ISSUE 17 • June 2003

Microelectronics *news*

The transition to lead-free soldering continues to be a major concern for the industry, and hence technical themes in this area continue to be developed in NPL-industry collaborative programmes. In particular, in the Measurements for Processability and Performance of Materials programme, two major projects "Modelling for faster reliability prediction" and "Characterisation tools for electronic assemblies" maintain NPL's support for industry by improving testing and processing practice for lead-free soldering systems. These are complemented by short-term projects focusing on specific industrial concerns. Some of the current initiatives regarding lead-free soldering are highlighted in this issue.

Countdown 2006

That lead-free soldering will soon be widely implemented by the electronics manufacturing industry is certain, and with legislation in place the countdown to July 2006 is underway. After this date the use of lead-containing solders for assembling a wide range of electronic equipment will be banned. This is the most significant change to electronics manufacture since the move away from CFCs in the early 1990s and arguably presents a greater challenge to an industry already facing other global pressures. Now the countdown is underway, there is an increasing demand for the generation of information to support the transition, and its rapid and wide dissemination. For nearly ten years NPL has been in the vanguard of generating and disseminating such information, and making it readily available to the industry.

Workshops

In 2003 NPL is holding fifteen workshops and management briefings around the country addressing important issues for designers, engineering and quality managers, management and buyers, and inspectors and rework engineers. The tutors are Alan Brewin and Bob Willis, and full details of venues, dates and content are downloadable from our website (www.npl.co.uk/ei/training).

Lead-free CD-ROM Cook Book.

NPL in collaboration with EPS, has generated a major interactive CD-ROM for use by practising engineers. The ***"Lead-free assembly and soldering Cookbook"*** addresses many aspects of lead-free technology including solderable finishes, component terminations, wave, reflow and hand soldering, reliability, and impact on existing equipment; it also provides an extended defects library and many processing clips. Via video interviews, key people from industry outline what they perceive as the major issues. The ***"Cook Book"***, now in its third revision, has become a bench-top reference for engineers across the country.

Accessible Resources for All

NPL offers a bespoke one-day on-site expert health check involving an interactive assessment of current practice focused on the impact of switching to a lead-free soldering technology. Health checks can be complemented by trouble-shooting, testing and training (on-site or at NPL), and by industrial secondment to NPL to facilitate knowledge transfer and staff training.

Frequently Asked Questions (FAQs)

Extending a comprehensive website containing a range of freely available information on all aspects of lead-free technology, a very popular FAQs section has been established, in which the answers are given to questions raised by industry.

This issue

Forthcoming Master Class

MST, MEMS, MOEMS and Nanotechnology is the intriguing title of the latest in the series of NPL Master Classes given by world renowned speakers. On 17 July 2003, Ken Gilleo (Cookson Electronics) will discuss the new technologies of MST (microstructure technology), MEMS (micro-electromechanical systems), MOEMS (optical MEMS) and nanotechnology. Ken will highlight aspects of packaging including wafer-level hermetic and low cost plastic near-hermetic processes, and will address their special benefits, their methods of production/fabrication, their wide-ranging applications, and indicate which belong in sci-fi.

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NPL
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CD Encapsulates NPL Work

A huge resource of information and data on electronics interconnection obtained by NPL over six years as part of DTI sponsored industry-collaborative projects, is now available on a single CD. Nearly 50 reports are included, covering: lead-free soldering, general soldering technologies, printing and dispensing of pastes, and encapsulant degradation.

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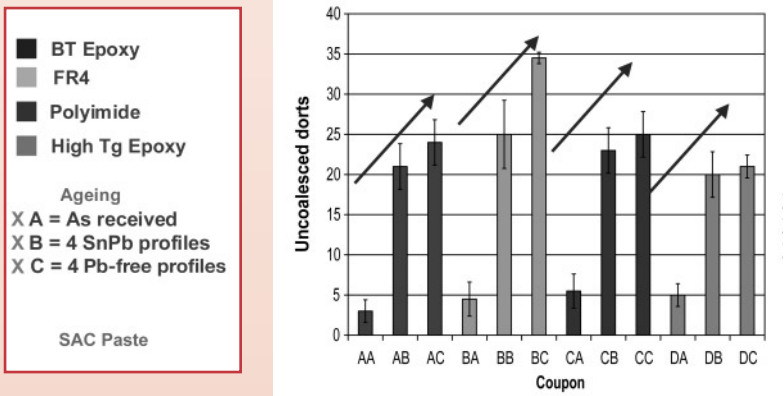
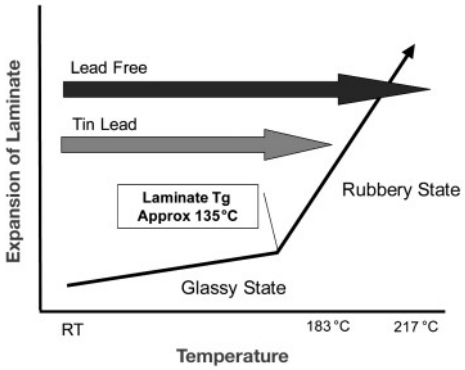
Are Laminates Resistant to Lead-free Reflow?

Industry has received both good and bad news on the reliability of laminates under lead-free reflow conditions. A comprehensive study by NPL explored the stability of a range of parameters after lead-free reflow processing.The results on different laminate types (BT epoxy; FR4; polyimide; high Tg epoxy), which were presented at the ***Annual Lead-free Conference***, indicated that many parameters were unaffected by the higher temperatures associated with lead-free processing. These included deformation under load (for all but the low Tg materials), X-Y dimensions, and SIR/electromigration issues. However, there were some adverse effects:

- reduced solderability of the board finish (ENIG) raising questions over multiple pass reflow processes
- increased deformation under load of the low Tg FR4; board clamping and support during reflow may become more critical
- decreased CAF (conductive anodic filamentation) resistance of standard FR4 material



Dot testing solderability results



Behaviour of FR4 above its Tg

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Joint Lead-free Seminar a Winner

The capacity audience of 130 were well rewarded by seven presentations of high quality at the fifth annual ***Lead-free Seminar***, organised jointly by NPL and the SMART Group. The papers covered all the major issues of current concern to the industry and, to the satisfaction of those present, in several instances solutions were discussed. Steven Andrews (DTI) opened the debate with the latest legislative details of the UK implementation of the EU ROHS Directive. The major concern of industry relates to lead-free product reliability, and several speakers addressed different aspects of the issue. Hector Steen (Henkel-Multicore) reviewed available data on solder joints concluding that in general there should be no problem. He emphasised the danger of extrapolating results from accelerated tests to real life conditions. Reliability of laminates was discussed by Alan Brewin (NPL), whilst Angus Westwater (Rohm Components) supported the strategy of changing to lead-free processes, but only when all components are lead-free.

The integrity of components as a result of lead-free soldering, was reviewed by Chris Hunt (NPL), and Steve Dowd (Indium Corp) outlined some pitfalls in lead-free soldering in mobile phone production, showing how they might be avoided. Finally, Mike Butler (Henkel-Loctite) indicated how suppliers were finding new adhesive materials compatible with the lead-free process. The Conference proceedings are available on request.

During the seminar 82 participants contributed to a wide-ranging survey, with some interesting findings:

- Many SME and large companies do not yet have a plan for introducing lead-free technologies
- 27 companies are committed to using SnAgCu solders; another 45 are considering the options.
- Gold on nickel was the most popular PCB finish
- 48 companies are considering the options for component terminations
- 17 companies are considering the use of nitrogen inerting

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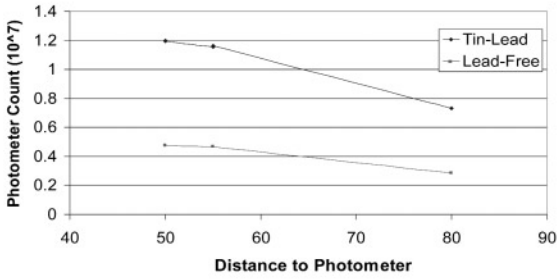
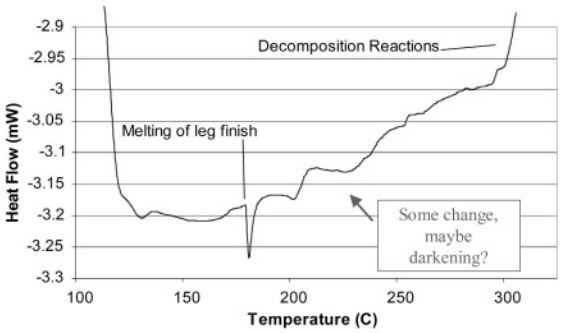
Lead-free Component Stability

PCB assemblers should be aware of potential compatibility issues with some components using lead-free soldering. That is the cautionary message from an NPL project exploring the functional and physical stability of components thought to be sensitive to the higher soldering temperatures associated with lead-free soldering. The components, selected by members of the **Soldering Science & Technology Club** (SSTC) included SM LEDs, polyester capacitors, aluminium electrolytic capacitors, SMT headers, crystal oscillators, BGAs, QFPs and four types of laminate (FR4; high Tg epoxy; BT epoxy; polyimide). They were studied with respect to dimensional stability, weight loss and electrical functionality. The encouraging results showed that the majority of the components were robust and acceptable for lead-free processing, allaying earlier concerns over component stability. However, there are concerns over some components:

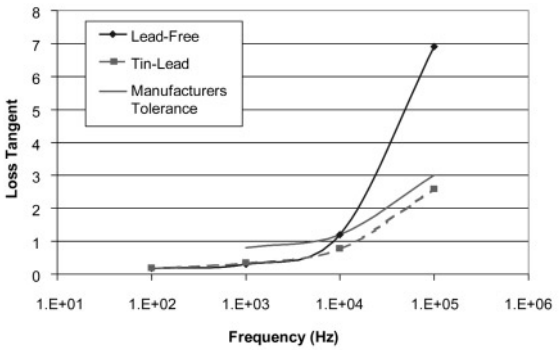
- Damage to polyester electrolytic capacitors may degrade the loss tangent to unacceptable levels, even though the capacitance remains within specification
- LED casing materials may darken from overheating reducing light emission levels
- Misalignment can occur with ultra fine pitch QFPs
- Low Tg laminates subjected to loading during lead-free reflow (e.g. inadequately supported heavy assemblies) may become warped
- Components and PCBs susceptible to moisture ingression and subsequent delamination may have increased susceptibility during lead-free soldering
- Increased ageing with lead-free processing may cause reductions in solderability of all laminate types. Subsequent soldering operations (e.g. with double-sided boards) may therefore have lower yields.



Discolouration of LED. Photometer analysis of Green SM LED's after reflow



DSC curve for gull-wing LED



Loss tangent for a polyester capacitor showing unacceptable performance at high frequency.

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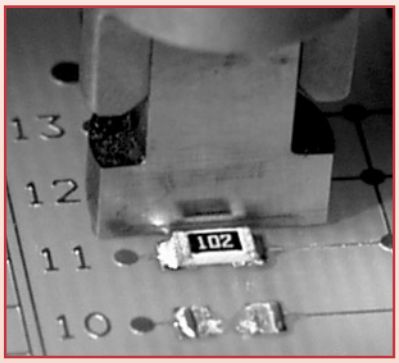
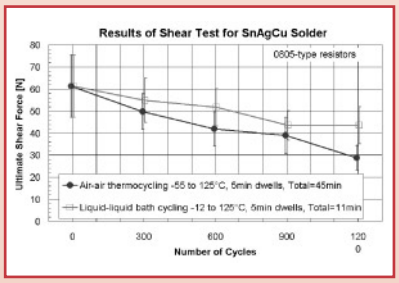
Thermal Cycling – The Way Forward

A key objective of the DTI-sponsored project ***"Measuring and modelling the materials properties impact on solder joint reliability"***, is the development of a tool kit of models and test methods to give a better understanding of lead-free solder joint reliability. An integral part of the tool kit is an appreciation of how thermal cycling tests generate accelerated ageing conditions representative of stresses from thermal expansion mismatch between components and substrates. It is also crucial to know how the micro-mechanical properties of the small joints vary with test regime. The NPL-led collaboration addressing this issue, has already released the first results of its study of both lead-free and lead-containing solders under several thermal cycling regimes. A special micro-mechanical test has been designed (using 2512 chip resistors on FR4 substrates) to study stress/strain hysteresis and ultimate shear strength on the small samples, under cycling tests varying temperature extremes, ramp rates and dwell times. Two (of five) test regimes have already been studied (-55 °C to +125 °C, cycle time 45 mins; and -10 °C to +100 °C, cycle time 10 mins), and the results demonstrate that these components are more resistant to shock than to thermal cycling.



Test set up showing one tested joint and one joint before test.



Variation of mech properties with number of cycles, for two test regimes and for D805 chip resistors soldered using SnAgCu alloy.

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SIR Testing Extended to AC circuits

As a result of collaboration between NPL, industry and academia, board assemblers will be able to design and test their product with greater confidence. A valuable extension of the proven SIR (surface insulation resistance) technique will provide a fuller understanding of the effects of contamination on board performance and reliability. For the first time the technique will use an AC driving voltage to promote failure mechanisms, thus replicating the situation in the majority of contemporary circuits, and addressing concerns on the value of conventional SIR tests using DC voltages applied to artificially aged samples. The new test is being developed against a background of rapidly decreasing circuit dimensions making boards more sensitive to surface contamination, and changes in process materials and chemistries associated with lead-free processing.

The project, part of the DTI-sponsored MPP (Measurements for Processability and Performance of Materials) programme, is exploring options of passive and active test approaches, effects of AC frequency and voltage, effects of a DC bias combined with an AC signal, geometries of the test vehicle design, and dependence on both temperature and humidity. Kent University has already surveyed industry practice and requirements, and has recommended parameters for test coupon and procedures. This AC SIR test, together with improved ion chromatography and pre-heated solderability tests – all focusing on the assessment of residues on new as well as failed circuits - will form a valuable tool kit for characterising PCAs much sought by industry.

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Credible Lead-free Materials Data at Last.

Credible materials property data for new lead-free alloys in solder joints whose geometries reflect those in modern assemblies are now becoming available through a new project led by NPL. Such data are vital for the application of advanced design and modelling methods, and will give confidence in understanding how very small lead-free joints perform in the field, and how product reliability will be affected by the change to lead-free soldering. These data are now being obtained using a miniaturised electro-thermomechanical (ETMT) instrument and unique miniature test pieces. Current data for modelling joint reliability came from measurements on bulk samples and do not represent the behaviour of alloys in much smaller joints. But new products and the ability to improve time to market mean that sensible modelling of joint reliability is essential. Industry is therefore demanding methods that yield credible data from appropriate volumes of solder. With the collaboration of both academia and industry, ETMT data are being generated and used to study the relationship between in-service conditions and performance, an understanding of which is particularly important for the new lead-free solders. Significantly, this is the first time that such creep data have been placed in the public domain. Already data for the SnAgCu alloy (the most promising lead-free alternative solder), have appeared on the NPL web site (www.npl.co.uk/ei/research/mpp52).

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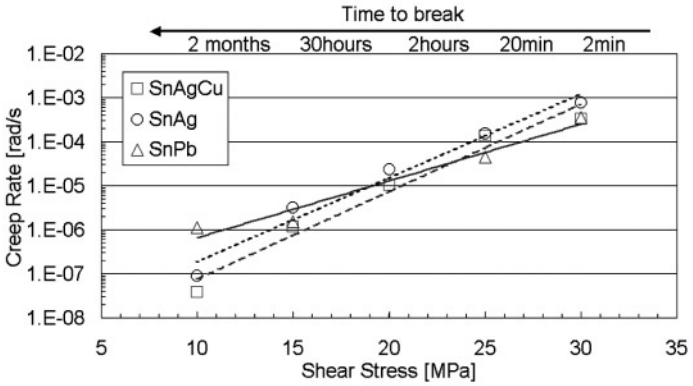

Creep rate as a function of shear strain for SAC, SnAg and SnPb at 21 °C

NPL Provides Help Clinic at NEPCON

At the recent NEPCON exhibition/conference in Brighton, (11-12 June) NPL played a major part in the "Lead-free Experience" arena. All aspects of manufacturing lead-free boards (equipment, production processes, testing, monitoring etc) were displayed and/or demonstrated in the area, but an integral part of the arena was a help service, in which NPL, in conjunction with Solectron and Sanmina, provided a successful independent complementary clinic or one-one discussion of lead-free issues. More than 110 individuals took advantage of this clinic. Current data for modelling joint reliability came from measurements on bulk samples and do not represent the behaviour of alloys in much smaller joints.

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

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