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Microelectronics *news*

An integral and significant part of the programmes undertaken by NPL is the transfer of information and new technology to industry, and of supporting their incorporation by industry, particularly by the SMEs. NPL's Electronics Interconnection Group has responded to the needs of industry by making the information widely available through many channels. In addition to the traditional reports, papers, conferences, seminars, workshops, clinics, site visits etc, programme outputs are available via:

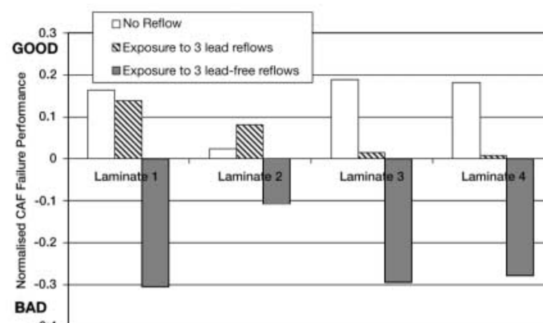
- *CD-ROM containing over 50 reports issued since 1996*
- *CD-ROM providing surface mount guidelines for lead-free processing*
- *CD-ROM for practising engineers; the Lead-free assembly and soldering Cookbook*
- *Code of Practice on Stencil Printing; exploring the limits of fine pitch printing for different pastes*
- *Code of Practice for Lead-free Soldering*
- *Extensive website with many downloadable documents*
- *Case histories for trouble-shooting process diagnostics on the website*

We welcome suggestions for other means for dissemination.

If you would like to know of anyone who would like to receive future editions free of charge, please contact us.

Conductive Anodic Filament Growth in PWB Substrates

CAF growth is now much better understood and can be largely avoided or minimised by optimising design, materials choice and/or processing. That is the encouraging finding of the recently completed collaborative project between NPL and eight industrial partners (2 suppliers, 3 board assemblers, 2 users, and a test equipment manufacturer). CAF involves the growth from anode to cathode of copper-containing salts along the glass fibres of the pcb leading to failure by reducing surface insulation resistance SIR) or destroying the anode integrity (see Issue 13). The collaborators developed a test method for CAF sensitivity based on measuring SIR, and demonstrated that whilst several parameters do have significant effects on CAF resistance (including design geometries, alignment to reinforcement, voltages, laminate system, reflow conditions, and laminate processing), others do not (e.g. board solderability surface finish, drill feed rate, high/low Tg designation of laminate; thermal shock of laminate).



Effect of reflow conditions on TTF for CAF growth; higher reflow temperature and lead-free soldering promote faster CAF growth.

On the downside, CAF growth is more likely using lead-free soldering than conventional SnPb soldering processes.

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MEASUREMENT METHODS FOR ELECTRICALLY CONDUCTING ADHESIVES

Recent SSTC Meeting 10 December 2003

Lead-free soldering issues were again the focus of the recent meeting of the Soldering Science & Technology Club with contributors from DTI, EPS, Loughborough University and NPL. Of particular interest to the audience of more than 80 were the findings of an NPL survey of which manufacturers provide commercial lead-free components, with data on termination types, materials/alloys used etc. Conference proceedings are now available.

NPL National Physical Laboratory

Successful Clinic at NEPCON

The overt success of the *Lead-free Experience* organised by The SMART Group at the NEPCON meeting in Brighton will result in its being repeated at the next meeting. Its three pronged approach (short presentations throughout the day, supplemented with trials of actual processing, and a clinic) proved both innovative and beneficial. NPL co-ordinated the technical papers, and in collaboration with Solectron and Sanmina organised the interactive clinic, *or Help Zone*, that provided advice/help on a diverse range of lead-free issues to >150 satisfied customers. Moreover, subsequent follow-up and interaction resulted in valuable and continuing practical advice, hands-on help, and knowledge transfer to industry.

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Ion Chromatography Made Easy

In response to the increasing industrial interest in using ion chromatography (IC) for the detection and identification of ionic contamination on PCBs, NPL is to prepare a *Code of Practice of PCB Residue Analysis*. It will discuss context and background as well as addressing issues such as extraction, IC column choice, eluent and its concentration, and data interpretation. The upsurge in interest in IC, once considered a technique for academia, originates from (a) the desire to increase process optimisation and control by knowing more about contaminants from handling, cleaning, solder mask, etc, and (b) from changes to IPC requirements for fluxes, which now require suppliers to quantify the halide content of the product rather than using the qualitative copper halo test. IC data allow halides to be both identified and quantified.

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The findings also emphasise the need for end users to test laminate susceptibility when qualifying product. It may not be sufficient just to specify that the laminate should be CAF-resistant, since there are larger differences in CAF resistance between board manufacturers than from preparing materials to a CAF-resistant specification.

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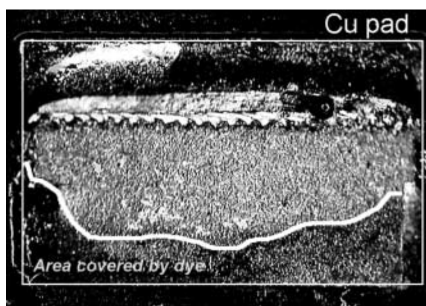
NPL Helps Lead-free Transition for Industry

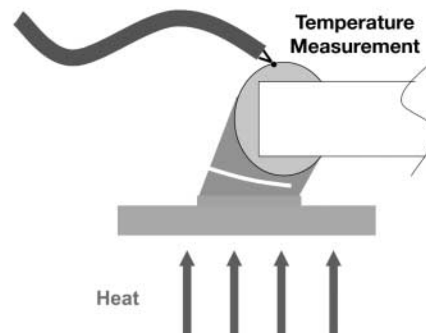
In its current DTI-sponsored programme *Measurements for the Processability and Performance of Materials*, NPL is studying good practice, test methods and models for measuring and predicting materials properties of lead-free solder joints. The aim is to help companies implement lead-free technology with increased confidence, particularly in fields requiring high reliability where there is currently limited information.

Crack Detection Methods

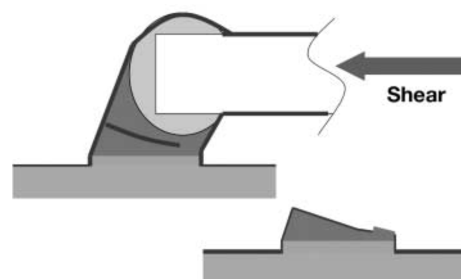
The industry urgently needs a reliable method for determining the rate of solder joint crack propagation during thermal cycling. Work at NPL to explore the possibility of using thermal conductivity of the stressed joint as a suitable monitor, has demonstrated that the thermal conductivity of the uncracked part of the joint dominates the signals obtained, making the technique unsuitable as a potential non-destructive monitor. However, although the traditional method of using coloured dyes on stressed solder joints is destructive, precluding further thermal cycling, it has been found to be useful by industry. Hence a protocol has been generated for its use.



Dye penetration of a lead-free solder joint after 1000 cycles.



Thermal conductivity testing.



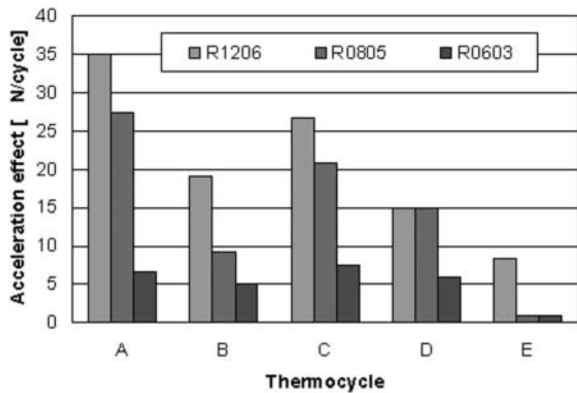
Die penetration testing.

Impact of Service Environment

NPL and its partners have successfully identified critical thermal cycling regimes representative of accelerated ageing conditions for lead-free solder alloys. Using shear and bend (compression) tests the damage incurred on each cycle of a range of cycling regimes for different component shapes/sizes has been measured. The variables for the cycling regimes chosen included high and low temperature extremes, ramp rates between temperature extremes, and dwells at temperature extremes. The data accumulated now permit a choice of regime that is suitable for particular components.

Model Predicting Thermocycling Load

A major requirement for industry is a model that can be used to predict failure of the lead-free joints (i.e. the lifetime of electronic assemblies) under a range of service factors. The results from the impact of the environment exercise (see above) have been used in the initial definition of such a model, which can now be used to predict failure for different thermal cycling regimes and different microstructures. The model is being successively refined as further data are accumulated from other tasks within this programme associated with the effects of voiding, volume of solder joint, and solderability. Further versions of the model will weight the various inputs according to data emanating from ETMT (electrothermal mechanical test) stress-strain loops of thermocycled specimens.



Cycle	Low temp [°C]	High temp [°C]	Ramp [°C/min]	Dwell min	Period min
A	-55	125	10	5	45
B	-55	125	18	10	40
C	-20	125	10	5	40
D	-12	125	65	5	11
E	-20	80	10	5	30
F	-55	125	55	0	6.6

Damage accumulation for various cycling regimes on joints soldered using SnAgCu alloy.

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New Legislation Looms

Industry will have further obligations regarding the environment if proposed new European legislation comes to fruition. It is based on the Duty of Care that all companies manufacturing, importing and using chemicals – regardless of quantity – have to use them in a way that does not affect human health or the environment. This is to be achieved by assessing the risks arising from manufacture or use of those chemicals, and taking the necessary measures to manage those risks. But there are problems - a real lack of existing data, and the slowness of the current assessment processes. The proposed new legislation (REACH – the Registration, Evaluation and Authorisation of Chemicals) seeks to work through *sustainable development to*

- achieve an appropriate balance between environmental, economic and social priorities
- remedy current weaknesses, preserve competitiveness and enhance innovation of the European chemical industry
- reverse responsibility from authorities to industry for testing and risk assessment
- increase transparency and information about chemicals

The work involved will be enormous, as producers and importers will have to provide data on at least 30,000 substances, and register the data with a central authority. Evaluation will be managed by Member State authorities, and authorisation will apply to substances of very high concern i.e. carcinogenic, metagenic, toxic to reproduction, or persistent organic pollutants. There have already been several stages of consultation of the proposals (DEFRA is the relevant UK department) and it is possible that the draft legislation will receive its first reading in the European Council by April 2004. Thereafter registration will depend on volume produced e.g. >1000 tonnes by 2006; >100 tonnes by 2009. But there are concerns over the workability of REACH prompting much negotiation to come.

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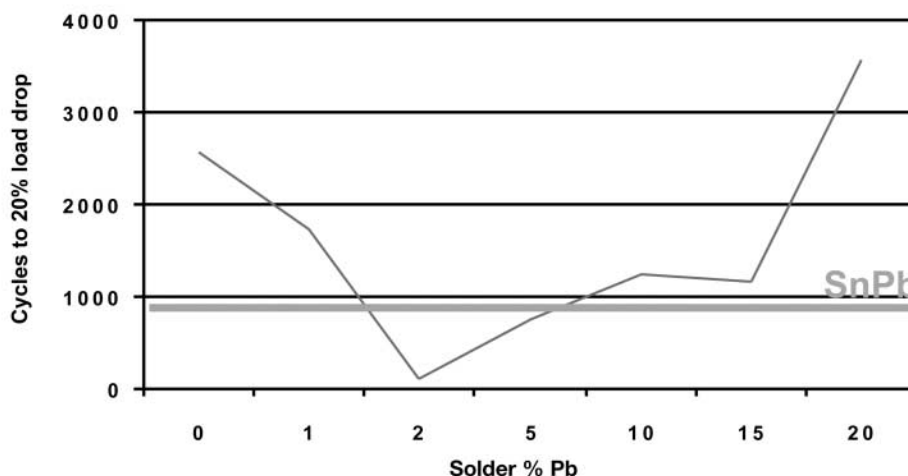

Variation of solder point strength with uptake of load in SnAgCu solder.

Ref: Fatigue Properties of Sn3.5Ag0.7Cu Solder Joints and Effects of Pb-Contamination: Swedish Institute for Metals Research Stockholm, Sweden; SMTA International Conference: September 22 - 26, 2002

Partnership Opportunities

Solder Contamination

Continuing its successful role in addressing specific process issues raised by industry, NPL is launching another short term project with an opportunity for industrial collaboration. A current concern for industry is the impact on reliability of the composition of unknown component alloy finishes during the transition to lead-free soldering. It has been suggested that if lead (e.g. from component terminations) contaminates lead-free solder (e.g. SnAgCu) in the solder joint, then the processing window is modified to produce weaker joints and shorter lifetimes. Another worry is the small percentage of lead in some nominally lead-free systems. Since few data exist, this project will generate credible data in a controlled manner, to explore this suggestion and identify any risks. Although the project has already attracted more than twelve industrial partners, there are opportunities for further involvement.

New Performance programme

The industry continues to face a number of major technical challenges, amongst which is the role of conformal coatings and their wider use in electronics assembly. Next year sees the start of a new suite of DTI-sponsored collaborative initiatives within the new *Measurement for Performance of New Materials* (aka *Performance*) Programme, to address these challenges. As part of this new Programme NPL will lead a project on encapsulants. The project will have significant industrial participation and will build on the foundation of the previous 3-year DME Programme. In the light of common misconceptions that moisture exclusion is the key protection mechanism, the project will attempt to ascertain the role of conformal coatings, how they work, how they should be specified, and study their test performances in aggressive environments (from automotive to medical, drilling to aviation). The Programme is in the formulation stage, and interest in participation, or comments on programme content, are welcomed.

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Countdown 2006 ....

Focusing on specific aspects of implementing lead-free processing for small groups of people with specific job functions, has proved a popular way of helping to prepare key industrial personnel for the transition to lead-free soldering. The interactive workshops, tailored for managers, designers, process engineers, inspectors and procurement officers, and staged around the country, also helped to identify the main concerns of industry during the transition stages (e.g. compatibility of SnPb components and lead-free alloys, the limited preparation by SMEs). The high demand for these workshops means that they are likely to be repeated. Dates are available from our website (**www.npl.co.uk/ei/training**).

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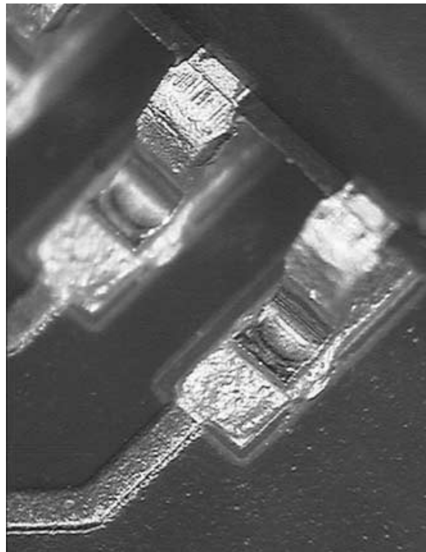
Measurement Methods for Electrically Conducting Adhesives

The growing interest in using conducting adhesives (CAs) in electronic assembly (see Issue 16, January 2003) has been reflected in the large industrial participation in a three-year DTI-sponsored collaborative project led by NPL and TWI. Twenty companies are already involved in the project which aims to:

- develop test methods to assess long-term reliability
- develop test methods to characterise dynamic and static strengths of CAs
- assess the strength test method as an in-process quality monitoring tool
- assess the relative performance of CAs



Typical CA joint .

A final phase involves building two demonstrators of working product to show the suitability of CAs as a low temperature fabrication method as an alternative to lead-free soldering. The programme, addressing practical processing issues, includes

- surveying material types and failure mechanisms (typically high joint electrical resistance)
- reviewing stress screening and electro-mechanical test methods
- specifying and generating test vehicles for both isotropic (ICAs) and anisotropic materials (ACAs)
- studying the effects on joint reliability of component finish (Sn, SnPb, PdNi, Au, SnAgCu)
- studying the effects on joint reliability of substrate finish (Sn, SnAgCu, SnCu(HASL), ENIG, OSP, Ag)
- studying the effects on joint reliability of joint characteristics (design, bonding area/thickness)

The first phase has already been completed. Suitable test patterns have been agreed, that for ICAs being very similar to the one used for studying lead-free soldering, allowing close comparison of test results. A suitable accelerated test regime has been agreed for differentiating the effects of experimental variables in order to ascertain which promote failure - damp heat, dry heat and thermal cycling are used to define test parameters to explore process issues.

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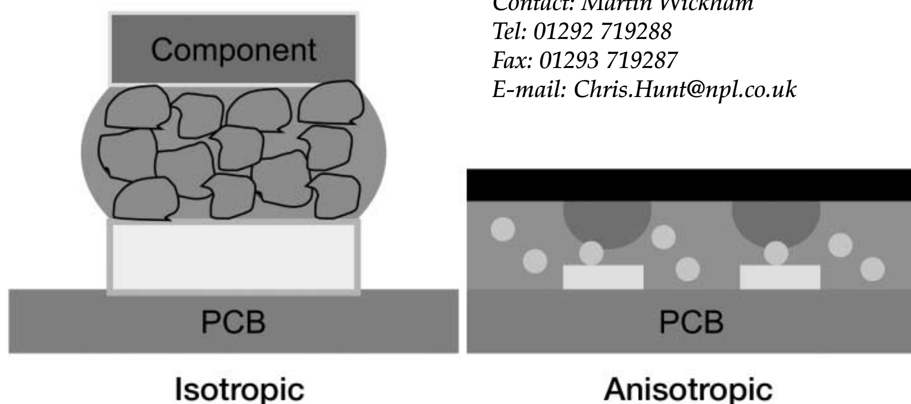

Anisotropic and Isotropic Conducting Adhesives.

For more details visit our web site
www.npl.co.uk/ei

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