NPL
National Physical Laboratory

Microelectronics *News*

A National Measurement Newsletter

Winter 2006 | Issue 22

As we rapidly approach the lead-free soldering deadline of July 2006, the industry is about to dispense with 50 years of hard-won service reliability experience of joints soldered with the ubiquitous SnPb solder. But we cannot replace it with corresponding data for lead-free solders, and this lack of reliability field data for lead-free product is of great concern to companies. Some information has been obtained on generic test boards, with encouraging results, and models have been developed so that lifetimes of joints in specific environments can be predicted with some confidence. But each combination of product, assembly system and application, is unique, and whilst some manufacturers can gauge product reliability from a mixture of modelling, trials to confirm the model's predictions, and early field experience, for many small businesses this is not possible. If you have concerns about the lack of field data, modelling your product etc, NPL may be able to help. We have carried out a number of such exercises, all in timescales commensurate with assemblers' requirements.

Chris Hunt

Dr Chris Hunt receives the IPC Distinguished Service Award from David Bergman

Contents:

Prestigious Award for NPL Team

The work of NPL for the global electronics interconnection industry, was given international recognition at the recent IPC Works 2005 meeting, held October 24-27 in Las Vegas. The IPC Distinguished Service Award was presented to three NPL workers, Dr. Chris Hunt, Alan Brewin and Ling Zou, by David Bergman, Technical Director of IPC. The award recognises the long-time NPL contribution to the industry and in particular the development of IPC-9691 and the understanding of conductive anodic filamentation (CAF) growth *(see issue 18)*.

dti
FUNDED BY THE DTI

National Physical Laboratory | Hampton Road | Teddington | Middlesex | United Kingdom | TW11 0LW
Switchboard 020 8977 3222 **NPL Helpline** 020 8943 6880 | **Fax** 020 8943 6458 | **www.npl.co.uk**

Concern Over Barrel-cracking

NPL with 16 collaborators, is to carry out a short study into the robustness of PCB vias and micro-vias at the higher soldering temperatures associated with lead-free systems.

There have been fears that, against a background of changing to lead-free soldering and miniaturisation of board technology, the reliability of the microvias and high aspect ratio vias may be disrupted (cracked), multi-layer substrates may delaminate, and the surface insulation properties may be degraded. The aim of the project is to develop a test method to measure any effect on reliability of the vias at these higher temperatures, and hence improve industry confidence in the reliability of PCBs after the change to lead-free systems.

Contact: Martin Wickham
Tel: 02392 719288
Fax: 02392 719287
E-mail: martin.wickham@npl.co.uk

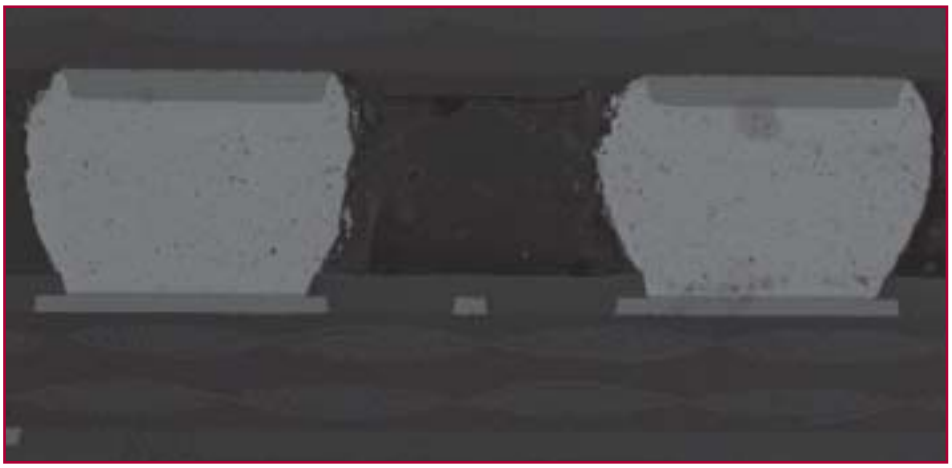
Transition Worries Eased

Concerns over the reliability of joints manufactured during the transition to lead-free soldering, have been eased as the result of a wide-ranging study undertaken by NPL and 24 industrial collaborators. Over 200,000 solder joints were manufactured on assemblies in a matrix experiment (SM and PTH components, lead-containing and lead-free terminations, SnPb and SnAgCu (SAC) solders.) All were thermally cycled (-55 °C to +125 °C) for 2000 cycles, and assessed using continuity, shear, pull and vibration tests.

Importantly, the results indicated there are no real solder joint reliability issues when mixing lead-free- and SnPb-terminated components and Pb-contaminated (1%Pb to 10%Pb) solder alloys. The one exception (tin-plated QFPs soldered with SAC; after 1000 thermal cycles) is attributed to batch-related solderability issues.

In the case of SOIC components, small quantities of lead contamination (<10%) in a lead-free joint may cause problems under certain processing conditions i.e. if the first side of a double sided assembly reaches temperatures >180 ºC during second side assembly, and there is stress on the joint (e.g. from warped assembly). The first side solder joint may separate or deform, producing an open joint, or worse, an electrically conducting joint with poor resistance to low cycle fatigue. However, there were no indications that lead-contamination of well formed joints, has any effect on low cycle fatigue resistance.

Contact: Martin Wickham
Tel: 02392 719288
Fax: 02392 719287
E-mail: martin.wickham@npl.co.uk



Section of two joints as manufactured from BGA soldered with SnPbAg solder paste showing reflow of the SAC ball (PCB uppermost) as manufactured.

Collaborators Invited

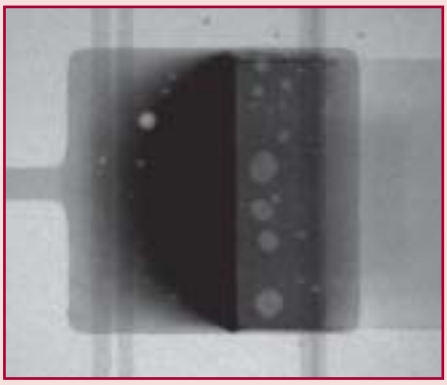
Continuing its successful role in addressing specific process issues, NPL has launched another three-year programme with an opportunity for industrial collaboration.

A current concern for companies is the impact of recycling legislation on the design and assembly of electronics equipment, specifically reduction of the annual 3.5 million tonnes of electronics waste. The new programme will study the feasibility of building recyclable electronics using new generations of conducting adhesives and recyclable substrates (subtractive and additive PCB technology). Interest in participation in the programme, or comment on its content, are welcomed.

Contact: Chris Hunt
Tel: 020 8943 7027
Fax: 020 8614 0428
E-mail: chris.hunt@npl.co.uk

Nothing Lost from Voiding

Concern over voiding, soldering and reliability of joints assembled using conventional SnPb solders is well known. However, there is a paucity of data on joints assembled using lead-free solders, surprising in view of industry's legislation-driven change to lead-free technologies.



Typical X-ray images of voiding in an R1206 component

Industry-supported work at NPL has dispelled the perception that lead-free soldering would be prone to excessive voiding and degraded reliability. In particular, the work demonstrated that voiding levels in lead-free solder can be kept well below the IPC specified maximum, a fact welcomed by industry.

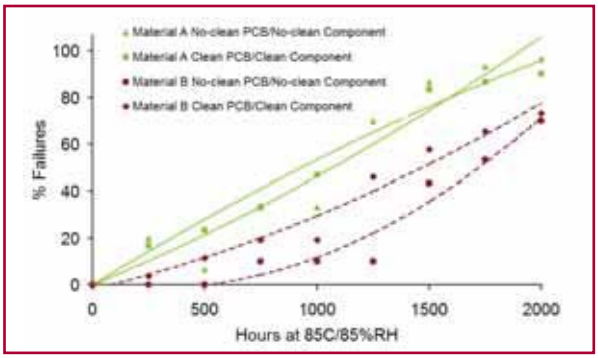
Encouragingly, the results showed that for a wide range of lead-free soldering conditions (using 7 solder pastes and several reflow profiles), it was difficult to generate the high levels of voiding previously shown with SnPb soldering. These low average voiding levels were consistent across a range of lead-free solder technologies, and were all well below the levels permitted in IPC A610 revision D. Supporting evidence was obtained by subjecting joints having up to 13% voiding, to extensive thermal cycling (-55 °C to +125 °C; 2000 cycles). As monitored using electrical resistance, shear strength, or shear strength deterioration during thermal cycling, there were no differences in reliability of the joints. The results clearly suggest that if the IPC maximum voiding levels are adhered to, there should be no adverse effect from voiding on the reliability of lead-free solder joints.

Contact: Martin Wickham
Tel: 02392 719288
Fax: 02392 719287
E-mail: martin.wickham@npl.co.uk

Can Conductive Adhesives Do the Job?

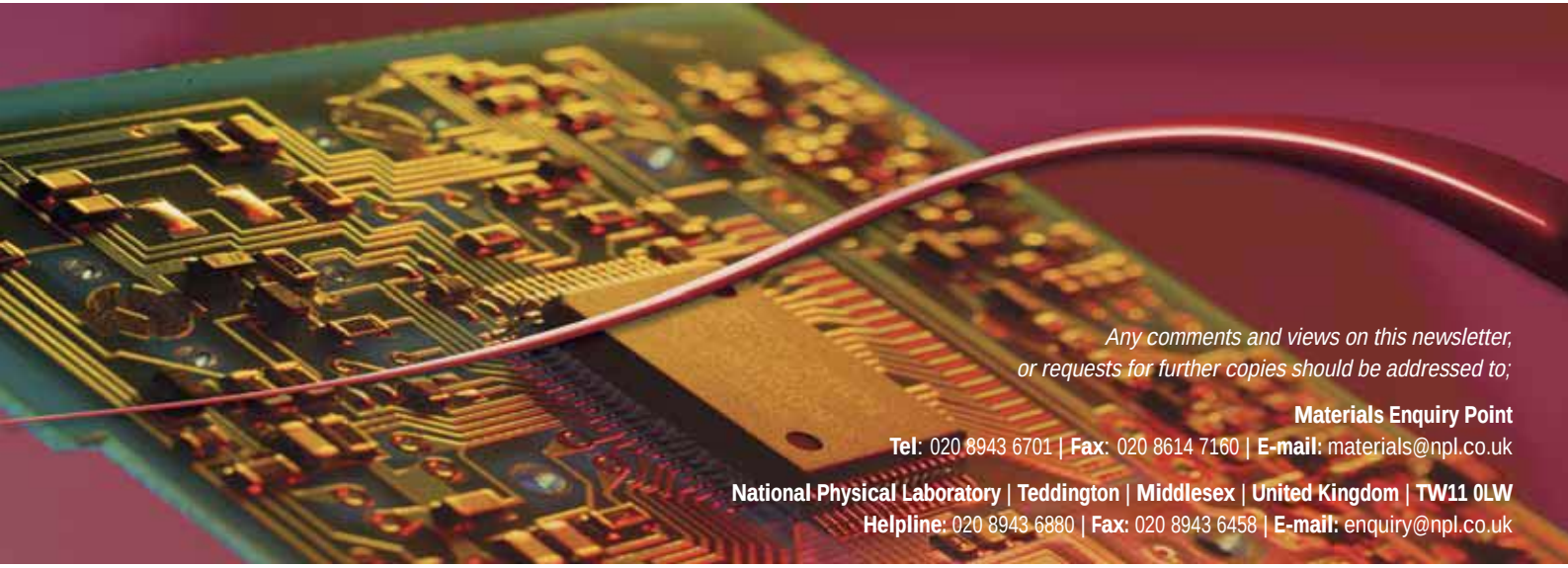
Some isotropic conductive adhesive (ICA) materials could be used to replace SnPb solders, but material selection is critical, since there are major differences in the performances of apparently similar materials.

That is the salutary outcome of the first stage of an NPL-industry collaboration to study the influence of component and PCB finishes on the reliability of ICA joints after environmental exposure. In the transition away from lead-containing solders, ICAs are again being considered as possible replacements, and it seems that current materials offer a wider applications window. The effect of different finishes was found to be very adhesive material dependent. One material produced joints, the reliabilities of which were relatively unaffected by changes in component or PCB surface finish, whilst the performances of another material varied markedly. Although joint reliability was only marginally influenced by the PCB finish, the component finish was very influential, suggesting some benefit can be gained if a choice of component finish is possible. Components with a PdNi finish generally performed better than those with a plated-tin finish. Again the results were material dependent, with the better performing material exhibiting little difference irrespective of the PCB finish. A follow-up stage is investigating whether stencil design rules can be used to reduce the amount of material needed to make a reliable joint – any significant reduction could result in cost savings. In addition, solder joints in a commercial product are being replaced by ICA joints as a means of comparing the effects of the two materials on long-term reliability.



Cumulative electrical failures for materials A and B; as-received and cleaned tin-plated substrates; as-received and cleaned tin-terminated components.

Contact: Martin Wickham
Tel: 02392 719288
Fax: 02392 719287
E-mail: martin.wickham@npl.co.uk



Any comments and views on this newsletter, or requests for further copies should be addressed to;

Materials Enquiry Point
Tel: 020 8943 6701 | **Fax**: 020 8614 7160 | **E-mail:** materials@npl.co.uk
National Physical Laboratory | **Teddington** | **Middlesex** | **United Kingdom** | **TW11 0LW**
Helpline: 020 8943 6880 | **Fax:** 020 8943 6458 | **E-mail:** enquiry@npl.co.uk

Are You Getting the Information?

Central to the work of NPL is the rapid and efficient transfer of information to industry, achieved via a number of routes. Typical recent examples include:

Conductive Adhesives Workshop
(29 June 2005 at TWI) – the first meeting in this area for some time provided a *status report* for the 50+ attendees. A general conclusion was that CAs are becoming more attractive and are being seriously considered for certain applications. A follow-up meeting was held on 13 Dec 2005 at NPL.

Electronics Assembly Conference
(SSTC meeting 13 July 2005 at NPL) – 10 speakers gave the 60+ attendees a forward look on emerging technologies, components, assembly, lead-free soldering and business issues.

Werner Engelmaier Masterclass
(12/13 Oct 2005 at NPL) – the 60 attendees had the benefit of his 40 years experience in the interconnection industry in his comprehensive review of the fundamentals of the reliability of solder joints and PCBs.

Lead-free Conference
(SSTC meeting 8 December 2005 at NPL) – the results of DTI and industry funded work into many aspects of lead-free soldering technologies were brought together for the 120+ attendees.

Breakfast meetings in collaboration with FSB
(Federation of Small Businesses) – used to update small businesses on specific aspects of lead-free soldering, focusing on legislation, compliance, supply chains, and stock.

Most Frequently Asked Questions
see www.npl.co.uk/ei/news/faqs.html
This is the most frequently hit page on our website.

Contact: Milos Dusek
Tel: 020 8943 6263
Fax: 020 8614 0428
E-mail: milos.dusek@npl.co.uk

New NPL Reports

- Measurement of creep rates and stress relaxation for micro-sized lead-free solder joints. NPL Report DEPC-MPR 021
- Shear strength of lead-free solder joints. NPL Measurement Note MN57
- Guidelines for measuring anionic contamination of PCBs and PCAs using ion chromatography. NPL Measurement Good Practice Guide No. 76
- Effect of PCB finish, processing and micro-structure on lead-free solder joint reliability. NPL Report DEPC-MPR 028
- Preliminary measurements of solder flux residues in an AC environment. NPL Report DEPC-MPR 029
- Measuring the reliability of electronics assemblies during the transition period to lead-free soldering. NPL Report DEPC-MPR 030
- Measuring the effect on isotropic electrically conductive adhesive reliability of substrate and component finishes. NPL Report DEPC-MPR 031
- The role of permeability and ion transport in conformal coating protection: NPL Report DEPC-MPR 032
- Effect of voiding on lead-free reliability. NPL Report DEPC-MPR 033

www.npl.co.uk/ei/publications/

Conformal Coatings: Permeable or Not?

An understanding of the degree of protection afforded by conformal coatings is closer following another on-going NPL-industry collaboration.

The initial findings demonstrate that surprisingly, whilst the coatings protect underlying electronics from corrosion by sodium chloride, this does not apply for exposure to dibasic acids which can corrode the underlying metallization i.e. the coatings are more robust towards ionic contamination than they are towards flux, highlighting the importance of board cleanliness to aid protection. Six generic types of coating currently used within the industry, were evaluated using several complementary techniques - surface insulation resistance, sequential electrochemical reduction analysis, diffusion cells, and gas chromatography mass spectroscopy. With the exception of the epoxy and water-based acrylic materials, the coatings provided similar levels of protection for different NaCl concentrations.

Contact: Angela Mensah
Tel: 020 8943 6759
Fax: 020 8614 0428
E-mail: angela.mensah@npl.co.uk

6138/0206