Journal of the

Institute of Circuit Technology

2010 Events

12th April - 15th April	ICT Annual Foundation Course , Loughborough University
18th - 19th May	*National Electronics Week UK Hall 1 Birmingham NEC*
7th-8th June	*EIPC Conference, Nuremberg www.sderhaag@eipc.org*
15th June	ICT 36th Annual Symposium Bracebridge Suite, National Motorcycle Museum at Solihull *30th*
30th June	*MAPS-UK "Beyond Solder" - NPL www.imaps.org.uk*
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

1st Febuary	17.00 Evening Seminar, Winsford
1st March	17.00 Evening Seminar, Arundel, Comfort Inn
4th April - 7th April	ICT Annual Foundation Course , Loughborough University

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vol.3 no.4 October 2010

Editorial

I well remember as a new graduate at British Aerospace being dressed from head to foot in rubber, complete with helmet and visor. No, this wasn't some fetish initiation ceremony, it was in preparation for disposing of and making up a new desmear solution.....concentrated sulphuric acid! What a joy that job was. That was around 1986 and it was with much relief that only a year or so later our suppliers rep told us of a new method of desmear which first involved a 'solvent swell' and was followed by a 'permanganate etch' and 'neutralizer'. Not only did it remove smear it produced a lovely honey comb texture on the resin. Successful trials followed and my days of dressing up in rubber were over....in the workplace at least. Over the following years there were some innovations. The use of electrochemical regeneration allowed the lifetime of the permanganate solution to be significantly extended, horizontal desmear could considerably reduce the dwell times and ultrasound seemed to enhance the process. The formulations of the 'solvent' also varied somewhat from one supplier to another but are generally from the same organic family.

'Swell' and 'Etch' desmear has certainly served the industry well for some time now but it has begun to struggle in recent years with the emergence of High Tg laminates. These resins tend to be more chemically inert and are therefore more difficult to desmear using the traditional chemistry.

The response to these issues has been of the sledgehammer variety. Higher temperatures have been used in the solvent bath with higher concentrations of solvent (even neat solvent) and more aggressive chemistry (and generally more noxious). Similar approaches have been tried on the 'etch' i.e. higher temperatures and concentrations. I know one PCB manufacture who is running at such a high potassium permanganate concentration that they must leave the solution at temperature and with the pumps running all the time. If they don't do this they will have a mass of permanganate crystals and a big headache on Monday morning. Of course switching to sodium permanganate will allow you to run at even higher concentrations.....and run up a higher chemical bill!

Perhaps these are not the most elegant solutions to this problem.

So what are the alternatives?

At the Sonochemistry Centre we have looked at using low frequency, high power ultrasound to surface modify PCB laminates through solutions as benign as water at low temperature. We've proved that we can get weight loss on high Tg laminate coupons which is equivalent to, or better than, that obtained in a traditional swell and etch process. Of course, getting weight loss on a coupon isn't the same as desmearing a through hole but it's a step in the right direction. Preliminary production trials using this ultrasonic technique have been carried out on drilled high Tg boards and are, as I write this, being prepared for ICD evaluation. Watch this space!

There may be other 'external energy' sources which could be utilized such as plasma, microwave or corona discharge. Ionic liquids could have a role to play in solving this issue. As they are non-aqueous they can be operated at temperatures in excess of 100 ºC and may open up the possibility for novel chemical formulations. Or perhaps we should think about using transient oxidative species such as free radicals which can be generated by several techniques including electrochemical, sonochemical, UV/ ozone etc.

I'm not sure that using more and more aggressive conditions and chemistries is the right approach to this issue. It seems like we're heading back towards the 'concentrated sulphuric acid' approach and I'm afraid that we'll soon be returning to the days when some poor baby faced graduate is going to have his inside leg measurements taken for those rubber pants!

Andy Cobley (*Deputy Chairman*)

Membership

New members notified by the Membership Secretary

Member (M.Inst.C.T.)

10169 Victor Lau
10170 Michael Bingham

Corrections and Clarifications

It is the policy of the Journal to correct errors in its next issue.

Please send corrections to : -

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Institute of Circuit Technology

Southern Area Evening Seminar

15th September 2010

Newtown House Hotel on Hayling Island

supported by Spirit Circuits.

Hayling Island, a small island off the south coast of England, connected to the mainland by a road bridge, west to Langstone Harbour and Chichester Harbour to the east, was the venue for the Institute of Circuit Technology Southern Area Evening Seminar on 15th September 2010. ICT Chairman, Professor Martin Goosey, welcomed delegates and gave a brief history of the Institute, now in its 37th year, its aims and objectives and future plans.

Les Round of Spirit Circuits gave the first presentation. He described the physical characteristics of insulated metal substrates and gave a practical overview of applications and processing techniques. With an opening statement that the failure rate of electronic devices doubles with every 10°C rise in temperature, he explained that the rapid market growth in LED lighting, power solutions, electric cars and LED-backlit LCD televisions had created a demand for metal-back printed circuits to aid heat dissipation. Insulated metal substrate materials were now available from at least 10 different suppliers, and the fabrication of metal-back boards was becoming a substantial niche area of specialist PCB manufacture. Aluminium was established as the most popular backing metal where unit cost and weight were primary considerations, but copper offered better thermal conductivity together with the opportunity to expansion-match designs with heavy copper circuit features. Fabrication of simple metal-back circuits followed the general process route of traditional single-sided PCB manufacture, albeit with some detail differences, and plated-through and multilayer constructions were practicable. It was important for designers to appreciate material cost, and to design with a view to maximising material utilisation from a 24″ x 18″ panel.

Neil Chamberlain from Polar Instruments talked about controlled impedance, loss simulation and test, and the products which have been developed to help designers and fabricators simulate trace geometries, make accurate prediction of impedance and communicate clearly documented stack-up information to each other. Accurate modelling was critically important, even though in practical terms the models were inevitably wrong as a consequence of local variations in glass-to-resin ratio in FR4 multilayer constructions, where the laminating process tended to result in a predominace of resin between traces. In other words, the nominal dielectric constant of a material was not in fact constant and this needed to be taken into account in the simulation and realistic tolerances applied. Looking to the future, the trend to ever-finer line widths and higher operating frequency would result in increased dielectric loss and skin loss, and lines could no longer be presumed lossless from a modelling and testing perspective. Impedance would not be a good enough measure, and attenuated loss measurement would be necessary. Suitable equipment had already been developed in order to make the actual testing easy and robust, but test coupon designs were more complex than impedance coupons.

Martin Randall reported the progress of the introduction of a

Lean Manufacturing culture into Spirit Circuits, an initiative taken at the beginning of 2010 with a staff awareness day followed by the appointment of an experienced Lean practitioner as facilitator, and which was already showing positive results and a culture change within the company. Spirit's objectives were primarily to improve quality, eliminate waste, save time and reduce cost, initially by concentrating on visual management and the introduction of a 5S philosophy. He showed before-and-after examples of improvements that had been made in factory layout and work practices, and the key performance factors such as on-time delivery, customer complaints and internal yields which Spirit used to monitor and measure the results of their Lean system. He admitted that the biggest problem was not in introducing the changes but in maintaining them, and that it was not actually Lean processes which got the results, but the pride and commitment of the people in an area to maintain the improvement and not allow a decline in standards. As part of the ongoing programme of 5S and value stream mapping, Spirit intended to extend Lean principles beyond manufacturing and into their sales and engineering departments.

Never one to be bound by tradition, nor afraid of being controversial, Spirit Circuits MD Steve Driver gave his thoughts on the UK market, the future of UK PCB manufacturing, and how to keep it in the UK. He used BPA figures as a reference: in 2000, the UK market for PCBs was $US884 million. By 2009, this had shrunk to $US202 million, of which 45% was military and aerospace and 33% industrial instrumentation and controls. Looking back to the beginnings of the industry which had evolved out of Paul Eisler's original invention, Driver designated the 1950-1970 period the Generation of Pioneers, the 1970-1990 period the Generation of Engineers, the 1990-2010 period the Generation of Mavericks, and looked for a label for the Fourth Generation from 2010 onwards. He chose to call it the Generation of Thinkers, and turned the "Don't just sit there - do something" philosophy on its head: "Don't just do something – sit there", in other words don't rush off and do things before you've sat down and thought the thing through.

Driver's theme for Spirit in 2010 was "Think 10", effectively a challenge to his team to think creatively and innovatively, and many beneficial initiatives had arisen as a result. He believed there to be a good future for the UK printed circuit industry, although further consolidation was inevitable, The overall market had contracted but the number of part numbers continued to increase and the quick-turn prototype market was particularly buoyant. There would be new technologies to address and new processes and materials to come to terms with. "Change will happen – it always does!" Using the Change House model to illustrate his final point, of the four rooms of change – contentment, denial, confusion and renewal – he recommended staying well away from the room of contentment and remaining always in the room of renewal.

Professor Goosey acknowledged the generosity of Spirit Circuits in supporting the seminar, one of the best-attended ICT evening events in recent memory with over 100 delegates present, and a particularly successful networking opportunity - old acquaintances were renewed and many new contacts were established. Lively discussion continued late into the evening.

www.instct.org

Pete Starkey
September 2010

Manufacturing Technology Centre - Electronics Manufacturing Launch

Ansty Park, Coventry

19th August 2010

Over forty million pounds of UK Government grants are being invested in the new Manufacturing Technology Centre (MTC) in Ansty, Coventry and the MTC is being established to support UK manufacturing companies and their supply chains in order to bring about major improvements in their manufacturing competitiveness. On 19th August, there was an event which was specifically aimed at launching the electronics research related activities of the centre.

The launch meeting began with a welcome by Neil Rawlinson of Aero Engine Controls (AEC), a joint venture company between Rolls Royce and Goodrich Corporation and examples of the company's engine control systems were demonstrated. Neil emphasised the importance of innovation in manufacturing for the UK economy and he described how the MTC would be part of a national network of manufacturing research centres.

Peter Flinn, the Project Director of the MTC, then gave an overview of the MTC's activities. The MTC was being established with funding from Advantage West Midlands (AWM) and the East Midlands Development Agency (EMDA) and it had four research partners, namely Birmingham, Loughborough and Nottingham Universities, as well as TWI, in Abington, Cambridge. There were also three industrial founder members, namely Airbus, Aero Engine Controls and Rolls Royce and the site was due to formally open in May 2011. The MTC would aim to combine research flowing from universities with industrially led development programmes and it would predominantly operate at the technology readiness levels of 4, 5 and 6. The MTC would have a focus on assembly, fabrication and joining and would include high integrity fabrication, net shape manufacturing, advanced tooling and fixturing and intelligent automation. Other themes would be added later. The research work programme had actually started and there were currently four projects underway.

David Blackwell of Aero Engine Controls (AEC) then gave a presentation on Manufacturing Challenges. Quality was the number one driver for the aerospace industry and this had to be achieved in products with life cycles of 40 years. With surface mount technology, the process could be completed without any manual intervention. AEC had invested heavily in surface mount manufacturing technology over the last 12 months and this had delivered a 66% reduction in defects. Every new product would be SMT- based and there would thus be continuing investment in SMT manufacturing capability. The company was also planning to replace existing through hole manufacturing technology with state of the art, fully automated equipment that would also be zero touch. Where the appropriate technology did not exist, AEC would work with the MTC to develop it. Examples of typical projects included solder jetting as a replacement for traditional screen printing, selective soldering to fully solder a complete mixed technology assembly, conformal auto-coating with zero masking on both SMT and mixed technology assemblies and aqueous□based cleaning processes for LCC and BGA devices.

The next presentation was given by Norman Stockham of TWI, who discusses the electronics activities at the MTC. The electronics input to the MTC would be provided by Loughborough University and TWI, who both had skills and capabilities in design, analysis, manufacturing technologies and electronics packaging, as well as PCB assembly. Combined, the two organisations had around 70 research staff engaged in electronics development and could cover the technology readiness levels from 1 to 9. The MTC would have a significant electronics assembly related capital investment, including a complete and flexible PCB assembly line along with selective soldering and inspection. This meant that a state of the art surface mount assembly line would be available from day one. This would be the first □ enon-production□ f production line in both the UK and the rest of Europe. It would enable unproven technologies to be explored and assessments to be made of changes to individual aspects of assembly and their impacts on subsequent assembly stages. The facility would also allow manufacturing engineers to learn the current state of the art at the centre. The starting point for the research programme was a project to improve production yields in printed circuit board assembly. The MTC was already looking at future research areas and these might include high temperature electronics, harsh environment packaging, mixed technology products, high reliability chip/device interconnects, high density packaging, 3D circuit assembly, harnessing and connectors, sustainability, obsolescence issues, and design for manufacturing for electronics and electro-mechanical systems. Norman concluded by explaining the benefits of participation in the electronics centre at the MTC.

Richard Mellor, Chief of Manufacturing Technology at Aero Engine Controls, then explained why AEC was involved in the MTC. He gave an overview of the company's products and these included high reliability electronic assemblies. New products had increasingly challenging requirements, such as elevated temperature and pressure operational requirements, tighter installation envelopes, new vibration signatures and additional functionality. These all had to be met with limited manufacturing engineering capacity and limited development capability from suppliers. It was also not always possible to use in house equipment for development activity. AEC had established experience of working with the advanced manufacturing research centre and their first year projects had already saved the company's 600k with cycle time reductions of 34% on existing equipment.

The final formal presentation of the morning was on the MTC's electronics vision and was given by Professor Paul Conway of Loughborough University and Norman Stockham of TWI. Paul began by reviewing the MTC's 1st stage research projects in more detail. The context for the MTC was being able to address the key challenges and barriers associated with unproven technologies, changes to processes and improvements in equipment. A key objective was to increase yields in PCB assembly processes by benchmarking against state of the art technology. There would be the ability to study solder paste application, board population, convection reflow, washing/cleaning and conformal coating. The state of the art SMT line would be supported by suppliers. There was also a large quantity of support equipment available such as micro-focal 3D X-ray, AOI, 3D metrology, temperature cycling, acoustic microscopy and other verification techniques. It was expected that cycle times and first pass yields should be improved by 50 to 60%. The MTC would also offer a wide range of collaborative benefits. Paul then introduced some of the industry trends and those mentioned included the "all electric aircraft" and automotive systems, where modern cars had up to 30 control units each with 200 components per unit. Medical implants were required to interact with the body but also needed to be protected from it, and vice versa. The UK also had strengths in oil exploration, power generation and mass transport and all of these had reliability challenges that needed to be addressed. Another challenge would be to supply design for manufacturing capability, particularly since much manufacturing had moved offshore and there was a loss of institutional DfM memory. The second part of the presentation was then given by Norman Stockham, who went into more detail on future challenges and the MTC's role in offering solutions. The example of solder-free joining for packing and assembly was cited as offering new opportunities. Other potential technology solutions from the MTC could include integration of new packaging solutions, enhanced inspection and testing capabilities, solutions for obsolescence, developing new materials and manufacturing processes. Norman then discussed the replacement of solders with conductive adhesives, which offered low temperature processing, fine pitch capability and environmental benefits. Solder assembly could also be replaced by wire bonding in some applications, as it offered design flexibility, high power and temperature capability and high process yields. Welding was another option, as it offered low resistance joints, with no requirement for plating and no need for flux/residue cleaning. Norman moved on to discuss the benefits of high density packaging using stacked die, system in package, package in package and embedded passive approaches. Spray coating of materials was another interesting area, where it was possible to spray coat circuits, e.g. copper on alumina, with reduced numbers of interfaces, high thermal conductivities, 3D geometries and other tailored properties. The MTC would also study quality monitoring and new test technologies, as there was a need to develop fast inspection processes that could accommodate hidden joints and failed interfaces. Norman concluded by explaining the approaches the MTC would use to address these future challenges.

The morning session concluded with an opportunity for the attendees to ask questions about the MTC and its operation etc. It was expected that the MTC would ultimately employ 70 or 80 permanent staff and recruitment was already underway. There would also be room for equivalent numbers of secondees from academia. The electronics launch event also included a visit to the new MTC building, which was currently under construction. The scale of the building itself was very impressive and it appeared that, once complete, the MTC would provide a showcase facility that would undoubtedly provide the type of support needed by British manufacturers.

Martin Goosey
19th August 2010

The Manufacturing Technology Centre under construction 20th August 2010

Development of an Ultra-Small Micro Drill Bit for Packaging Substrates

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Shenzhen Jinzhou Precision Technology Corp.,
People's Republic of China

Abstract

Purpose-

To present key points regarding the development of an ultra-small micro drill bit for packaging substrate hole processing.

Design/methodology/approach-

Key points for the development of ultra-small drill bits are presented. These are based on a study of the influential mechanisms of micro drill bit material properties, key parameters and coating techniques on the behaviours of micro drill bit. Experiments were conducted to verify the drilling capability of the developed ultra-small micro drill bits.

Findings-

The material properties of micro drill bits are of great importance in ensuring the performance. Helix angle, primary face angle and point angle are three key parameters that significantly influence drill bit behaviour. CAE analysis, temperature monitoring and video monitoring techniques in high speed drilling are useful tools for achieving the optimal design of ultra-small drill bits. Using coating technology on ultra-small drill bits can improve their hit limits by nearly four times.

Originality/value-

The paper highlights key points to consider when developing ultra-small micro drill bits. The presented points can provide an overall understanding of the challenges and solutions during ultra-small micro drill bit design. Additionally, this paper presents a solution for packaging substrate ultra-small hole processing by mechanical drilling.

Keywords:
printed circuit board,
packaging substrate,
ultra-small micro drill bit,
mechanical drilling

1. Introduction

With the development of electronics and information technology, the percentages of microvia boards, flexible circuit boards and packaging substrates among PCBs are continuously increasing. Data in Figure 1 shows that this percentage will reach 13.7%, 16.2% and 14.7% in 2013, respectively[1]The typical feature of the above three types of PCBs is that the hole diameter is very small. Figure 2 displays a chart presented by JEITA in 2009 and it can be seen that 0.075 mm diameter holes could be processed by mechanical drilling in 2008[2].

Even though laser drilling has high efficiency in ultra-small hole (diameter <0.1mm) drilling processes, mechanical drilling still has attractive advantages in terms of hole quality and the processing capabilities for through holes. Especially, with the wide use of high spindle speed drilling machines, the drilling efficiency of mechanical drilling has improved significantly. It can be predicted that the mechanical drilling of ultra-small holes must become increasingly popular in the near future in the PCB industry[3]To complete the mechanical drilling of micro holes, it is essential to develop appropriate ultra-small micro drill bits with excellent overall performances. Thus, it is desirable to present the key points about ultra-small drill bit design and to provide a solution for ultra-small hole drilling of packaging substrates.

2. Material requirements and wear failure mechanisms of ultra-small micro drill bit

The development of a micro drill bit requires attention to three key factors: material properties, structure and parameters design and the processing techniques for the micro drill bit, as shown in Figure 3. The material requirements for ultra-small micro drill bits are very strict. Generally, materials for ultra-small micro drill bits should have the following characteristics: fine tungsten carbide (WC) grain size; high hardness with superior wear resistance capability and high strength with a good anti-breakage capability. Of course, it is somehow difficult to achieve the most favourable values of grain size, hardness and strength simultaneously. The most important

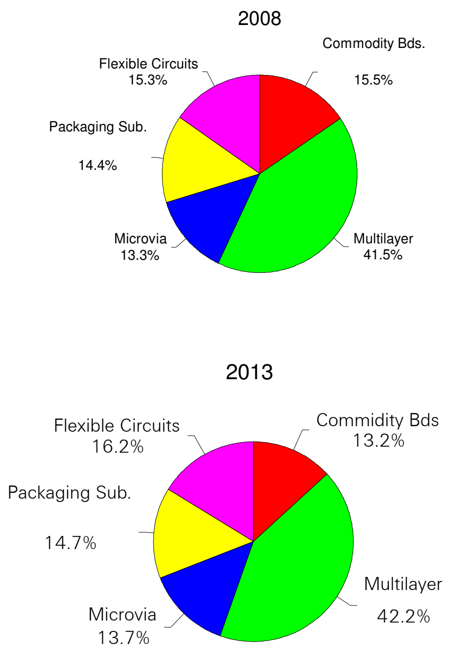

Fig. 1 PCB market forecast by Prismark

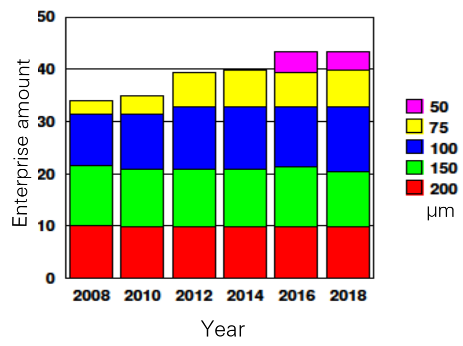

Fig.2 Roadmap of mechanically drilled hole diametres for packaging substrares

consideration is how to ensure the overall performance of the micro drill bit. As tungsten carbide with nano-scale grain size has excellent mechanical properties and superior cutting performance, it is the main choice for the manufacture of ultra-small micro drill bits[4]. However, it is still difficult to achieve a breakthrough in the mass production of tungsten carbide with a grain size below 100 nm. Currently, the appropriate grain size of carbide for ultra-small micro drill bits is around 200 nm.

In order to ensure the wear resistance of micro drill bits, the wear mechanism in high-speed drilling processes must be studied to determine the main wear form of the drill bit. In general, typical wear forms of micro drill bits include abrasive wear, adhesive wear, diffusion wear and chemical wear. The wear mechanisms can be studied through experiments with scanning electron microscopy. Results show that the key wear form of ultra-small micro drill bits is abrasive wear. The abrasive wear is mechanical wear caused by hard particle abrasion on the tool surface. Other forms of wear, such as chemical wear and diffusion wear are rarely observed. This finding can be used to guide the research and development of materials for ultra-small micro drill bits.

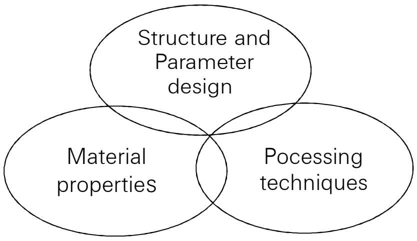

Fig. 3 Key points for development of micro drill bits

3. Parameters for the design of ultra-small micro drill bits

3.1 Design of key parameters of ultra-small micro drill bits

One key consideration when designing ultra-small micro drill bits is how to prevent drill breakage. The occurrence of drill breakage is closely related to the micro drill bit's debris evacuation capacity. The helix angle of a micro drill bit is a very important parameter influencing its debris evacuation force. As shown in Fig 4, a large helix angle is beneficial for increasing the debris evacuation force. Therefore, a larger helix angle should be applied to ensure the micro drill bit debris evacuation capability and to prevent drill breakage.

With a large helix angle, a sharp cutting edge and good debris evacuation can be obtained, but the large helix angle leads to weakened strength of the cutting edge and the possibility of point chip, therefore, the anti-breakage performance of the drill bit gets worse. Micro drill bit cutting edge strength can be evaluated by the angle between the micro drill bit helix groove surface and the primary facet, as shown in Figure 5. The influence of helix angle on micro drill bit cutting edge strength is illustrated in Fig. 6. It can be found from this figure that the strength of the cutting edge is weak when a large helix angle is employed, while the cutting edge strength of a micro drill bit can be improved by employing a small primary face angle. As a large helix angle is utilized in ultra-small micro drill bits, a small primary face angle is recommended to ensure sufficient cutting edge strength.

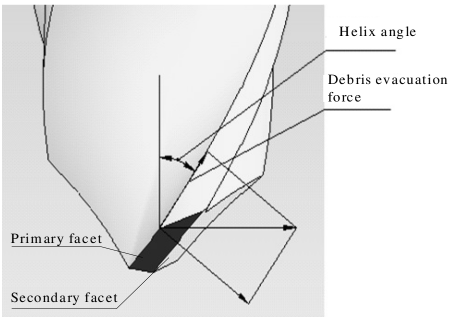

Fig. 4 Relationship between helix angle and debri evacuation force

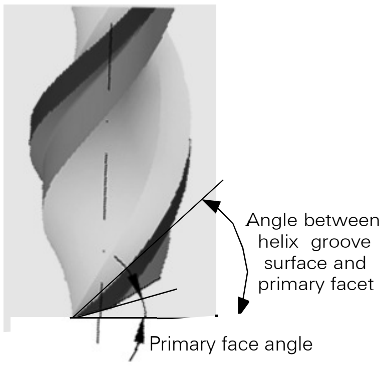

Fig. 5 Illustration of angle between helix groove surface and primary facet

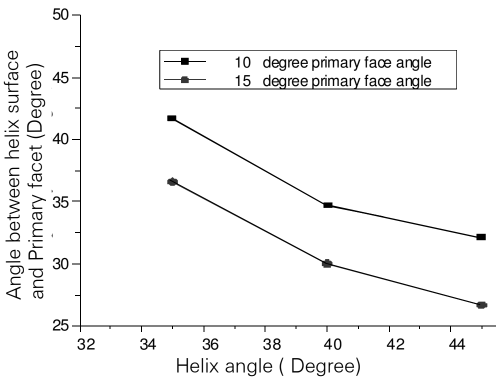

Fig. 6 Influence of helix angle on cutting edge strength

The drill point angle is another key parameter to be considered during ultra-small micro drill bit design. In conventional size micro drill bit design, a large point angle, generally 130, is applied. Easily evacuated granular debris is generated in the drilling process by using such drill bits. If a drill bit with a smaller point angle is used, the strip form chip is evacuated and the debris evacuation condition becomes worse.

However, the influence of point angle on the cutting capability of an ultra-small micro drill bit must be taken into consideration. If a large point angle is employed, the cutting edge becomes short (see Fig. 7) and the cutting capability is reduced. Therefore, a small point angle should be designed for an ultra-small micro drill bit to guarantee sufficient cutting edge length and cutting capability.

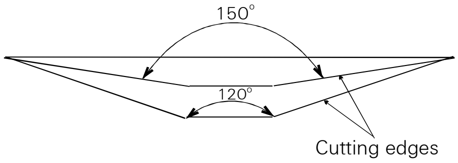

Fig. 7 Influence of drill bit point angle on length of cutting edge

3.2 Optimal design of ultra-small micro drill bits

CAE analysis was used to identify the influential mechanisms of key micro drill bit parameters on strength and rigidity. The analysis was conducted by following the procedures shown in Fig 8.

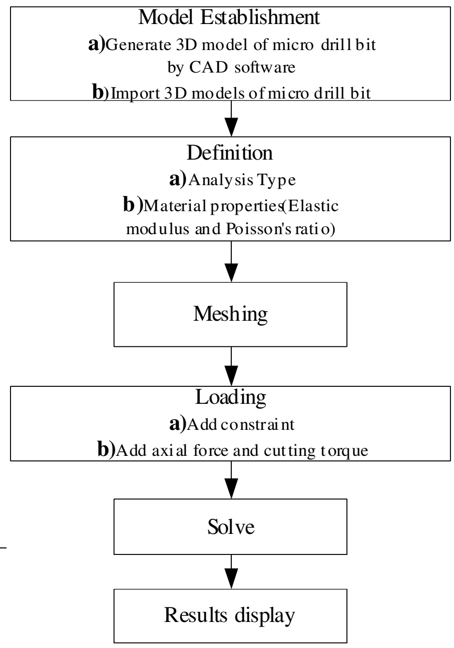

Figure 8 Flow chart of the CAE analysis

In order to provide more information for the design optimization of ultra-small drill bits, it is desirable to monitor the temperature and the video during the high speed drilling process. As infrared thermography can obtain non-contact temperature measurements with high accuracy and has the ability to record the temperature continuously, infrared thermography was employed to monitor the drilling temperature. The output from the thermography was connected to a computer to process the obtained temperature information and to store temperature data.

In order to study the drilling mechanisms of ultra-small micro drill bits in high speed drilling processes, video monitoring using a high speed video camera was utilized to identify the fracture failure mechanism and the entry behaviours of micro drill bits, as well as the characteristics of debris evacuation.

The key point when using a video monitoring system is that as the spindle speed generally operates at over 300,000 rpm for packaging substrate hole drilling. The video camera must have a fast enough capability to capture the video data without any loss. In addition, the light source of the video camera is particularly important and it is difficult to get a clear video recording without the use of an appropriate light source.

4. Drilling tests on developed ultra-small micro drill bits

To confirm the aforementioned key points, 0.1 mm diameter micro drill bits with relatively big helix angles, small primary face angles and small point angles were designed and manufactured. Then, the developed ultra-small micro drill bits were tested on a HITACHI high speed drilling machine. The drilling conditions are listed in Table 1.

Throughout the drilling process, no drill breakage was observed and the hole wall roughness, as well as the hole registration, were satisfactory.

The typical test results are displayed in Figures 9, 10 and 11. The maximum hole registration deviation was within the 1 mil range and the maximum hole wall roughness was also well controlled under 5 μm.

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Micro drill Bit	Drilling machine	PCB	Spindle speed	Infeed rate	Hits limit
ϕ0.1 x 1.8mm	HITACHI 1S213E	BT Doublesided 0.15mm x 5	300krpm	40mm/s	5000 (New drill) +5000(repoint1) +5000(repoint2)

Table 1 Drilling conditions for 0.1 mm diameter micro drill bits

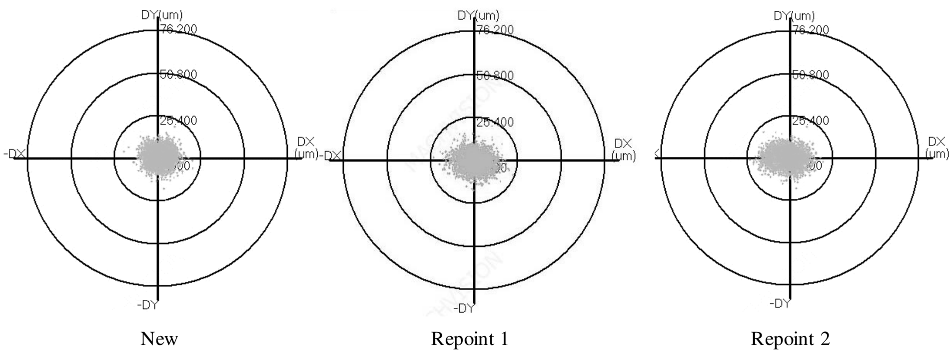

Figure 9 Hole registration accuracy chart

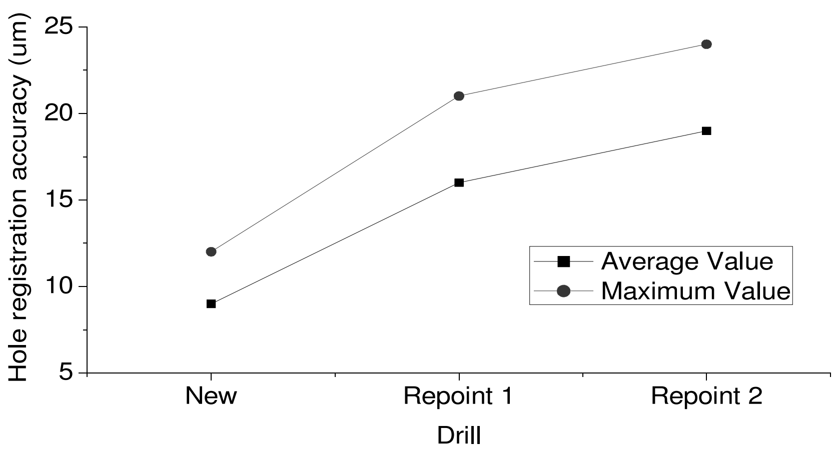

Figure 10 Hole registration accuracy data

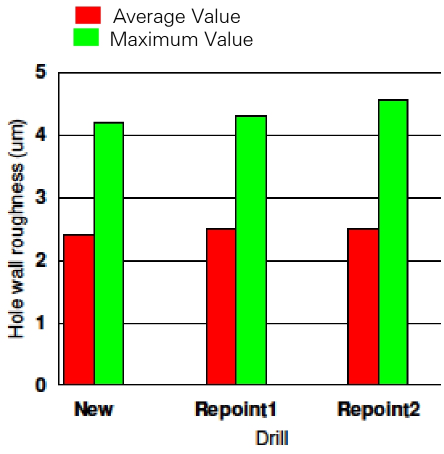

Figure 11 Hole wall roughness results

5. Coating of ultra-small micro drill bits

Currently, coating technologies that could be used for PCB tools, including drill bit and router bits, have only been reported in the literature. No real breakthrough and the industrialization of coated PCB tools has yet been realized. As PCB tools have relatively complex shapes and high-precision cutting edges, it is desirable to develop a unique coating technology for PCB tools, in other words, the coating techniques for ordinary cutting tools can not be directly applied to PCB tools. In this paper, a coating technique called SHC for ultra-small micro drill bits, developed by Shenzhen Jinzhou Precision Technology Corporation, is presented. The features of this coating technique are:

1) A low coating deposition temperature, which has little influence on the micro drill bit substrate.
2) Very smooth coating surfaces can be achieved.
3) Friction between the debris and micro drill bit flute is significantly reduced.
4) Low drilling temperature.
5) Greatly reduced chemical corrosion.

The performance of SHC coated ultra-small micro drill bits was verified by drilling tests. The drilling conditions are listed in Table 2 and the results are shown in Figure 12. It can be observed that the hits limit of coated micro drill bits improved by nearly four times compared with an uncoated tool. The drilling capability of the SHC coated tools is therefore increased

Micro drill bit	Drilling machine	Drilling parameters	PCB
ϕ0.1×1.8 mm coated and uncoated micro drill bits	HITACHI 1S213E	Spindle speed: 295 krpm Infeed rate: 45 mm/s Retract rate: 423 mm/s	0.8 mm×1 8-layered

Table 2 Drilling conditions for coated micro drill bits

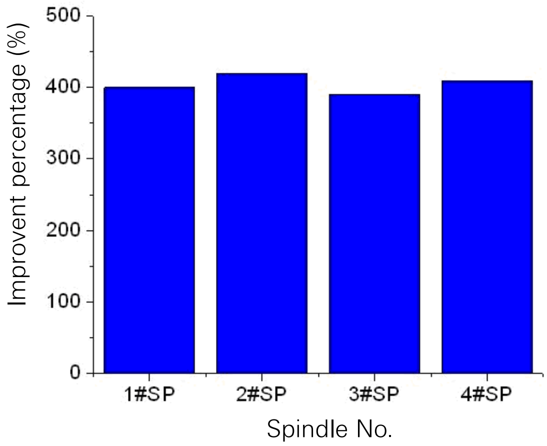

Fig. 12 Hit limit improvement percentage for coated micro drill bits

6. Conclusions

The raw material properties of ultra-small drill bits are of great importance for ensuring drill bit performance. The ideal tungsten carbide for ultra-small drill bits should be fine grained as well as having sufficient hardness and strength. The main form of ultra-small drill bit wear in high-speed drilling processes is abrasive wear. It is beneficial to employ a large helix angle, a small primary face angle and a small point angle when designing ultra-small micro drill bits. CAE analysis, on-line temperature and video monitoring in high-speed drilling processes can be applied to guide optimal micro drill bit design. The use of coating technology is a powerful tool to enhance the performances of ultra-small micro drill bits. The hits limit can be improved by nearly four times for a coated micro drill bits compared with an uncoated tool. Testing results show that the developed 0.1 mm diameter micro drill bits have excellent performances in terms of anti-breakage, hole registration and hole wall roughness, which provide a perfect solution for ultra-small hole drilling of packaging substrates.

References

1. Shiuh-Kao Chiang (2009), "Global electronics and printed circuit markets and future developments", *CPCA PCB Executive Management Market Meeting Presentation*, p55.
2. Japan Electronics & Information Technology Industries Association (2009), "Japan Jisso Technology Roadmap 2009", p169 (In Japanese)
3. Lianyu Fu, Jianguo Qu and Haibin Chen, "Mechanical Drilling of Printed Circuit Boards: the State of the Art", *Circuit World, Volume 33,* No.4, (2007), pp.3-8
4. Haibin Chen, Lianyu Fu and Weixian Zou (2008), "Trends of micro drill bit for PCB" , *Printed Circuit Information*, No.8, pp. 34-37 (In Chinese)

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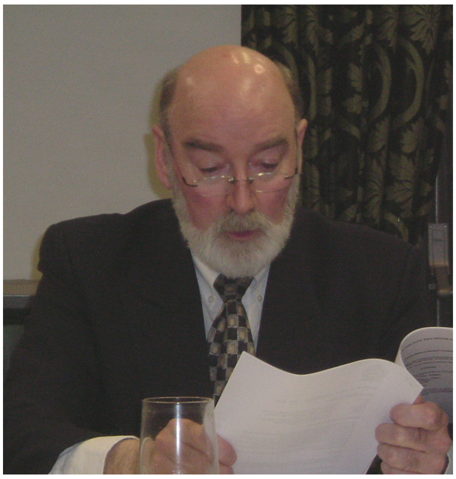

The Membership Secretary`s notes - October 2010

For some time we have been conscious of the fact that many of our members, for various reasons, are unable to attend our evening events and our annual symposium. Two recent events have enabled us to embark on a project to bring these occasions to all our members. Our recent symposium at Hayling Island was the first event, it drew over 100 registrations, our largest event in recent years and we wanted to be able to capture the occasion and thanks to support from Spirit Circuits, were able to have the event videoed for posterity. The second was the re-launch of our remodelled website under the guidance of Richard Wood-Roe. The new website has many more facilities and has been designed to be more user-friendly to members and guests.

Our intention is to have an edited version of our Hayling Island Seminar available on demand for all our members.

We intend to extend this slightly further at our next Darlington Evening Seminar in November, by having the presentations recorded off-line, again for the use of all our members on our website.

Neither of these new benefits will replace the excellent write-ups carried out by our Recorder,- Pete Starkey. Pete' s technical knowledge and skill with words, captures the essence of the presentation and the moment, seemingly effortlessly and will continue to be central to bringing these events to all our members.

Bill Wilkie

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