PCBs?***
Dr James Shaw-Stewart Senior Lecturer and researcher at Coventry.

**"Business Outlook Global Electronics Industry"**
Francesca Stern, of FSC.

**"An update on the MacFest project and a summary of the crabs project "**
Professor Martin Goosey

***Supported by Exception PCB Solutions***

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