Journal of the

Institute of Circuit Technology

2010 Events

15th September	17.00	Evening Seminar, Newtown House Hotel in Hayling Island supported by Spirit Circuits. www.newtownhouse.co.uk
2nd November	17.00	Evening Seminar, Darlington bill.wilkie@InstCT.org
9th - 12th November		*Electronica 2010, Munich International Fair, Germany* *www.electronica.de*

2011 Events

25th January		*EIPC Road Show on Reliability at Enthone Ltd., Woking* *kWestenberg@eipc.org*
1st Febuary	15.30 17.00	Afternoon facilities tour of CCE Evening Seminar, Chimney House Hotel, Sandbach. www.brook-hotels.co.uk/hotels/chimney-house-hotel-sandbach bill.wilkie@InstCT.org - *see back cover*
1st March	17.00	Evening Seminar, Arundel, Comfort Inn bill.wilkie@InstCT.org
11th April - 14th April		**ICT Annual Foundation Course ,** Loughborough University

Contents

Events Diary 1

Editorial 2
Council Members 2
Membership News 2

Studies into Ultrasound Desmear processes 3-8

ICT Darlington Seminar, 2nd November 2010 9-10

Electronica 2010 9th - 12th November 11-12

Solder Paste Test Print 13

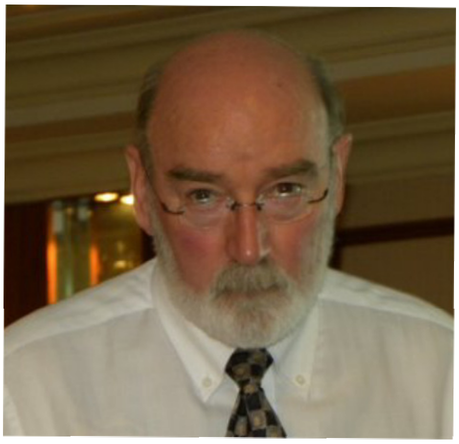
HDI PCB Production in Europe 14

ICT Group Members 15
Mem.Sec's Notes 15

Notices 16

vol.4 no.1 January 2011

Editorial



Bill Wilkie

I joined the ICT in 1980, some six years after it was founded and still have the original letter sent by Bruce Routledge on the 26th June 1980 (back cover). The industry has changed a bit since then and so have we. The subs have certainly gone up from my £10 bankers order and at that time the wait between application and acceptance could be up to six months, while the matter was debated at a suitable council meeting. Thirty years later, most applications come via our website and are dealt with on line in 5 days. Similarly, board lead times have gone from 12 weeks for a 4 layer to a few days.

If you tell the youngsters of today that we coated single flexibles on a Littlejohn Whirler by pouring liquid KMER resist onto the centre of the spinning panel, [*I used bicromated fish glue,- editor*] they wouldn't believe you. Unlike Andy in the last editorial there was no elf-n-safety or protective clothing and the resist spun onto your trouser knees and dried so that you cracked when walking.
Now we can make circuitry using modified inkjet printers and the days of the Star Trek replicator are approaching.

Back in 1980, giant electronics firms such as Marconi, ITT, Cambridge, Plessey and Ferranti and equally large computer manufacturers like ICL, IBM, Burroughs and HP all produced their own boards in house and for the most part funded extensive R&D programs. The Post Office (GPO) was a major customer for 4-layer TXE4 telephone exchange boards with 5 micron gold edge connectors. Even with miniaturisation, volumes grew at a factor of x25 from 1980 to the late nineties, led initially by the ubiquitous personal computer. There were approximately 500 fabricators in the British Isles at that time and although the vast majority were small outfits many were in the early stages of producing multilayers but by the mass bonding technique.

Most if not all were laid low due to poor management decisions, which leads me to believe that the companies left today are only in existence due to good management.

Growth since the mid nineties has continued almost unabated albeit off-shore with HDI, optoelectronics and Printed electronics all leading the way.

The ICT had over 400 members in its heyday when the industry employed in excess of 20000 people. Although our membership dropped to around 100 at the start of this century, it has recovered strongly and we now have a membership of 230 and our last Southern Area Evening Seminar at Hayling Island attracted over 100 registrations. Thanks to our supporters, we were able to have this event videoed for members unable to attend and this is a theme that we hope to continue in 2011.

Bill Wilkie,

ICT Membership Sec. & Technical Director

Membership

New members notified by the Membership Secretary

Member (M.Inst.C.T.)

10168 Andy Greasley
10169 Victor Lau
10170 Michael Bingham
10171 Lee Lloyd
10173 Chris Kenward

Fellow (F.Inst.C.T.)

10172 Steve Driver

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@btinternet.com

The Journal of the Institute of Circuit Technology is edited by Bruce Routledge on behalf of the
Institute of Circuit Technology.
32 Stretton Close, Penn. High Wycombe, Buckinghamshire, HP10 8EW
E-mail : bruce.rout@btinternet.com

Initial studies into the use of ultrasound to reduce process temperatures and chemical usage in the PCB desmear process

Andy Cobley[1],
Lindsay Edgar[3],
Martin Goosey[4],
Rod Kellner[2],
Tim Mason[1]

1) Coventry University,
2) Env-Aqua Solutions Ltd
3) GSPK Circuits Ltd
4) MTG Research Ltd

1. Introduction

The surface modification techniques used in printed circuit board (PCB) manufacture have a dual purpose. Not only must they texture the hole wall laminate to enable good adhesion between the substrate and the electroless copper but also the process must 'desmear' the drilled hole. During the drilling of through holes in a circuit board the drill bit becomes very hot [1] and may exceed the glass transition temperature (Tg) of the laminate material. In this way, epoxy is transferred to the drill bit and is 'smeared' on to subsequently drilled hole walls. This is particularly problematic when drilling multi-layer boards (MLBs), as the epoxy can be smeared across the inner-layers of these boards inhibiting electrical connection. It is therefore important that the surface modification process not only textures the epoxy laminate but also removes any smeared epoxy from the inner-layers.

One of the early methods of desmearing PCBs was by immersing the board in concentrated sulphuric acid (Angstenberger 1994, Deckert 1987, Wynschenk and Delgobbo 1986). This was clearly an extremely hazardous procedure, difficult to control and produced a 'glassy' morphology to the hole walls which made electroless copper adhesion problematic (Deckert 1987, Wynschenk and Delgobbo 1986). Chromic acid was also used (Angsten-berger1994, (up to 1000g /l) but, although quite effective, the main issue in this case was the difficulty in removing all traces of hexavalent chrome from the very porous texture produced (Deckert 1987). In the early 1980's most of the PCB industry converted to using 'swell and etch' desmear processes (Deckert 1987, Wynschenk and Delgobbo 1986). In these techniques the boards are first immersed in a hot, alkaline solution containing one or more solvents (Mandich 1994) and this leads to the 'swelling' of the resin. After rinsing the boards are then placed in a hot, alkaline permanganate solution which 'etches' the laminate, removing any smeared epoxy and leaving the laminate with a honeycomb type texture (Deckert 1987). The final step of the process is neutralisation, which removes any manganese residues from the hole walls (Thorn and Walsh 1991). It is claimed that these 'swell and etch' processes cause significant reductions in PCB through hole defects such as hole wall pull away, blistering and blow holes, whilst dramatically improving the peel strength of the electroplated deposit. In recent years there has been a move to high Tg laminates (Goosey and Poole 2004) that are more chemically inert and this has required the use of more aggressive desmear conditions. These have included using more aggressive and concentrated solvent swells and higher concentration permanganate solutions at high temperature. This trend means that the desmear process has now become a process which uses much energy and resources (i.e. chemicals). Not only does this impact on the sustainability of the process in terms of its carbon footprint, water usage and waste treatment, but it can significantly add to production costs.

This study investigates the use of ultrasound in the permanganate part of the desmear process as an enabling technology to reduce the amount of energy required and chemicals used in this essential step in the PCB manufacturing sequence. The work builds on previous studies (Mason, Cobley, Graves et al 2011, Cobley and Mason 2008, Cobley and Mason 2007) which have shown that ultrasound, at an optimised frequency and power, can bring about significant surface modification on a range of non-conductive materials.

2. Method

The experiments performed in this evaluation can be divided into the three main parts and are detailed as follows.

i) Initial screening experiments

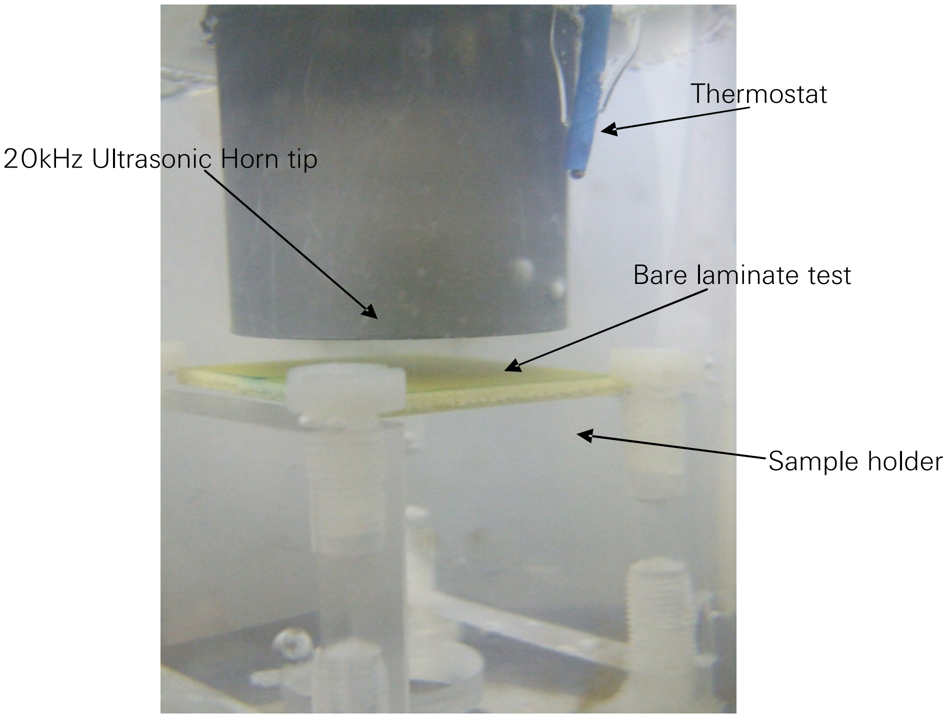
This work involved the use of a relatively high Tg laminate, Isola 370HR. For these initial experiments the material was supplied as undrilled and copper clad. The copper was etched off at Kelan Circuits (now GSPK Circuits Ltd) to reveal the base laminate and then brushed.
Test coupons of this material of dimensions 3 cm x 3 cm were then cut for the screening experiments. Kelan Circuits employ a horizontal desmear process and the times and temperatures utilized in this study were chosen to closely match those used in their production process. The main variables investigated centred around the use of the permanganate 'etch' solution i.e. concentration of potassium permanganate, concentration of sodium hydroxide and operating temperature. One set of runs was also carried out which used no solvent swell.

Table 1 summarizes the desmear conditions used and the variables.

Process	Make-Up	Temp. (C)	Time (min.)
M-Treat AQ (Solvent Swell)	20%v/v M-Treat K, 22g/l NaOH	60	1.4
Rinse			2.0
M-Permanganate P	0,33,65g/l M-Permanganate P 0 or 32g/l NaOH	5,25,40,60,85	2.8
Rinse			3 x 1.0
Neutralizer	3% (v/v) H_2SO_4, 3% (v/v) 37% H_2O_2	Ambient	0.8
Rinse			2.0
Deionized (DI) Rinse			1.0

The permanganate etch was used with and without ultrasound. When no ultrasound was utilized (silent conditions), the permanganate solution was vigorously stirred (500 rpm) on a thermostatic hot plate. Ultrasound was introduced to the permanganate solution via a Sonic Systems Ltd processor (model P100/3-20) with a 20 kHz ultrasonic horn (model 99892) which had been hard chrome plated and had a horn diameter of 27 mm. The applied power was 50 W throughout all the experiments. The test coupon was secured in a holder with a probe to sample distance of 5 mm. It should be noted this meant that most of the ultrasonic field only affected the side of the test coupon facing the probe. Fig.1 shows a close-up of this experimental set-up. A jacketed beaker was used to contain the 'etch' solution which was attached to a chiller. This allowed a constant temperature to be maintained.

Figure 1. Experimental set-up for runs involving ultrasound.



Three test coupons were prepared under each of the experimental conditions and the only response measured was weight loss. The procedure for determining weight loss was as follows:

1. Dry in Oven at 120ºC for 24 hrs
2. Cool in desiccator for 1 hour
3. Weigh to four decimal places
4. Process
5. Dry in Oven at 120ºC for 24hrs
6. Cool in desiccators for 1 hour
7. Weigh to four decimal places

The weight loss was then calculated as:

$$\text{Wht.loss (mg/cm}^2\text{)} = \frac{\text{Int. Wht. (g) - Fin.Wht (g)}}{\text{Tot. surface area (cm}^2\text{) x 1000}}$$

ii) Confirmatory experiments

Alhough weight loss gives some information on the efficacy of a desmear process and is a relatively quick and easy way of screening process conditions, the results must be verified by through hole assessments. In these confirmatory runs some of the most promising process conditions from the screening tests were repeated on drilled through holes in a four-layer multi-layer board (MLB). The hole diameter was 0.9 mm and the laminate was again Isola 370HR. An additional variable was also introduced at this stage of the work. As mentioned above, the initial experimental set up meant that, effectively,only one side of the board was affected by the ultrasonic field. For this reason the test coupons were turned over or 'flipped' half way through the process time to determine if this improved the effectiveness of the desmear.

After desmear the through holes were sectioned and assessed for smear removal using a Jeol 6060LV Scanning Electron Microscope (SEM).

iii) Process validation at Kelan Circuits.

In the final part of the study the two ultrasonic desmear conditions which had given the optimal smear removal and hole conditioning were used to desmear a further four drilled MLB test coupons (as described above) under laboratory conditions at Coventry University.

After desmear they were then processed down the horizontal 'making hole conductive' (MHC) line at Kelan Circuits. Kelan use a 'black hole' system for MHC with the process conditions shown in Table 2.

Process Name	Temp. ^{0}C	Con-tact Time sec
Blackhole Cleaner	52-57	36
Spray Rinse x 2	Ambient	28
Blackhole HT (1)	32-35	36
Blackhole HT (2)	32-35	28
Drain		53
Hot Air Dry	57-63	53

Table 2. Black Hole process used at Kelan Circuits.

Drilled MLB coupons were also processed in the standard desmear line at Kelan Circuits to act as a control. All the test coupons were then electroplated with copper and finally coated with silver using a standard immersion process. After this

Run No.	Solvent	Permanganate Temp. ^{0}C	Permanganate Conc. g/l	NaOH g/l	Mean Weight Loss mg/cm^2 Silent	Mean Weight Loss mg/cm^2 Ultrasound
1	Yes	60	65	32	0.0969	0.1732
2	Yes	85	65	32	0.1477 (Baseline)	0.2577
3	Yes	5	33	32	0.0232	0.0819
4	Yes	25	33	32	0.0310	0.0982
5	Yes	40	33	32	0.0369	0.1325
6	Yes	60	33	32	0.0655	0.1549
7	Yes	85	33	32	0.0981	0.1669
8	Yes	5	0	32	0.0147	0.1234
9	Yes	25	0	32	0.0081	0.1054
10	Yes	40	0	32	0.0213	0.1087
11	Yes	60	0	32	0.0097	0.1171
12	Yes	85	0	32	0.0114	0.1233
13	Yes	5	0	0	0.0050	0.1423
14	Yes	25	0	0	-0.0014	0.1314
15	Yes	40	0	0	-0.0051	0.1165
16	Yes	60	0	0	0.0161	0.1235
17	Yes	85	0	0	0.0211	0.1515
18	No	5	0	0	0.0450	0.1415
19	No	25	0	0	0.0539	0.1325
20	No	40	0	0	0.0440	0.1206
21	No	60	0	0	0.0409	0.1071
22	No	85	0	0	0.0344	0.1460

Table 3 gives the weight loss results for the various ultrasonic and 'silent' conditions used in the desmear process.

they were solder floated (1x10 sec. at 260 ºC) and then sectioned and examined for inter-connection defects (ICDs)

3. Results and Discussion

3.1) Initial screening experiments

It shoud be noted that, for the experiments which used the full strength permanganate (65 g/l), no temperatures below 60ºC were employed. This is because at this concentration, higher temperatures are required to maintain the permanganate in solution.
The desmear conditions currently used at Kelan Circuits are represented in run 2 under 'silent' conditions. The weight loss obtained under these conditions is therefore designated as the 'baseline' figure. The results are also illustrated graphically in Figures 2-6. It should be noted that in these figures the dashed line represents the 'baseline' weight loss.

Fig. 2 Etch solution - 65g/l $KMnO_4$, 32g/l NaOH Solvent - Runs 1 & 2, Table 3

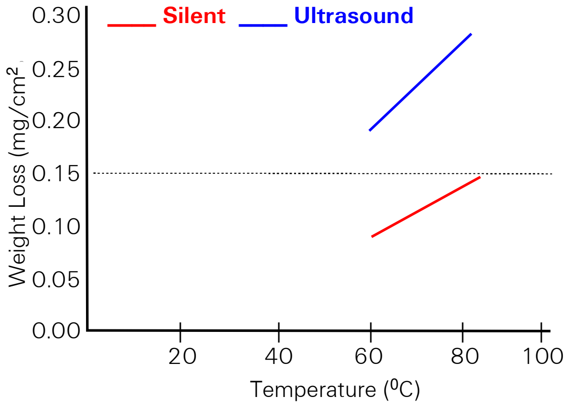


Fig. 3 Etch solution - 33g/l $KMnO_4$, 32g/l NaOH Solvent - Runs 3-7, Table 3

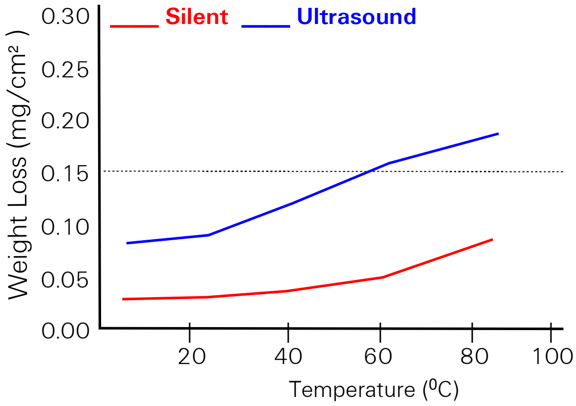


Fig. 4 Etch solution - 0g/l $KMnO_4$, 32g/l NaOH Solvent - Runs 8-12, Table 3

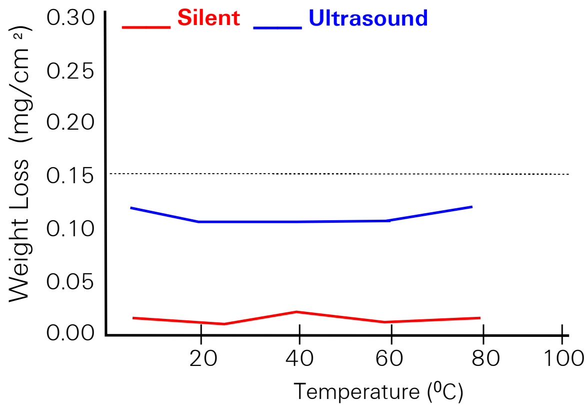


Fig. 5 Etch solution - 0g/l $KMnO_4$, 0g/l NaOH (i.e. DI Water) Solvent - Runs 13-17 Table 3

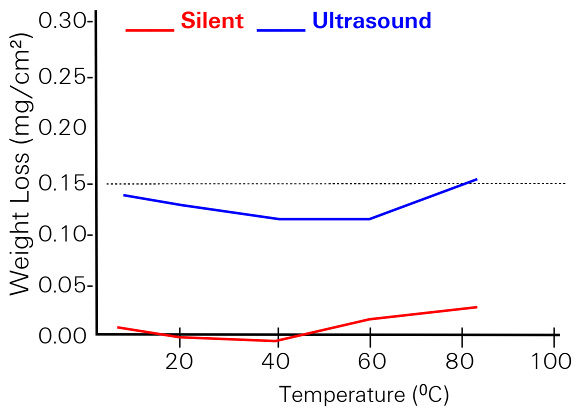
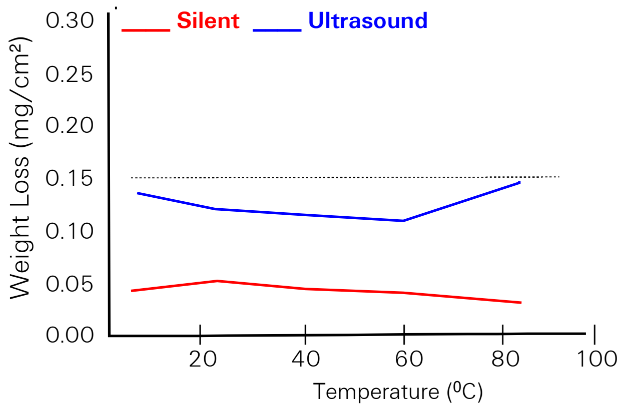


Fig. 6 Etch solution - 0g/l $KMnO_4$, 0g/l NaOH (i.e. DI Water) No Solvent - Runs 18-22 Table 3



It is quite clear from these results that whatever 'etch' conditions were used, the introduction of an ultrasonic field always significantly improved the weight loss obtained. When full strength permanganate was employed (Table 3, Runs 1 and 2, Figure 2) the utilization of a 20 kHz ultrasonic horn almost doubled the weight loss. If the permanganate concentration was halved then, at the higher temperatures (Table 3, Runs 3-5, Figure 3), the presence of an acoustic field caused the weight loss to rise by a factor of three, compared to the silent tests. Despite the obvious effect of ultrasound, consideration of Figures 2 and 3 and Table 3 (Runs 1-5) indicates that temperature is the main effect on weight loss if permanganate is present in the 'etch' and as it was raised so the weight loss increased under both silent and ultrasonic conditions.

When permanganate was removed from the 'etch' there was, as expected, a dramatic effect on weight loss under normal conditions (Table 3), but ultrasound provided a marked enhancement, and Figures 4-6 indicate that ultrasound (rather than temperature) is now the main effect. Indeed, the weight losses obtained when an ultrasonic horn was used were, in some cases, an order or magnitude higher than the corresponding 'silent' experiments. The results obtained when using ultrasound in water alone tended to be somewhat higher than those achieved in sodium hydroxide (compare Figures 4 and 5) and were very similar to those obtained if no solvent swell was employed (compare Figure 5 and 6).

The effects brought about by ultrasound in surface treatment are the result of a phenomenon known as acoustic cavitation and, in particular, the violent collapse of cavitation bubbles (Mason, Cobley, Graves et al 2011, Cobley and Mason 2008, Cobley and Mason 2007). A study of the resulting effects of acoustic cavitation on chemistry is termed sonochemistry and water is an excellent medium in which to apply it. The reason why water is so good for sonochemistry is due to its hydrogen bonded structure. For a molecule of such low molecular weight, water has a relatively high viscosity and low vapour pressure at room temperature. This means that during cavitation bubble formation the rarefaction phase of the acoustic wave must possess considerable energy in order to pull the molecules apart (the so-called cavitation threshold). Once formed the bubbles can go on to grow during succeeding waves and eventually reach an unstable size and collapse. In the case of water, this collapse is violent enough to generate high energy hotspots with temperatures of 5000 ° and pressures on implosion of greater than 2000 atmospheres. This extreme energy from collapse is assisted by the low vapour pressure of water, which means that very little gas (water vapour) will enter the bubble to cushion the violence of the implosion. When the water temperature is raised the collapse is less violent due to increased vapour pressure and more entering the bubble. For other common solvents with less hydrogen bonding and higher vapour pressures than water e.g. ethanol, the collapse energy will be much less.

Figures 5 and 6 also show a very similar shape to the weight loss curve obtained in an acoustic field with weight loss non-uniform and the highest values being obtained either at the lowest or highest temperatures. This shape can be attributed to the competition between the effect of temperature on two different etch mechanisms;-

Ultrasound :from the above it would be expected that higher weight losses due to cavitation would be expected at lower temperatures where collapse energy is high. Conversely, as the temperature in the system approaches the boiling point of water, the influence of ultrasound should reduce as more water vapour enters the cavitation bubbles before collapse. Thus, ultrasonic effects decrease with temperature.

Chemical : the increase in weight loss at the most elevated temperatures suggests that some chemical effects are occurring.

Thus, it is logical to conclude that a combination of ultrasonic and chemical etch would be influenced mainly by ultrasound at lower temperatures, which decreases as temperature rises leading to lower weight loss. As the temperature rises further the drop in weight loss is compensated by some other mechanism, most likely an increase in the chemical effects which continues to rise so that, at the most elevated temperature, the chemical effect becomes predominant. The shaded values in Table 1 highlight the weight loss results which were close to or exceeded those obtained using the standard desmear process parameters employed at Kelan Circuits. These results suggest that if ultrasound is used in the 'etch' stage of the desmear process then the process temperature could be reduced to 60ºC and the permanganate concentration halved. Figure 5 also implies that at either high or low temperatures, weight losses close to the baseline can be obtained by if ultrasound is applied through water alone.

3.2 Confirmatory Experiments

Following the results from the screening tests, the process conditions shown in Table 4 were used to desmear through holes in a four-layer MLB. In addition, the effect of 'flipping' the samples half way through the process was investigated.

The results in Table 4 indicate that the only runs which gave smear-free inner-layers were those that had been processed through a permanganate-containing etch. In addition, ultrasound improved the desmear quality when full strength permanganate was employed at 60ºC (Table 4, Runs 24 and 32). This result

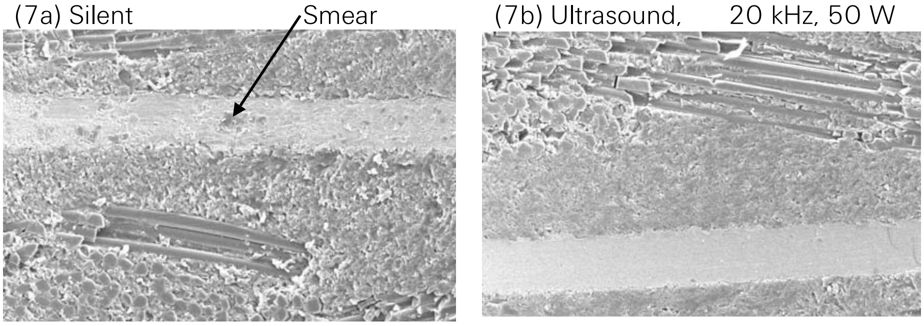
Run No.	Silent / Ultrasound	Solvent Yes/No	Permanganate Temp. ⁰C	Permanganate Conc. g/l	NaOH g/l	Desmear assessment by SEM
23	Silent	Yes	85	65	32	No smear
24	Silent	Yes	60	65	32	Smear
25	Silent	Yes	85	33	32	No smear
26	Silent	Yes	60	33	32	Smear
27	Silent	Yes	85	0	0	Smear
28	Silent	Yes	5	0	0	Smear
29	Silent	No	85	0	0	Smear
30	Silent	No	5	0	0	Smear
31	Ultrasound	Yes	86	65	32	No smear
32	Ultrasound	Yes	62	65	32	No smear
33	Ultrasound	Yes	84	33	32	No smear
34	Ultrasound	Yes	63	33	32	Smear
35	Ultrasound	Yes	84	0	0	Smear
36	Ultrasound	Yes	6	0	0	Smear
37	Ultrasound	No	86	0	0	Smear
38	Ultrasound	No	5	0	0	Smear

Table 4. SEM desmear assessment using four-layer MLB test coupons.

is further emphasised by consideration of Figures 7a and b, which show desmeared inner layers produced under these conditions without and with ultrasound respectively.

Fig. 7 Inner layers desmeared under the following conditions
etch solution - $KMnO_4$ - 65g/l, NaOH - 32g/l, temp. - 60 C

(7a) Silent (7b) Ultrasound, 20 kHz, 50 W (applied power)

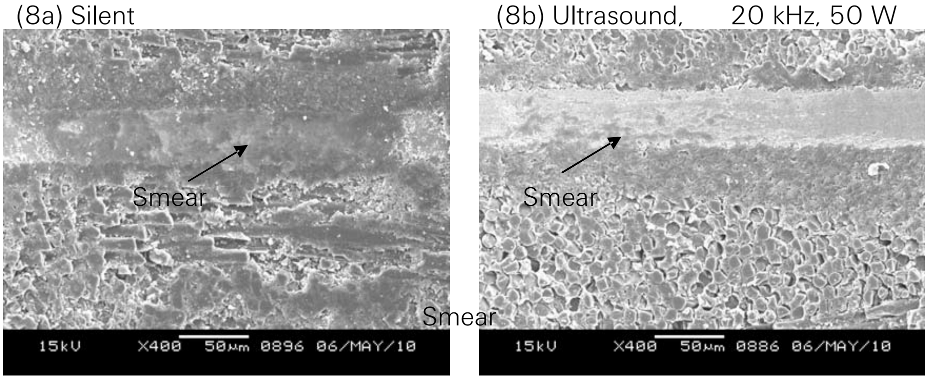


15kU X400 5µm 0900 06/05/10 15kU X400 5µm 0901 06/05/10

In addition, although the desmear processes which did not contain permanganate all showed smear on the inner-layers whether the samples were sonicated or not, the use of ultrasound did in fact still improve the desmear quality. The SEMs from runs 30 and 38 demonstrate this very clearly and are shown in Figures 8a and b respectively.

Fig. 8 Inner layers desmeared under the following conditions.
No solvent swell
etch solution - $KMnO_4$ - 0g/l, NaOH - 0g/l, (i.e. DI Water) temp.- 5C

(8a) Silent (8b) Ultrasound, 20 kHz, 50 W (applied power)



As previously stated, the experimental set-up used in this study meant that, when ultrasound was used, one side of the test coupon would mainly be affected by the acoustic field. For this reason the affect of turning the coupon over (flipping) half way through the process time was studied and the results are given in Table 5.

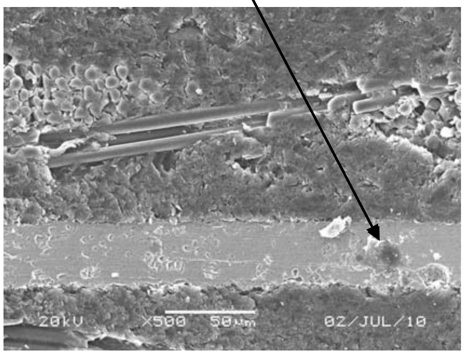
Run-No	Sol-vent	Flip-ped	Permanganate Temp. °C	Conc. g/l	NaOH g/l	Desmear Assessment by SEM
39	Yes	No	60	65	32	75% of inner layers clean 25% had some debris present No smear observed
40	Yes	Yes	60	65	32	All inner layers clean No smear observed
41	Yes	No	60	33	32	50% of inner layers clean 25% had some debris 25% had smear present
42	Yes	Yes	60	33	32	88% of inner layers clean 12% had some debris present No smear observed

Table 5. Effect of 'flipping' on ultrasonic desmear assessment using four-layer MLB test coupons.

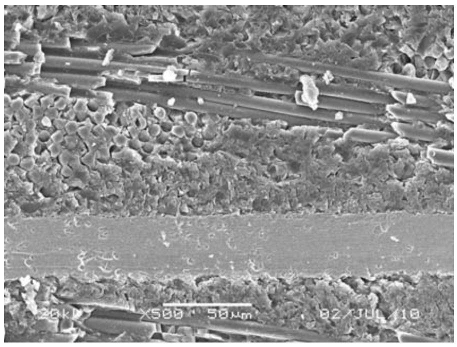
Because the main objective of this study was to reduce process temperatures and chemical usage, only the process conditions which fell into this category were chosen for this final test. The results suggested that 'flipping' the test coupons enhanced the ultrasonic desmear and appeared to enable half strength permanganate to be used at reduced temperature. SEMs of inner-layers from runs 41 and 42 (Figure 9 (a) and (b) respectively) clearly show the effect.

Fig. 9. Inner layers desmeared under the following conditions.
No solvent swell.
Etch solution - KMnO4 – 0 g/l, NaOH – 0 g/l (i.e. DI water),
Temperature - 5 ºC
Ultrasound – 20 kHz, 50 W (applied power)

(9a) No flip



(9b) Flipped



3.3) Process validation at Kelan Circuits

The ultrasonic desmear conditions used in runs 40 and 42 (Table 6) were repeated to process further four-layer test coupons (three for each condition). The desmeared coupons were then transported to Kelan Circuits, where they were processed through MHC, electroplated and then finished with immersion silver.
The 0.9 mm holes were then solder floated and sectioned before examination under an optical microscope. A total of 64 inner-layers was assessed for ICDs. The results are given in Table 6 following page.

Run No.	Solvent	Samples flipped	Permanganate Temp. ⁰C	Conc. g/l	NaOH g/l	ICD rate (%)
Std. Kelan Desmear	Yes	N/A	85	65	32	0
40	Yes	Yes	60	33	32	0
42	Yes	Yes	60	33	32	0.0

Table 6. Ultrasonic versus Standard Desmear

These results show that, when using the Isola 370HR four-layer test coupon with 0.9 mm holes, the use of ultrasound could produce ICD-free inner-layers using reduced temperature permanganate either at full strength or half-strength.

4. Conclusions

The results from the initial screening study showed that whenever the 20 kHz ultrasonic probe was introduced to the 'etch' stage of the desmear process, significantly higher weight loss was obtained. This effect was even more pronounced if a permanganate 'free' etch was used. It was also found that the use of ultrasound could produce weight loss which was equivalent to or better than the baseline (i.e. standard permanganate etch conditions) at low temperatures and with half strength, or even without permanganate, in the etch.

Based on these screening tests, further experiments were carried out on four-layer MLB test coupons which were assessed for smear using an SEM. The results showed that only those boards processed with permanganate in the etch were smear-free, although ultrasound could enable low temperature processing. However, although non-permanganate containing etches could not produce smear-free inner-layers, the results suggested a significant improvement over those desmeared under silent conditions. In addition, flipping the samples half way through the ultrasonic desmear process was found to enhance the process.

Final process validation runs at Kelan Circuits suggested that ICD-free boards could be obtained if ultrasound was used in either a full strength or half-strength permanganate solution at 60ºC.

References

Angstenberge,r A. (1994) "Desmear - a key proces in the manufacture of reliable through-hole plated printed circuit boards". *Galvanotechnik*. 85 (11), 3819-3829

Deckert C. A., (1987) "Advances in MLB technology" *Circuit World*. 13 (3), 29-35

Wynschenk J. Delgobbo A., (1986) "Genuine etchback using permanganate systems" *Circuit World*. 13 (1), 78-84

Mandich N. V., (1994). "Chemistry of solvent conditioning prior to permanganate etching of PCB's" *Trans. IMF*. 72(1), 41-44

Thorn C. E, Walsh M. K., (1991) "The Mechanisms of permanganate desmear" *PC Fab.,*, 30-32

Goosey M., Poole M., (2004) "An introduction to high performance laminates and the importance of using optimised chemical processes in PCB fabrication" Circuit World, 30 (4), 34-39

Mason T. J., Cobley A. J., Graves J. E., Morgan D., (2011) "New evidence for the inverse dependence of mechanical and chemical effects on the frequency of ultrasound" *Ultrasonics Sonochemistry*. 18, 226-30

Cobley A. J,, Mason T. J., (2008) "The sonochemical surface modification of materials for electronic manufacturing. The effect of ultrasonic source to sample distance" *Circuit World*. 34 (3), 18-22

Cobley A. J., Mason T J.(2007) "The evaluation of sonochemical techniques for sustainable surface modification in electronic manufacturing" *Circuit World*. 33 (3), 29-34

Mason T. J., Lorimer J. P., (2002) Applied Sonochemistry, Wiley VCH. ISBN 3-527-30205-0

Acknowledgment

An earlier version of this paper has been submitted for publication in the journal Circuit World, Volume 37, Issue 1.

The Institute of Circuit Technology Darlington Evening Seminar 2nd November 2010

Cold, dark, wet, windy; great drifts of soggy fallen leaves: driving into Darlington in the north-east of England on the evening of 2nd November was not the most inspirational of experiences! But British PCB guys are robust and resilient, and a fair crowd congregated at the Devonport Hotel for another excellent technical seminar and networking event organised with support from Merlin Flex-Ability Ltd and introduced by

Bill Wilkie.
ICT Technical Director

The first presentation was

A comparison of via reliability after lead-free soldering using thermal cycling and interconnection stress testing.

Martin Wickham
National Physical Laboratory

Objectives of the project were to evaluate the effects of via proximity and the inclusion or exclusion of non-functional pads, and to compare the relative performance of the two test methods. Test coupons were based on a 10-layer daisy-chain design of 2.5 mm finished thickness, with 10:1 aspect-ratio via holes on 1.0 and 0.8 mm pitch. Microvias were included in the design. The coupons were subjected to reflow conditioning in a 7-zone oven with a peak temperature of 260°C before testing. Thermal cycling conditions were 3000 cycles -55°C to +150°C with 5 minute dwell and all substrates were continuously monitored. Failure was indicated if chain resistance exceeded 5'Ω. Interconnection stress test coupons were heated from ambient to 150°C in 3 min. and cooled back to ambient in 2 min., with continuous resistance monitoring. The 10% rejection criterion was 100 milliohms. The test results indicated that there were no significant differences in via reliability between fine and coarse grid pitches. Coupons with immersion silver finish and high aspect ratio vias showed earlier failure if non-functional pads were left in place. The two test methods gave comparable results: interconnection stress testing was good if a rapid evaluation was required, thermal cycling was preferred if a wide range of experimental parameters were to be tested. Wickham remarked that test coupon manufacturing consistency was an issue: some data had to be discarded as a consequence of variable copper plating thickness and brittle electroless nickel.

Discussion of methods of calculating, specifying and measuring electrical characteristics of PCBs.

James Stapley
Polar Instruments
Applications Support Engineer

An enlightening presentation about practical aspects of controlled impedance, loss simulation and test. Designers and fabricators now had access to material libraries and the facility to simulate trace geometries, make accurate prediction of impedance and communicate clearly documented stack-up information to each other, and good communication saved costly rebuilds. Accurate modelling was critically important, although in real multi layer constructions, the detail local distribution of glass and resin could lead to variances between calculated and actual dielectric values, requiring meaningful tolerances to be applied. Material selection was critical to the performance of the final product. Solder mask could have a dramatic effect on the impedance of surface traces, as much as 10'Ω depending on geometry, and needed to be taken into account in the modelling. Stapley commented that all models were wrong, but some were useful! Historically, impedance modelling assumed lines to be loss-less, but future trends to finer line-widths and higher operating frequencies would result in increased dielectric loss and skin loss in transmission lines, and these would need to be taken into consideration in modelling and testing. Regarding impedance testing, time domain reflectometry had evolved to be straightforward and robust, and it was important to recognise that TDR testing was a manufacturing validation, rather than a design validation.

Martin Wickham returned to report on :-

The progress of the NPL Joint Industry Project on delamination and storage issues with PCB's, Observing and measuring the mechanism and effects of moisture absorption.

He described the details of two measurement methods that had been evaluated: route impulse energy and capacitance. The route impulse energy technique used time domain reflectometry, and measured the difference in loss between two identically constructed PCB transmission lines of different lengths, with similar test equipment to that used for routine impedance measurement andsome additional software. Good correlation between RIE and moisture ingression had been observed, and a significant change in RIE was measured on 6-layer test boards after 2-3 days damp heat conditioning. The method could potentially be used for delamination measurement if delamination occurred between signal line and ground plane. The capacitance method gave a meaningful measure of moisture content as a means of detecting conditions for early failure through delamination. A mass increase of 0.35% due to water absorption corresponded to a capacitance increase of around 10%, and capacitance measurement showed no obvious distinction between board types. Wickham went on to explain how moisture uptake effects could be modelled, and showed some surprising results on moisture distribution within PCBs during baking. In certain cases, baking resulted in driving moisture further into the structure of the board. Boards that were stored in high temperature and humidity environments absorbed greater amounts of moisture than those stored in cooler environments, making them more prone to delamination during the reflow process. The general conclusion was "Store in a cool dry place"

Designing flexible circuits to meet present-day reliability, cost and lead-time demands.

Mark Merifield,
Operations Manager
Merlin Flex-Ability

Gave a very informative presentation. He stressed the importance of the designer establishing a good line of engineering communication with the manufacturer as early as possible in the design cycle, understanding what were preferred panel formats for assembly and test, how to get good material utilisation, and how to correctly specify profile tooling with regard to quantity and dimensional tolerance requirements. Material selection was particularly significant: wherever possible standard materials were preferred, copper thickness 18 or 35 micron and polyimide thickness 25 or 50 micron. Costs and lead-times increased dramatically if non-standard materials or builds were specified. Merifield reviewed general application requirements: physical, electrical and mechanical, and typical layout and design rules. He listed Merlin Flex-Ability's standard manufacturing capabilities and design preferences. His general advice was to get the manufacturer involved early, to design in accordance with IPC2223, to keep the design within standard manufacturing capabilities and to use standard constructions and materials wherever possible.

The effect of ultrasound in the permanganate desmear process.

Dr Andy Cobley,
ICT Vice-Chairman

Gave the final presentation with a brief update of proof-of-concept experiments carried out at Coventry University's Sonochemistry Centre.

A proprietary permanganate desmear process had been operated at various concentrations and temperatures, with and without ultrasonic agitation. Weight loss had been measured on FR4 laminate, and plated-through holes had been visually assessed by scanning electron microscopy. It had been observed that ultrasound always produced higher weight loss on coupons than the equivalent process without ultrasound, that smear removal was generally better with ultrasound than without, and that ultrasound enabled the production of samples free of interconnection defects with full strength and half strength permanganate at 60ºC

Each of the presentations sparked lively interactive discussion, and some informal debate carried on well into the evening. A group of laminators congregated in the bar, reminisced about the good old days, as laminators generally tend to on such occasions, and argued at length about the relative merits of their competitors' products. When someone suggested it was bed-time, a faint voice from the back was heard to protest: "But we haven't talked about bow and twist yet..."

Pete Starkey
November 2010

Solder Paste Test Print

Bob Willis

"Testing first-off paste prints without contaminating the PCB, its simple and does not leave any mess!"

What are paste test prints; well before you print a board with solder paste you should print a sample to establish the quality of printing.
I have often heard the statement in SMT production lines world wide "Our second print is always better", so why print the first board when it's not necessary? If you print a sample board and the quality of the print is not satisfactory, outside of your criteria, technicians will take the board and clean it prior to reprinting. These boards are referred to as wash offs and should always be marked on their edge for future reference in production and tractability.

Wherever possible cleaning should be avoided, as it's difficult to do successfully and is very likely to leave solder balls on the surface of the board. (Fig.1)You will find solder balls in through holes, vias and also lodged in solder mask windows. This will be obvious with manual cleaning and may also be found during semi automatic cleaning of assemblies, it can be a nightmare after first side build, so why do it?

There are simple and practical ways of printing a first off without the paste touching the board surface. Using a low tack clead (Fig.2) on a reel and can be spliced to a specific widths by the supplier. A section of the roll is placed on the surface of a table or flat surface. A sample board is placed on the tacky surface of the film and using a knife the film overhang is removed.

Turning the board over allows confirmation of successful coverage without any lifting or crinkles in the film which may impede successful printing due to the uneven surface lifting the stencil. The board can then be loaded into the printer and printed using all the same printing parameters. (Fig.3)The surface fiducial marks can easily be seen through the film. After printing the quality of paste definition can be determined. Alignment, paste volume and any paste squeegee out from the apertures due to excess pressure, print speed and damage to the stencil can easily be assessed. (Fig.4)

Today we use a range of PCB surface finishes and some are more affected by cleaning than others and with what type of cleaning materials. In order of performance after any cleaning process copper OSP is worst and solder coated is best along with gold over nickel, silver and tin are in the middle. One of the nice things with solder coating is that any surface contamination is ruptured as the solder reflows.

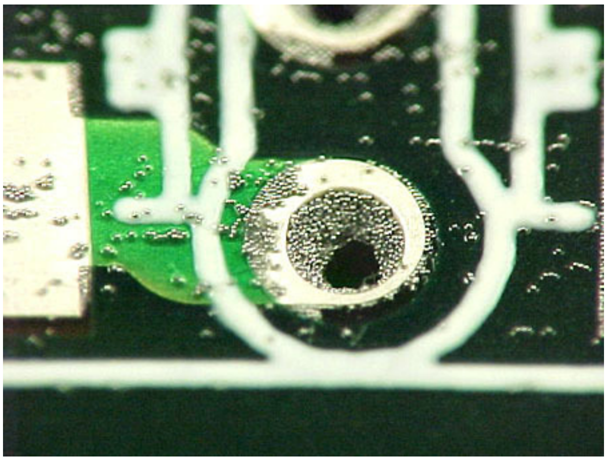


Fig.1 Solder balls on the surface of the board

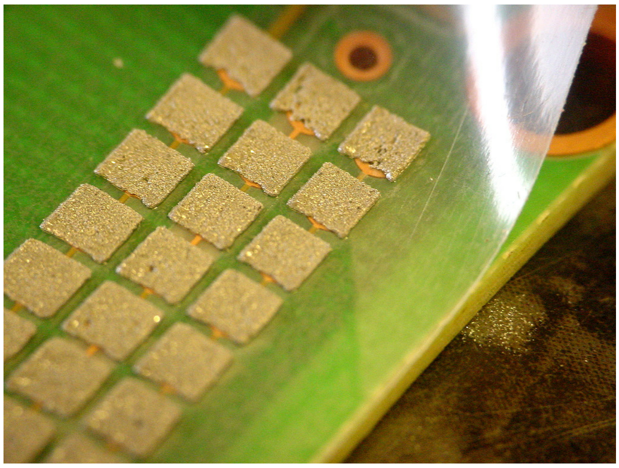
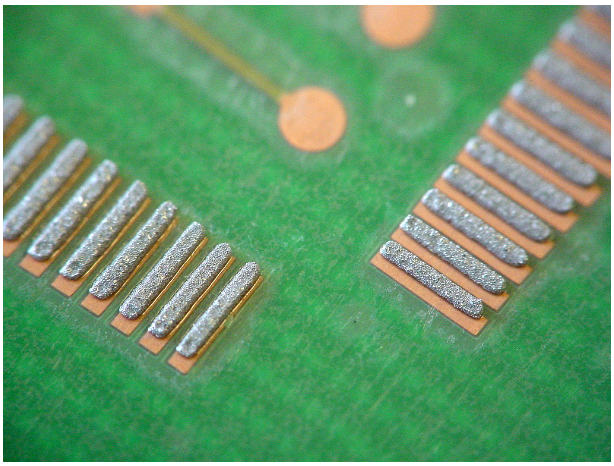


Fig.2 Using a low tack clead



Fig,3 Solder Paste Test Print - showing necessary adjustment.

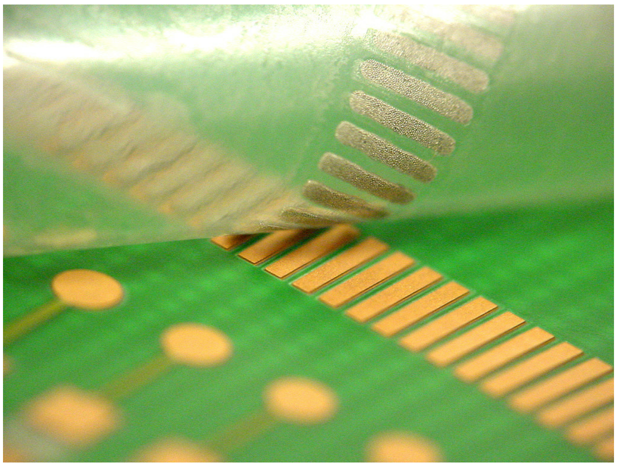


Fig.4 Peeling off low tack clead.

Bob Willis is a process engineer working in the electronics industry, providing training, consultancy and product failure analysis. Bob also offers on site workshops on conventional and lead-free for customers. www.askbobwillis.com

Electronica 2010
Munich, Germany
9 to 12 November 2010

For anyone familiar with the electronics industry, November in Munich means one of two things; Electronica or Productronica. These are the two exhibitions that are held in November on alternate years at the Neue Messe in Munich. This year it was Electronica 2010, the 24th trade show and exhibition covering electronic components, systems and applications.

For anyone who has not visited Electronica, the sheer scale of the exhibition is at first difficult to comprehend, but the official figures produced by the organisers help to give some idea of its magnitude. There were almost 2600 exhibitors occupying 143,500 square meters of space in 13 large halls, with over 500 organisations exhibiting just on photovoltaics related products and technology. In addition to the exhibition, there was a full supporting programme of almost 240 lectures and panel discussions covering a wide range of subject material from automotive electronics to wireless technology.

Visitors to Electronica also had the opportunity to visit Hybridica, the international trade fair for the development and manufacture of metal-plastic hybrid components which ran concurrently.

Although for many people it is Productronica that is most associated with Printed Circuit Boards (PCBs), Electronica provides a valuable opportunity for PCB fabricators to demonstrate their capabilities and products to new and existing customers. Consequently, one of the thirteen halls, Hall B1, was well populated with PCB manufacturing companies from across Europe and further afield. The Austrian company AT&S had an extremely large stand, while other well known board makers such as Fuba, Somacis and Graphic Plc were all to be found nearby, along with supporting companies such as Polar Instruments. Perhaps not surprisingly, there were also quite a few Chinese circuit board makers present.

Unless one has almost unlimited time available to visit Electronica, it is impossible to achieve a comprehensive visit to the whole exhibition. Nevertheless, it was quite apparent from simply walking around the various halls, just how much interest there was in new lighting, display and LED based

products and technology. With the established requirement for displays to be as flat, energy efficient and high resolution as possible, it was clear that display manufacturers were focussing on these attributes in the products they had put on show.

Samsung, for example, presented its new, large format HD displays that were intended for use in e-signage applications, such as those that are found at airports and shopping centres etc.

In Hall A3 there was a ‘Display/e-Singage’ forum which, under the logo of ‘big sizes, low energy, 3D and touch’, offered both a range formal speaker presentations and an area for exhibitors to promote their products.

With sales of LEDs being predicted to double by 2013, to a figure of €14.3 billion, it is not hard to see why there were so many new products on show, especially those in the fields of very bright LEDs and OLEDs.

There was also a significant focus on automotive electronics, with the organisers estimating that around 20% of the exhibitors at Electronica were either presenting products related to the automotive sector or future mobility applications. As part of Electronica, there was also the Electronica Automotive Conference and an ‘Automotive Forum’. The conference was held on November 8 and 9, with the first day focussing on markets and strategies, while the second day covered more technical aspects.

Companies promoting products and technologies around renewable energy were also well represented at Electronica. Exhibitors showed storage technologies for wind and solar power plants, components for power electronics, inverters and energy harvesting solutions for building services and industrial applications. Energy efficiency also became part of the trade fair itself with entire stands being equipped with LED lighting for the first time. This offered the organisers the advantages, compared with conventional lighting, of reduced heat generation and lower energy consumption.

Electronic applications in medical technology were also very much present at the exhibition, with more than 1100 exhibitors displaying many innovative new products and technologies in this area. They presented, for example, electronic components for the latest generation of intelligent prostheses, portable medical devices such as blood sugar testers and pulse monitors, implantable blood pressure sensors and remote monitoring and control systems for heart pacemakers. With so many exhibitors showing such a wide range of products it was a clear demonstration of the contribution that medical electronics is now able to make to the quality of life of many people and also an indication of what it will be able to do in the future.

This was the second time that Hybridica had been held in conjunction with Electronica and for 2010 the focus was on moulded interconnect devices (MIDs) and related technologies. In Hall C1 there was a joint 3D MID stand which was occupied by more than a dozen companies and which gave visitors the opportunity to see some of the latest developments in MID technology. Companies exhibiting on this stand included Evonik Degussa, Harting and Laser Micronics, as well as the Institute for Manufacturing Automation and Production Systems from Erlangen University. Hall C1 also had a demonstration of the latest technology for reel to reel manufacturing of hybrid components and it contained examples of new developments in stamping machines, injection moulding, strip feed systems, strip welding, quality monitoring and automated removal. The resulting so-called 'glass production line' provided an excellent example of recent company collaborations to provide an innovative and effective solution in state of the art hybrid manufacturing.

With key themes for 2010 including 'the importance of the electronics industry in coping with economic and environmental challenge', Electronica 2010 was an exhibition that provided the electronics industry with an opportunity to show its future capabilities to a large audience. It was truly huge in scale and offered a massive selection of information from a wide range of disparate sources. Data produced by the organisers on the day after the show indicated that over 70,000 people from 115 countries had visited the event and that there had been exhibitors from 45 different countries. Overall, the general mood at Electronica seemed to be very positive and it had clearly been influenced by the upturn in the industry that had been witnessed over the last few months.

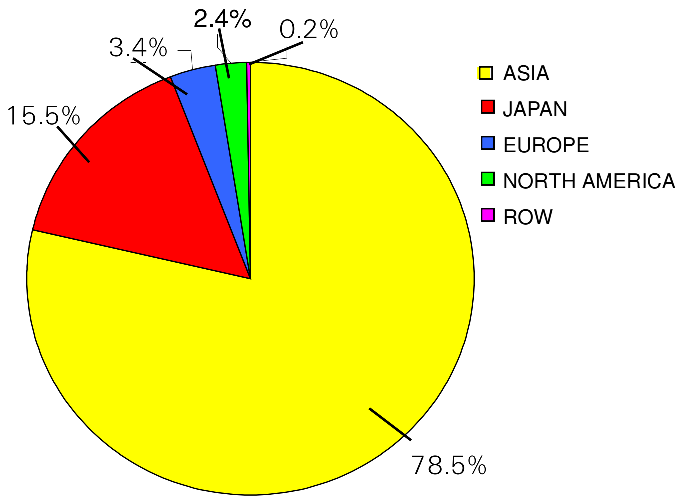
For readers who are regular attendees of Electronica, this will be a familiar picture but, for those who have never before visited one of these exhibitions, it is an event that should not be missed. In addition, Munich is an excellent city for a visit and I very much look forward to attending Productronica 2011.

Martin Goosey
November 2011

HDI PCB Production in Europe

Francesca Stern -
BPA Consulting Ltd

Worldwide HDI production in 2009 was 18.3 million sq. metres, just 2% down on the 18.7 million sq. metres of 2008. In Europe, several fabricators closed or restructured in Europe leading to an overall loss of output. Europe now accounts for just 3.4% in volume of world output (down from 5% in 2005 and 25% in 2000).

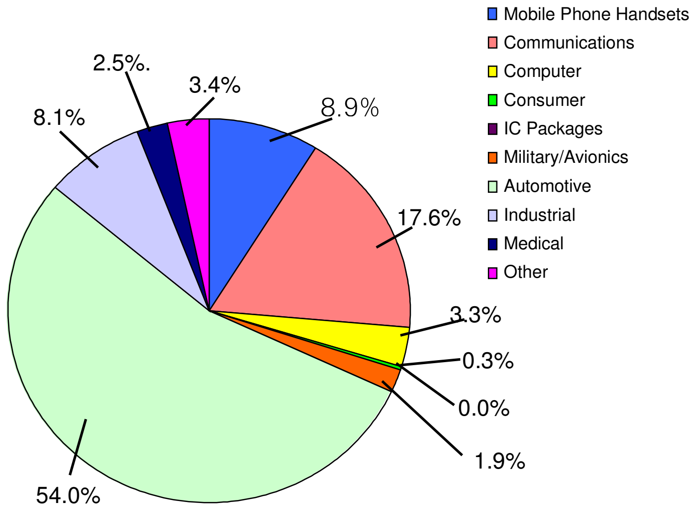


18.3 million sq.m.

Fig.1 **Worldwide HDI PCB Production 2009**

Mobile phones accounted for 47% of world HDI production in 2009. However, in Europe where mobile phone PCB production has all gone offshore, automotive accounts for the largest segment. With the shift of AT&S production offshore and the contraction of Aspocomp, mobile phone handsets have not been the dominant application in Europe for some years.

Fig. 2 **2009 HDI Production in Europe by End Application**



Europe 2009: Total 0.63 million

Despite the recent downturn in the Automotive Industry,requirements for additional functionality and safety enhancements for high end vehicles has sustained demand for high end boards for this market. The average vehicle contains between thirty and forty electronic control units while a high end vehicle may have as many as eighty. The minimum pin pitch for the main processor package is still at 1 mm. However, other components that are found on the ECU e.g. power management, safety microcontrollers and communication semiconductor packages have pin pitches of 0.8mm,0.65 mm or less. This is what is driving the use of HDI boards as well as the need for size reduction for some applications where there is limited space for the ECU. The higher count layer boards may have 2 or 3 build-up layers each side of the core. Microvia dia. in the automotive sector are usually > 100µm compared with < 100µm for mobile phones but this will reduce as increased routing density is required. Lines and spaces on HDI layers will also reduce over the next five years to accommodate the line routing required of some devices.

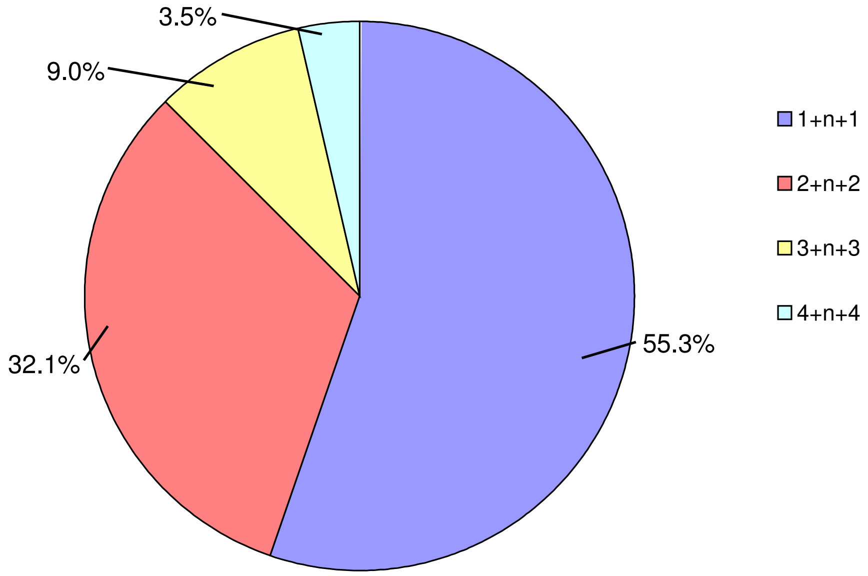


Fig. 3 **Number of Buildup layers HDI Production in Europe**

Group Members of The Institute of Circuit Technology **January 2011**

Organisation	Address	Communication
Anglia Circuits Ltd.	Burrel Road, St.Ives, Huntingdon PE27 3LB	01480 467 770 www.angliacircuits.com
Atotech UK Ltd.	William Street, West Bromwich. B70 0BE	01210 067 777 www.atotech.de
CCE Europe	Wharton Ind. Est., Nat Lane, Winsford	01606 861 155 www.ccee.co.uk
Electra Polymers Ltd.	Roughway Mill, Dunks Green, Tonbridge TN11 9SG	01732 811 118 www.electrapolymers.com
Faraday Printed Circuits Ltd	15-19 Faraday Close, Pattinson North Ind. Est., Washington. NE38 8QJ	01914 153 350 www.faraday-circuits.co.uk
Flex-Ability Ltd	Prospect Way, Park View Ind. Est., Hartlepool TS25 1UD	01429 860 233 www.flex-ability.co.uk
Graphic plc	Down End, Lords Meadow Ind. Est., Crediton EX17 1HN	01363 774 874 www.graphic.plc.uk
Invotec Group Ltd	Hedging Lane, Dosthill , Tamworth B77 5HH	01827 263 000 www.invotecgroup.com
Merlin Artetch Ltd.	Riverside Ind. Est. ,Littlehampton BN17 5DF	01903 725 365 www.falconpcbgroup.com
Kelan Circuits Ltd	Wetherby Road, Boroughbridge, YO51 9UY	01423 321 100 www.kelan.co.uk
Stevenage Circuits Ltd	Caxton Way, Stevenage. SG1 2DF	01438 751 800 www.stevenagecircuits.co.uk
Teknoflex Ltd	Quarry Lane, Chichester PO19 8PE	01243 832 80 www.teknoflex.com

It is the end of another year at the Institute and the close of the third year of our on-line journal. Membership at the end of this year stands at a very healthy 232 and we are looking forward to seeing many new members next year, so if you know of anyone who might benefit from joining the ICT, please tell them to get in touch or apply on-line at www.InstCT.org

As well as our on-line journal, members benefits include the Marketing outlook column from Walt Custer and the EIPC Speed News available from our website. You can also now log on and update your profile.

We are preparing for the next ICT evening Seminar at a new venue – the Chimney House Hotel at Sandbach, coupled with a visit to CCE Europe in the afternoon and we hope to see as many of our members as possible.

The KO meeting of our ASPIS project took place this month with delegates from all the partners meeting at the ITRI offices in St Albans. We have been working towards this meeting since the autumn of 2008, so it is good to finally see progress on the project following the protracted bidding period.

It only remains for me to wish that all our members had a merry Christmas and a Happy and Prosperous New Year .

Bill Wilkie

The Institute of Circuit Technology Winsford Evening Seminar

The Institute of Circuit Technology are holding their next Evening Seminar in the Winsford Area, on Tuesday the 1st February 2010.
There will be four papers , followed by a buffet.
There will also be a facility tour of **CCE** at 15.30 with refreshments.

VENUE : Chimney House Hotel, Sandbach.
DATE : Tuesday, 1st February 2010
TIME : 17:30 with registration at 17:00.

The event is supported by CCE Europe

AGENDA

1) **Martin Goosey/Andy Cobley will give a paper on Ultrasonic Desmear.**
2) **Alex Bindel will talk about integrating RFID's into PCB's**
3) **Gabriel Benmayor will give a paper on Technosystems Equipment**
4) **Tom Parker of CCE will also give a paper**

Bill Wilkie - Technical Director ICT
www.InstCT.org
Tel - 01573 226131
bill.wilkie@instCT.org

Bill's letter confirming application 26/06/1980

Institute of Circuit Technology

Secretary: The Institute of Circuit Technology Ltd
Bruce Routledge
5 Windrush Close
Ickenham
Middlesex UB10 8EJ
Telephone: Ruislip 37961

W.A. Wilkie Esq.A.M.INST.C.T.,
Cranbrook,
11, Kingscroft,
Kelso,
Roxburghshire.

26th June, 1980

Dear Mr.Wilkie,

Thank you for your Bankers Order for £10.00 and we now have pleasure in enclosing your Associate Membership Card No.558.

The Certificate confirming your appointment has now been printed and is being inscribed with your name, it will be forwarded to you shortly.

Yours sincerely,

BRUCE ROUTLEDGE
Secretary

Council 1979-80: R. Josephs J.S. Brooks R.V. Broughton D.R. Clayton A.J. Fitzpatrick-Brown T.P. Hogan M. Hubert W. MacLeod Ross H.G. Manf R.A. Neale R.H. Noble J.B. O'Hara B. Routledge R. Rozario S.J. Singleton A.J. Spencer D.A. Taylor J.B. Walker G.C. Wil W. Goldie (Editor of Circuit World)

Registered No. 1096446 (England) Registered Address: 18 Prospect Road, Southborough, Tunbridge Wells, Kent, TN4 0EL

EIPC European Institute of Printed Circuits
Programme:
EIPC Winter Conference Cologne 2011
"Impact on PCB material, process and equipment innovation"

Dear Colleague

We are very pleased indeed to bring you news of the EIPC Winter Conference, which is to be held in that wonderful German city of Cologne on 3rd & 4th February 2011.

In an exciting courtship of theory and practice, we have arranged a visit to the factory of ISOLA GmbH and CCI Eurolam in Düren in the afternoon of the first day, with the Keynote Session of the conference being delivered in the morning by no less than Ray Sharpe, the CEO of the ISOLA Group to get the conference under way.

Other topical matters for presentation and discussion will include the business outlook from the immutable Walt Custer, a look at power electronics by the avuncular Hans Friedrichkreit, lean manufacturing from Spirit Circuits, and power pricing by the authoritative Simon Kucher & Partners. The knowledge of Albemarle and Multilayer Technology GmbH & Co. KG will dispel any lack of comprehension about flame retardants and UL approvals.

Day Two brings in a platoon of well-armed speakers, who will look at embedded component technology, advanced processing technology, which includes a fascinating paper on the use of ultrasound for low temperature plating, and then matters steer towards reliability and a second but important look at UL. The new challenges & solutions by UL and the status of the industry.

All in all, it's going to be a cracking programme, and the two days will be the usual combination of matters technical, social, vinous and gastronomic. All in all, not to be missed.

You will now need to know how to register - in one easy step: you can download the registration form here. You can download the detailed programme by clicking here or visiting the EIPC website www.eipc.org. For more information you can contact Sonja Derhaag at the EIPC office +31-43-3440872 or sderhaag@eipc.org.

We look forward to seeing you in Cologne, and remain with our best regards,

Yours sincerely,
The EIPC Team