NPL National Physical Laboratory

Microelectronics NEWS

A National Measurement Newsletter

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Issues relating to lead-free soldering continue to dominate the electronics interconnection industry, particularly those relating to supply chains and compliance, and this newsletter reflects that emphasis. NPL has a continuing and leading role of supporting industry in lead-free activities, both in generating the technology itself and in its successful transfer to industry. As the countdown to 2006 gathers pace NPL has responded to requests from industry and has increased its activity in two critical areas. First, it provides confidential one-one support via site visits to focus on implementation and compliance issues relevant to that site. Second, is maintaining a broad level of industry interaction at local, regional, national and international meetings via seminars, workshops, and presentations. Typical of the latter are recent invited workshops given at the SE Manufacturing Show (London February), NEPCON (see elsewhere in this issue), SMART meeting (Brighton, November), ECCI meeting (Glasgow, September), EPC Conference (Cologne, October), CARTS meeting (Nice, October), and the Welsh & SW Manufacturing Show (Cardiff, October). Copies of the presentations are available on request.

Chris Hunt

This Issue

Lid Taken off Passive Components	1
Pad Design, Stand-Off and Evolver	2
Are Supply Chains Ready?	2
SSTC Meeting Underlines Issues	3
New Instrument for Micro-Joint Materials Data Generation	3
Webcast	4
Lead-Free Transition Reliability	4
Another Successful Clinic at Nepcon	4
New Manager of Test Services	4

Lid Taken off Passive Components

The electrical performance characteristics of embedded passives can be very different from those of their SM counterparts, thereby offering significant competitive advantages. This was an intriguing message from the latest NPL Masterclass by leading world speakers.

Expertly delivered, Richard Ulrich (University of Arkansas) guided the audience through the technology drivers, potential applications, commercialised technology, the economics and possible future directions in embedded passive components, and processing for organic boards. Resistors, capacitors, inductors, substrates, thick and thin film technologies, embedded and integral components – all were included.

The future certainly seems to be one of building the components directly into the substrate. Indeed, Dr Ulrich geared his presentation towards the implementation of these components, in order to help potential users make decisions about their applicability in a given situation.

This approach also brought an emphasis on electrical testing since it was asserted that users of passive components will find themselves producing them and not just buying them. Dr Ulrich is senior author of "Integrated Passive Component Technology" published by Wiley Press, the first book dedicated to this subject.

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Pad Design, Stand-off and Evolver

An understanding of what controls component stand-off and how this can be used to optimise joint configuration (stand-off, fillet shape etc) in lead-free joints is a step nearer as the result of an exciting on-going collaboration between NPL and Greenwich University. Test results have been compared with predictions using Surface Evolver, a proven modelling package used extensively within the industry to predict fillet geometry and solder joint shapes. The model requires data on surface tension, density, contact angle, solder volume and geometric constraints. But understanding what factors may help solder to remain under the termination (planarity, voids, intermetallic growth, trapped flux) but which are not considered in the Evolver model, is crucial. Since large stand-offs are usually associated with improved reliability, assemblers have a particular interest in the design of the pad (e.g. amount of pad under and outside the component footprint) and its effect on stand-off. The initial results from tests using different pad sizes, solder paste volumes and fillet shape, confirm that pad design is indeed a major factor in determining stand-off, and suggest ways in which the Evolver model may be enhanced.

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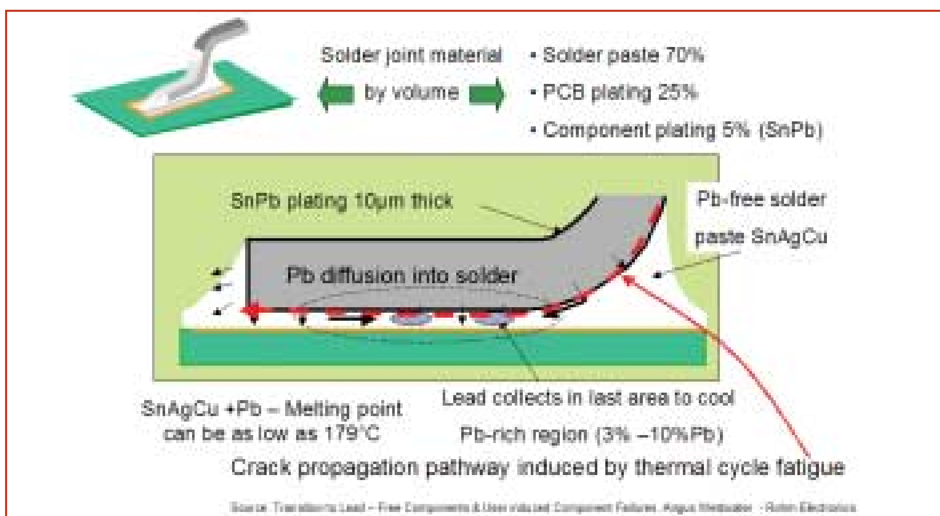
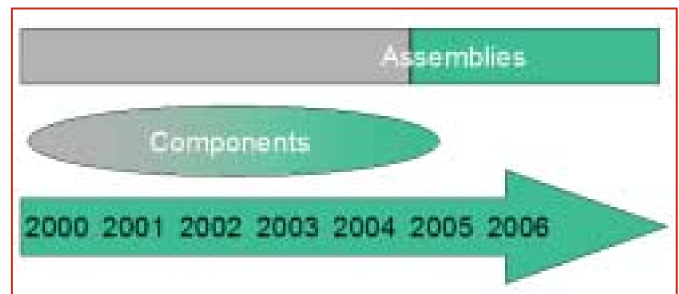


Lead-free joint failure from lead contamination.

Are Supply Chains Ready?

That lead-free soldering will soon be widely implemented in electronic assemblies is certain, and the countdown to July 2006 is well underway. After this date the use of lead-containing solders for assembling a wide range of electronic equipment will be banned. Whilst the engineering and technology challenges have attracted widespread attention and development, full implementation of lead-free soldering technology is still beset with non-technology issues, which generally have received little attention. At the recent meeting of the NPL Soldering Science & Technology Club (SSTC) Martin Wickham (SM Club) highlighted some examples, which have come to light as part of the NPL-industry co-operation. All require action now to ensure that supply chains will be ready when full implementation occurs. Typical issues, on all of which NPL can offer advice, include:

- Labelling requirements – these are not yet fully agreed; manufacturers, importers, distributors and recycling facilities may be requested to provide information at national level.
- Component availability – obtaining parts which have lead-free terminations, or can withstand the higher lead-free processing temperatures, is a key issue. Assemblers need to review stock and trace the status of incoming components immediately.
- Lead contamination – using lead-containing plated components in lead-free soldering can risk the formation of lead-rich phases weakening the component-solder interface (see Issue 18 December 2003).
- Re-qualification – will a change of component or product design require it to be requalified? If so, will test houses be over-loaded as July 2006 approaches?



Typical target date for switch to lead-free processing.

- Re-badging – badging companies can still be responsible under the WEEE/ROHS Directive, so careful definition of requirements on the supplier is essential.
- Equipment upgrades - there may be delays in delivery if suppliers are overloaded as the deadline approaches.
- Bill of materials – this must be reviewed for compliance to ROHS and lead-free specification. Early clarification of who owns this task is crucial.
- Enforced obsolescence – some components may not have lead-free versions, resulting in accelerated obsolescence, and possible product redesign or re-specification.

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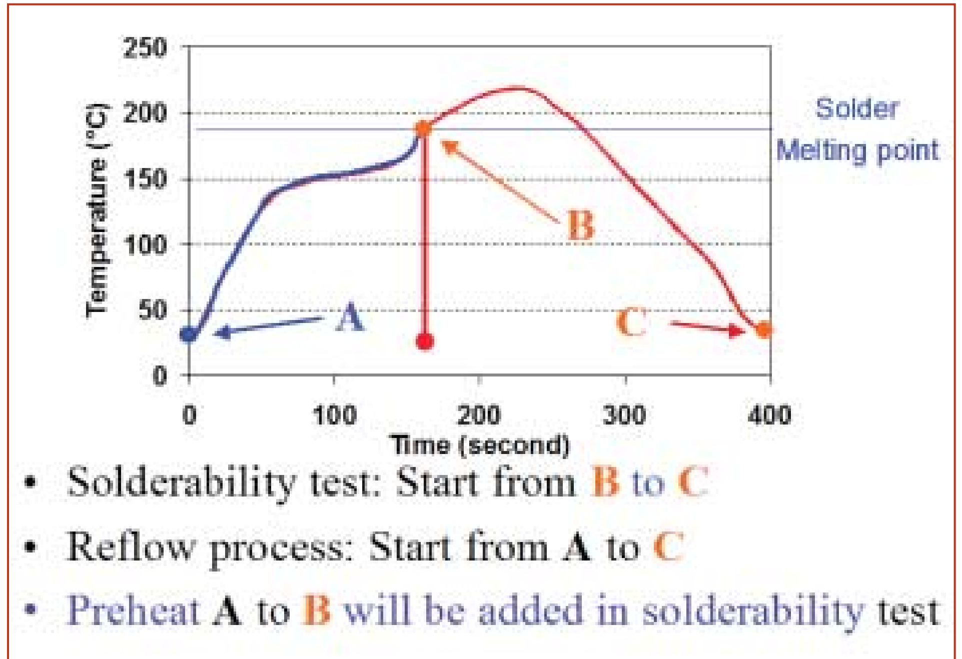
SSTC Meeting Underlines Issues

Mirroring current interests in the industry, the successful summer meeting of the Soldering Science & Technology Club (SSTC) focused not only on lead-free technologies but also on other processing technologies giving some concerns. The first to pose questions and supply some answers was Martin Wickham speaking about supply chain issues (see elsewhere in this issue). Picking up the theme of worrying timescales Ian Wilding (Henkel) reviewed the position of lead-free wave soldering with only two years to the ban on lead. Although many of the expected issues have or can be resolved, lead contamination is still a worry since lead-free boards and components cannot yet be fully sourced. Bob Willis (EPS) challenged some of the myths relating to fillet lifting, supporting his answers with a series of illustrations. In a more academic approach Salih Gungor (Open University) discussed the application of optical strain measurements to solder joints, but the technique depends on having an optically flat surface on the joint. Predicting damage in thermally cycled solder joints was addressed by Steve Ridout (Greenwich University). He concluded that for lead-free solder fatigue, new models would be required incorporating 3D simulation that can indicate both the direction of crack propagation and the effects of ramp rates/dwells.
Milos Dusek (NPL) showed how some consideration of pad design could improve joint reliability, whilst Ling Zou (NPL) explained the benefits for solderability testing of using a preheat. It is too early to answer the question "Are conductive adhesives a viable lead-free alternative", but following some collaborative work with TWI Martin Wickham was able to conclude that they may be suitable for consumer applications where reliability levels are not those expected from avionics and military. The recognition that SIR results on assembled boards are influenced by whether the driving voltage is AC or DC provides a major step in understanding the effects of contamination on board reliability – see issue 19. This was emphasised by Alan Brewin (NPL) who also suggested that flux issues with the higher temperature lead-free processing, may require fluxes reformulation.



Solderability temperature profile

Fillet lifting and tearing during wave soldering

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New Instrument for Micro-joint Materials Data Generation

As device and joint miniaturisation accelerate there is a concurrent requirement for materials data on SM solder joints having geometries similar to those of current product, and obtained under conditions paralleling those of field service. However, the development of suitable measuring equipment has not proceeded in parallel. But now the ability to generate such data will soon be a reality following new work at NPL. The realisation of a suitable instrument has been based on the long-term experience of the proven ETMT (electrothermal mechanical test) equipment, but overcomes its limitations of speed and incremental displacement. The new instrument can be used at very low strains on samples 2 mm long x 0.3 mm high, with displacements much less than 1 µm. Importantly, the robust design is such that the whole instrument can be incorporated into a thermal cycling chamber.

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Webcast

Continuing its role in rapid knowledge transfer to industry, NPL is developing a WEBCAST system. Users register on-line and are presented with the required presentation on a password protected site. The users are then given an access code for a conference call at a given time. This will soon be available at: www.npl.co.uk/ei

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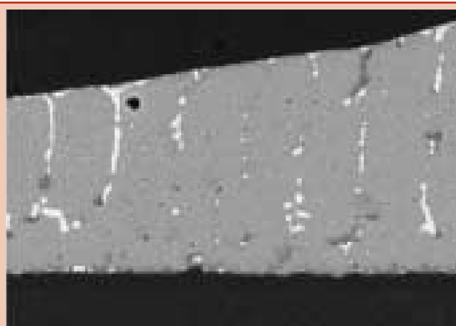
Lead-Free Transition Reliability

A current concern for the industry during the transition to lead-free soldering is the impact on joint reliability of the presence of small amounts of lead in a nominally lead-free solder. It has been suggested that if lead (e.g. from component terminations of unknown alloy finish) contaminates lead-free solder in the joint, then reliability will be affected. NPL, with fifteen industrial partners, is undertaking a searching interactive project which aims to determine what levels of lead cause detrimental effects to the joint. An early result of keen interest to all assemblers is that low levels of lead (1 to 5% of the solder joint mass) in the joints of SOIC, R1206 and BGA components, result in segregation of the lead. The impact of such segregation on joint reliability, is being urgently explored. Data are being generated after thermal cycling tests (-55 °C to +125 °C; 2000 cycles) on boards having a range of components assembled using different combinations of solder paste, PCB finish and component termination material. Joints are being characterised electrically and via microsectioning, EDX and shear testing. Image analysis is being used to determine both the phase proportions and the critical levels of lead and their distribution. An outline of this project is available on the website: http://www.npl.co.uk/ei/studio/



Lead segregation from lead contamination in a lead-free solder joint

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'New Appointment Offers UK Manufacturers Lead-Free Support'

The Electronics Group at NPL proudly announce the appointment of Ling Zou as Test Service Manager. NPL offer a wide range of services and consultancy to the UK electronics industry. Ling's arrival is timely; as the ban on lead approaches many will need assistance in getting the most from lead-free trials. Her extensive background in solderability, reliability and lead-free issues will be key in aiding customers in the transition period.
As well as a consultancy role in all areas of electronics reliability, NPL test services include;
Surface Insulation Resistance
Solderability Testing
Micro-sectioning, Joint and Materials Analysis
SEM / EDX
Thermal Cycling / Liquid to Liquid Thermal Shock
Auger Spectroscopy
Tin-Whisker Testing
Joint Shear
Solvent Extract Conductivity

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Another Successful Clinic at NEPCON

NPL was again invited to be an integral part of the successful Lead-free Experience organised by The SMART Group at NEPCON. The three pronged approach (short presentations throughout the day, supplemented with trials of actual processing, and an interactive clinic) was clearly in tune with visitor requirements, providing a practical and immediate vehicle for knowledge transfer, to the industry. Technical presentations from Rob Horseley (Celestica) and Steve Mainwaring (Selectron) were well received providing an excellent platform for the clinic in which help/advice was given on a one-one basis to > 100 satisfied customers.

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