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Microelectronics news

The recent progress of the WEEE and ROHS legislation has caused another upsurge of interest in many aspects of lead-free soldering worldwide. This renewed interest is reflected in the work covered by this issue. As far as the European legislation is concerned, on 19 December 2002 the European Parliament gave its expected consent to what had been agreed in final conciliation negotiations with the Council of Ministers in October 2002. The Directives will come into force on the day of publication (expected shortly), and national laws must be in place within eighteen months of that date.

Importantly for the electronics manufacturing industry, the ban on the use of lead (and other heavy metals and some flame retardants) will be effective from 1 July 2006. Additionally, it seems that a consensus is near on the definition of "lead-free". Although this is not mentioned in the WEEE/ROHS Directives, the sister EOLV (end-of-life vehicles) Directive defines 0.1% lead as the threshold for "lead-free", and it is likely that the same threshold will be used for WEEE/ROHS.

A New Look SSTC

Immediate Access

The new look Soldering Science and Technology Club (SSTC) now offers a wider range of services to industry. Key to the changes is combining its proven steady flow of existing information to practising engineers, with immediate access to new data. Members can download new reports as soon as they are published, and abstracts are available at www.npl.co.uk/ei/publications/.

As a leading forum since 1980 for the exchange of information and ideas amongst engineers in the electronics interconnection industry, the SSTC has been in the vanguard of disseminating practical information and acting as an independent source of research for the industry. This new facility provides an important added time benefit. But membership of the new SSTC also provides other advantages:

- 20% discount of SSTC meetings
- 20% discount on training workshops
- 10% discount on test work

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New CD

Recent and past work, far from being shelved, is now also given renewed emphasis. In support of the new SSTC initiatives, all the major NPL reports from 1996 to 2002 (nearly 50) have been brought together and condensed onto a single CD which is now available.

During the past six years the DTI has sponsored a number of key initiatives in the area of electronics interconnection, most notably three core programmes (each three years duration), and a series of shorter, focused (Studio) projects with high levels of industry participation providing rapid uptake and implementation. This CD, costing £99, includes nearly 50 reports from these projects which cover four main topics:

- lead-free soldering
- general soldering technologies
- printing and dispensing
- encapsulant degradation.

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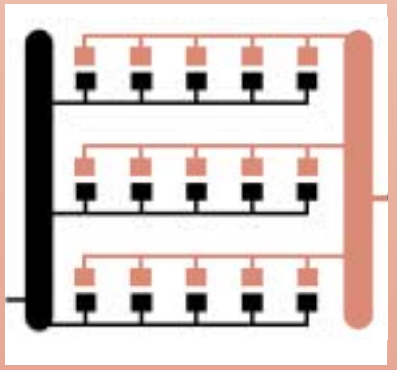
This issue



Recommended SIR test pattern for chip components.

National Physical Laboratory

Modelling Solder Joints

The ability to gather credible materials data on solder joints with geometries similar to those of current product, is clearer following collaborative work between Greenwich University and NPL. Such data are used in modelling for reliability prediction, and the novel ETMT (electro thermal mechanical test) method (based on shear) offers enormous potential in providing these materials data quickly and in a usable format – see Issue 14, July 2002 and Issue 5, July 1999. One of the issues in using this technique has now been resolved. The work has highlighted a need to understand and redefine the experimental arrangement. In particular, the solder creep data must be de-convolved to eliminate the significant contribution of the laminate. Further collaboration will examine the effects of bending and bowing of the laminate on the materials data sought.

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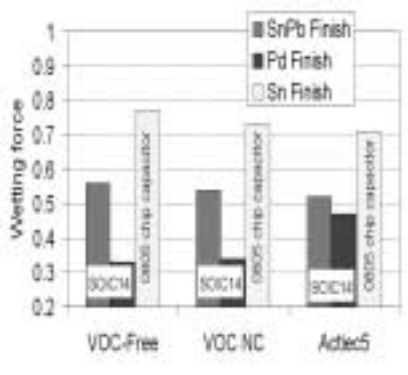

The variation of components' solderability with test flux type.

Realistic Solderability Testing with Lead-free Solders

Some recent work has given wider application to a conventional and trusted test. Historically, solderability testing has been based on using rosin fluxes, but in modern assembly technologies the levels of rosin have decreased remarkably. The resultant call for a new more realistic test using fluxes currently employed in the industry (e.g. no-clean) has now been successfully answered. New NPL work has explored the use of two new test fluxes based on weak organic acids, one solvent-based and one water-based (i.e. VOC-free). Encouragingly, the work demonstrates, that when formulated with an acid number 40-45, both flux systems:

- show maximum solderability for fresh components
- can discriminate fresh and aged components
- represent fluxes used in today's industry
- can clean the solder globule at elevated lead-free soldering temperatures

Crucially, therefore, these two new fluxes can be used with the existing test equipment and procedures in tests, which relate closely to current industry assembly practice. They can be used for testing both conventional lead-containing and new lead-free solders, with both SnPb and Sn finishes. Another key finding was that solderability is dependent not just on flux activity, but also on flux chemistry and interaction of the flux with the finish material. The new test is therefore ideal for discriminating between the performances of components with different finishes. Indeed, Pd, SnPb and Sn finishes displayed very different wetting characteristics.

The beneficial impact of nitrogen inerting with SnAgCu lead-free solder, especially in opening the narrow process window, was reconfirmed in this work.

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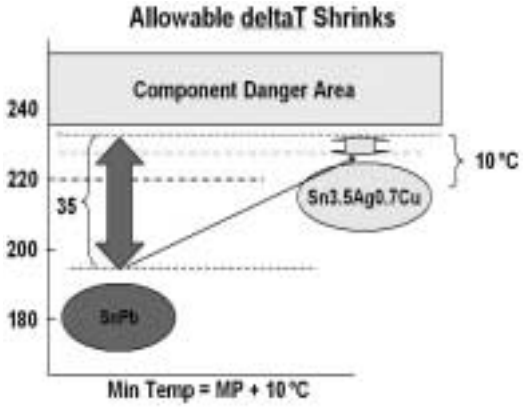

The narrowness of the processing window using lead-free solders as compared with that of SnPb.

Centre of Excellence for Lead-free

NPL is now offering an exciting and new four point service, geared to helping the industry in a very practical way, as it implements lead-free soldering technology:

- on-site "health checks" to identify the specific issues to be addressed
- secondments to NPL from industry to allow technology transfer in the most direct manner whilst providing focused staff development
- trouble-shooting, evaluations and training on site or at NPL
- general ad hoc help and advice

The service can be tailored to a company's particular needs. Importantly, the services are supported by a comprehensive and accessible information resource generated over the past decade in a series of DTI and industry-sponsored programmes (see page 1 this issue).

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SSTC Meeting Focuses on Lead-free

Lead-free soldering again provided the focus for the successful autumn SSTC meeting "***Achieving and monitoring lead-free product reliability and performance***". Six of the nine papers presented addressed aspects of lead-free soldering, most concentrating on predicting joint reliability, measuring reliability or assessing actual performance. Picking up the theme of lack of reliability data, Milos Dusek (NPL) speculated on what needs to be done in the time

constrained by legislation, and what will be achieved in current DTI projects. Elaine Bevan (TRW Automotive) explained the development work being undertaken at TRW to implement a lead-free strategy, against a background of automotive electronics increasingly being used in safety critical applications, especially for high reliability in harsh environments. Issues in developing a VOC-free liquid flux which is compatible with minimum defects and lead-free wave soldering, were discussed by Tim Lawrence (Loctite-Multicore). He demonstrated that water-based fluxes confer significant benefit in wave soldering. A piece of good news was delivered by Peter Starkey (Starkey Technical Services). He was confident that competent pcb fabricators will have no difficulty in producing fit-for-purpose bare boards for lead-free assembly. But a cautionary note was sounded – design authorities must understand what materials and processes are available, and clearly specify their requirements.

Away from main stream lead-free soldering presentations, Colin Smith (BAE Systems) gave an illuminating insight into failure analysis of electronic components and interconnection systems, and the additional problems posed by lead-free systems. Alan Brewin (NPL) reviewed the impact of CAF (conductive anodic filaments) susceptibility on the reliability of pcb substrates – see Issues 11 and 13 - highlighting their location, growth, detection, and prevention. The importance of validating soldering processes, and of using SIR (surface insulation resistance) techniques for the validation, were discussed by Alan Brewin (NPL) – the details of the test procedure and data interpretation are presented in an NPL report.

Electrolytic capacitor after lead-free soldering showing significant expansion in top and bottom of casing.

The proceedings of the entire meeting (@£50) are now available.

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Pitfalls to Lead-free Soldering

The worries over potential problems with lead-free soldering should be eased as a result of NPL work over the past several years. At the recent SSTC Autumn meeting (see elsewhere in this issue) Martin Wickham provided a very clear, but non-exhaustive, listing of the major areas of concern covering printing, reflow soldering, suitability of reflow ovens, component and substrate suitability, sensitivity of components, the effect of nitrogen inerting, visual, optical and X-ray inspection, rework, and cleaning.

The listing, which is included in the proceedings of the SSTC meeting, is the collation of evidence accumulated over a series of projects with significant participation by industry. It provides a useful guide to "do's and don'ts", or at least where to "be careful". As the drive to lead-free soldering gathers momentum, the industry is working to address many of these issues, and there was a clear indication of what has already been achieved by the components suppliers, designers and assemblers, with the tantalising addition of what the industry should be doing today.

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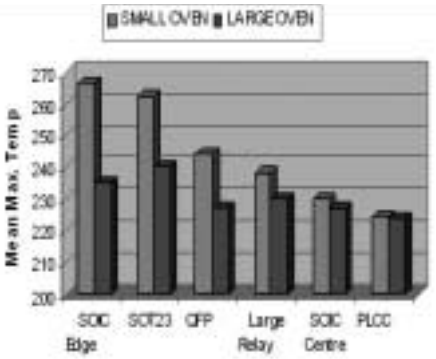

Mean max temperature experienced by components during reflow. In the small oven the smaller components will experience excessive temperatures.

NPL and TWI to collaborate on Conductive Adhesives

The potential of CAs in electronic assembly will be clarified as a result of a proposed collaboration sponsored by the DTI in its MPP (Measurements for the Processability and Performance of Materials) programme. The possibility of using CAs has long been touted, but except for niche applications, their up-take has been minimal. They are perceived by industry to have questionable reliability, a high cost relative to solder, and a low mechanical strength. Yet in times of change away from lead-containing solders, the constraints on recycling, and the emergence of new materials, interest in CAs is recurring. This proposed collaboration will explore both isotropic and anisotropic materials to:

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

The three-year project, due to begin in early 2003, offers the opportunity for wide industrial involvement. Two sister projects are already underway within the MPP programme: (i) measuring and modelling the materials properties impact on solder joint reliability, and (ii) characterisation tools for electronic assemblies – see Issue 14, July 2002.

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Successful Master Class Highlights Data Shortage

The audience at the latest NPL Master Class by world renowned speakers, were left in no doubt that a lack of data on solder joint reliability remains the single most important factor in the successful implementation of lead-free soldering technologies. In his day long presentation "Solder joint reliability; from tin-lead to lead-free assemblies", Jean-Paul Clech (EPSI Inc) provided a comprehensive review of modelling techniques and experimental data available. Such information is crucial to industry to help it face the challenges of embracing lead-free soldering. For example, he concluded that sufficient relevant reliability data for the lead-free solder front-runner, SnAgCu, were just not available. The generation of a credible reliability model was therefore not yet possible. However, data are emerging on several fronts e.g. regarding the effects of the thermal cycling range, component types and geometries on performance ranking, which should help the modelling approach.

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Design Guidelines Point The Way

How to establish and maintain low defect levels in solder paste printing is now clearer following the release of NPL's *Guidelines for ultra-fine pitch solder paste printing*. The results of a series of projects involving a number of industrial partners (inc. DEK UK, Loctite Multicore Solders, Kester Solders, Electro-Science Laboratories, Indium Corp) have been distilled into these practical guidelines. They demonstrate that in order to achieve quality printing for ultra-fine pitch (≤ 150 µm aperture opening) several aspects must be considered. For example

- thinner stencils achieve better paste release
- the aperture shape is less important than maximising the aperture open area
- for apertures ≤100 µm, electroformed stencils perform better than electropolished or laser cut stencils
- pastes with finer particle size achieve better packing densities for small aperture openings but may be prone to greater solder balling
- circular apertures give slightly better paste release than square apertures of the same open area
- minimum aperture openings are dictated by stencil thickness and manufacturing technology; aperture openings with diameters or widths smaller than stencil thickness are not recommended for any stencil technology
- practical limits for square and circular apertures are suggested

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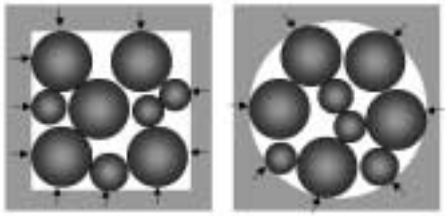
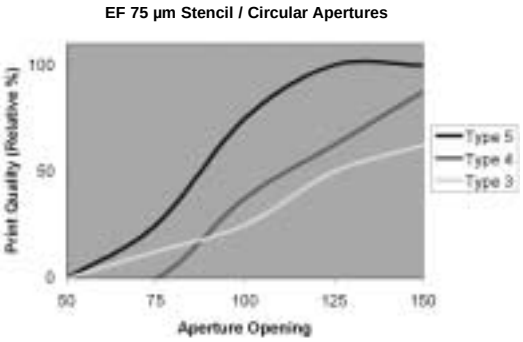
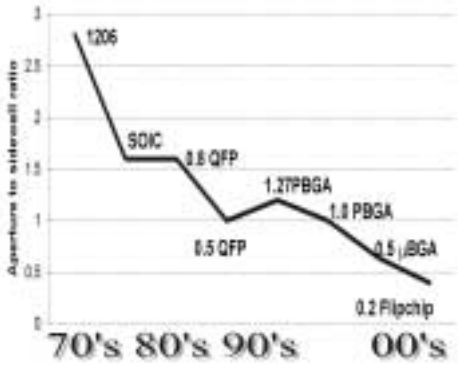


Comparison of particle edge touching in square and circular apertures (touching particles are marked).



Comparison of relative print quality for 75 µm electroformed stencil for three paste types.



Comparison of aperture area to sidewall area ratio for typical components.

- 75 µm is the practical minimum stencil thickness
- thinner stencils may not provide sufficient paste volume for larger pitch components

New NPL Reports Now Available

- Development of new solderability test fluxes
- Design guidelines for ultra-fine pitch solder paste printing
- Test procedure for process validation using surface insulation resistance
- A test procedure for measurement of solder volume on reliability.

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

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