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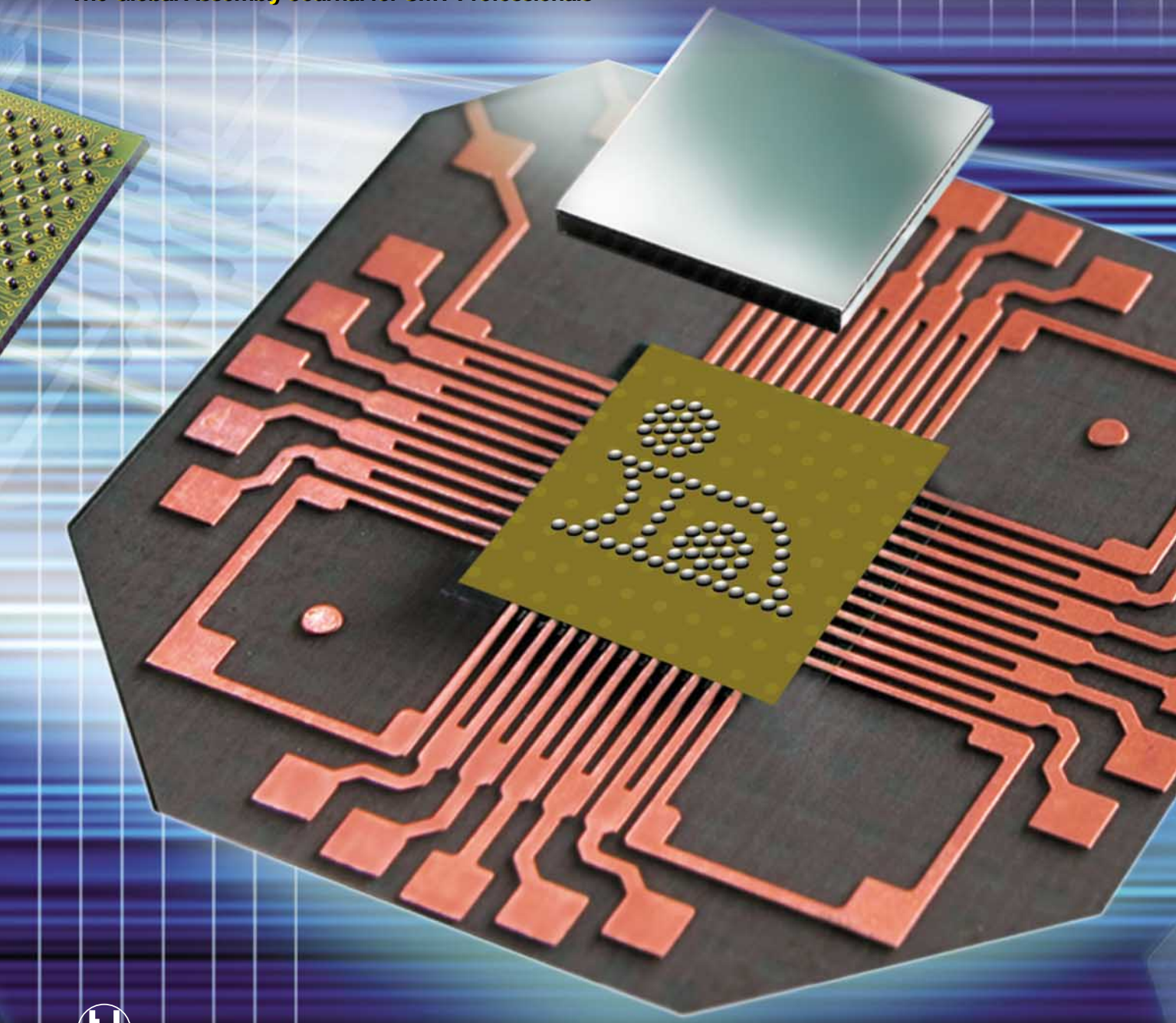

LEAD FREE SOLDERING AND THE IMPLICATIONS FOR BARCODE LABELS

Lead free soldering and the implications for barcode labels

Pb-free processes require higher temperatures than traditional eutectic solder. This impacts upon the thermal capability of any components used, including labels used for barcoding and traceability. This article explores the selection of Pb-free temperature profile capable labels, the various materials available, and the cost implications.

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Keywords:
Pb-free, lead free, labels, bar coding, traceability, high temperature materials.

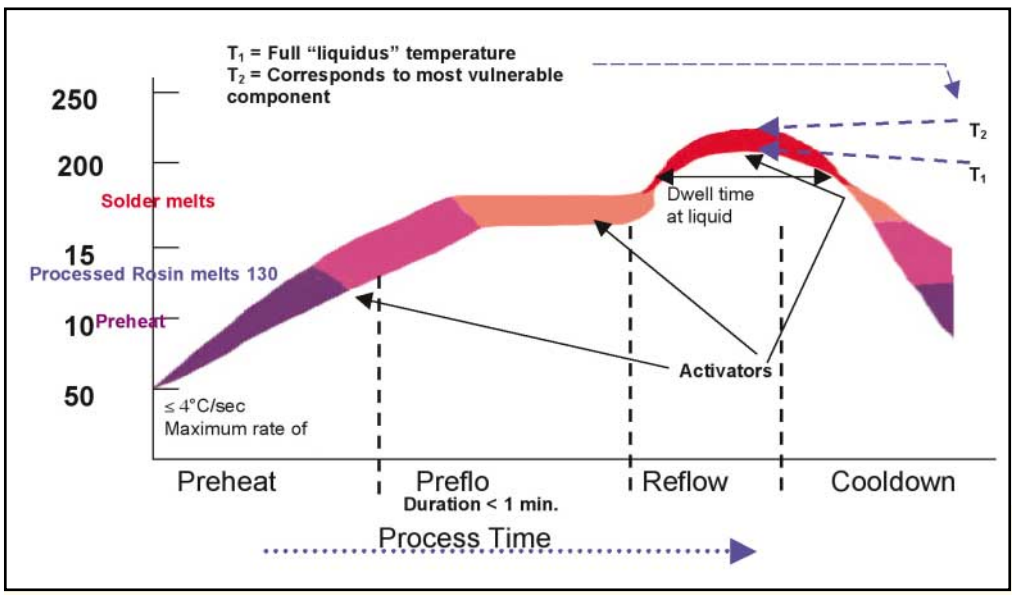

Figure 1. A typical reflow profile.

Introduction

Increasing worldwide interest for lead free soldering will bring about significant changes in the circuit board manufacturing environment. In response, the thermal environments encountered in manufacturing will change (because of the higher temperatures required for no-lead soldering), which will influence the saponifiers, cleaners, and fluxes used. These changes will influence process times and product throughput, as well as have effects on critical components. Barcode labels are now well established as indispensable components, which may also be affected by thermal changes in the PCB manufacturing process.

Even the polyimide you use today may have trouble tomorrow.

Current soldering processes

The current manufacturing processes for electronic products are well characterized and understood. Many blends of tin and lead are available to satisfy the many different process requirements experienced today. In this relatively stable process world, the cleaning processes and chemicals have been optimized to achieve Six Sigma performance in manufacturing reliability. Process temperatures used for soldering operations today range between one and 80 to 240 degrees centigrade.

The Environmental push for the 'greening of the globe' has given impetus to lead free soldering processes as the world economy exponentially consumes electronic products (which use solders containing lead).

Ultimately, this will lead to exponential growth in lead-containing solid waste streams, as new electronics obsolete older generations of equipment, and are subsequently discarded. However, the change to lead-free solder has major implications for the entire manufacturing process. The current commercial blends of tin, copper, bismuth, and antimony provide a liquid phase (molten solder) in the range between 260-280°C. These higher temperatures rise above the temperatures of the Most Vulnerable Component (MVC). The MVC is the highest temperature that the most sensitive component can withstand, without compromising performance.

Experimental quaternary mixtures of tin, bismuth, indium, and zinc, with liquid

phase ranges of 180-200°C are under development, but are still very expensive. Most significantly, the new oxides generated from these metals during the soldering operation are new, and difficult to clean, which causes concern for cleaning operations. *Figure 1* depicts a typical re-flow profile.

This depiction is meant to only portray the general characteristics of all profiles, rather than specifics of any particular thermal profile. The Y axis portrays operating temperatures in degrees C, while the X axis shows progress in relative process time (seconds to minutes), as the PCB moves through the manufacturing process, from pre-heat through pre-flow, re-flow, and into cool-down.

As the product moves into the range of temperatures for the preheat cycle, solder paste materials begin to melt. Rosins melt at about 130°C beginning in pre-flow. As the product moves from preheat into reflow, various chemical activators allowing for better 'wetting out' of the metal surfaces. Conventional solder starts to melt at about 180°C as the board moves into the reflow zones of the process. Temperature T1 signifies the lowest temperature required to achieve the full liquid (molten solder) state. Temperature T2 corresponds to the highest allowed temperature permitted for the most vulnerable component (MVC).

Figure 2 shows the effects of an approximate 30-50°C shift depicting the new temperatures required for lead (Pb) free soldering. The most significant thing to note is the upward temperature change required of the most convert vulnerable component, or the new critical T1and T2 points.

Now we come to the bar code label, which has come to be viewed as an important component also. As such, the bar code label carries information, which has high value.

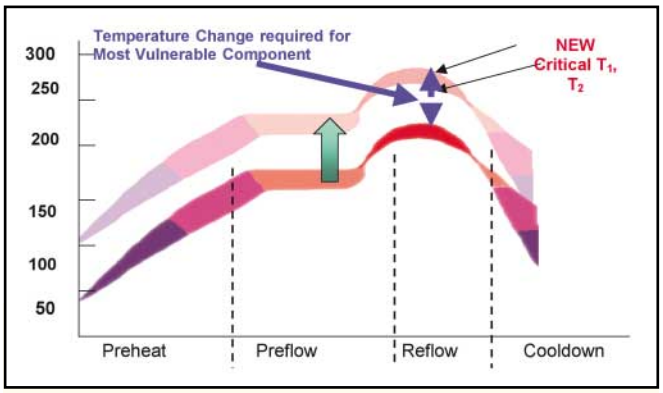

Figure 2. Shows the effects of an approximate 30-50°C shift depicting the new temperatures required for lead (Pb) free soldering.

That value may be mandated by the end-user customer; by the manufacturer's own internal inventory control needs (manage stocking levels, production planning); for process control purposes (to have real-time status reports on process conditions and product flow), and even have individual boards control their own process environment by means of the bar code information contained thereon. If the information is missing for any reason (unscannable, label falls off), then either the products do not comply with customer specifications, or the manufacturer does not gain the benefits of the bar code technology employed, or both. *Figure 3* shows what happens to labels, if they do not withstand the environmental thermal changes.
As shown in the *Figure 3*, the labels can discolor, curl, and may decompose, or fall off of the circuit board or component to which they are attached. *Figure 4* figure depicts the continuum of thermal performance for labels produced and used in PCB manufacturing today.

There is a correlation between price and performance; as the performance demands increase, so does the price. Although today a manufacturer might be using less expensive (hence less thermally resistant) labels quite satisfactorily, such

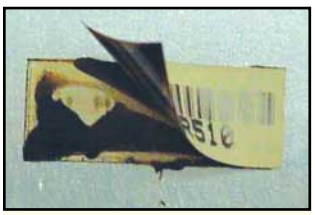

Figure 3. Photograph of polyimide label subjected to 300 °C for 50 min.

as a polyester or polyetherimide. As the process's thermal environments shift to higher temperatures, the 'cooler' spots become 'less cool'. Consequently, the manufacturer may have to change materials, with a subsequent increase in cost.

Surprisingly, even if a manufacturer is already using polyimide labels today it does not necessarily mean these labels will work in the new thermal environments. Polyimide labels vary in their thermal characteristics.

However, using polyimide labels today does not mean increase in cost upon switching to the newer generation of polyimide labels. These new materials, XF 581, 582, 583, and 584 are available today from Polyonics.

As the photograph shows *(Figure 5)* the Polyonics X F five '81 and '82 label's high temperature performance is better than another label's, because of the different polyimide materials, when the labels were exposed side-by-side at 600 °F (312°C) for 50 minutes.

There's a second aspect of the new lead-free initiative, in that the labels themselves clearly need to be 'lead-free, that is, they can contain no heavy metals such as lead or chromium. Moreover, the new labels cannot contain chlorinated or brominated materials, commonly used as flame retardant additives in many plastic and adhesive materials. As the processes change, all of the process variables must be re-evaluated, such as chemical cleaners, label materials and thermal transfer ribbons.

New working relationships will be necessary:

1. The label material suppliers will need to work closely with the chemical cleaning companies for testing the new cleaners as they evolve;
2. The label material suppliers will also need to work more closely than before with the ribbon

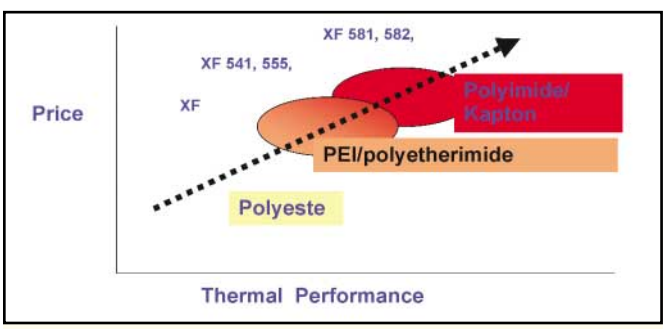

Figure 4. Thermal performance is correlates to material choices affecting price.

Figure 5. The thermal performance of Polymide materials may vary between different the brands available.

and printer companies, to ensure these products are compatible with the new requirements; and,

3. The end users (manufacturers, OEM's, and EMS providers) must be aware of the necessity of testing these label 'components' rather than assume that all polyimide labels are the same.

Actual field test results will help materials suppliers 'stay ahead of the curve' as they develop cost-effective, new generation labeling materials, needed as part of the global lead-free initiative.

Dr. James R. Williams is Chairman of Polyonics, and holds a Ph.D. in Polymer Chemistry and an MBA. He was the founder of Imtec, Inc, a well-known supplier of bar code printing systems for harsh environment labelling, before founding Polyonics 10 years ago, which also specializes in label materials for high temperature applications.

Dr. Williams participates widely in seminars and symposia on harsh environment and industrial labelling applications; harsh environment bar code systems, and more recently issues facing bar code technologies as the electronics industry endeavours to comply with RoHS and WEEE. Polyonics is headquartered in New Hampshire USA, with offices in Chicago, Salt Lake City, Singapore and Shanghai.
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Table 1. This heavy metals and lead-free table, derived from Polyonics' disclosure statement, provides a useful checklist for label purchasers.

Environment Related substance		Use/Not Use
Heavy Metals	Cadmium and cadmium compounds	Not used
	Lead and lead compounds	Not used
	Mercury and mercury compounds	Not used
	Hexavalent chromium compounds	Not used
Chlorinated Organic Compounds	Polychlorinated biphenyls (PCB)	Not used
	Polychlorinated naphthalenes (PCN)	Not used
	Chlorinated paraffins (CP)	Not used
	Mirex (Perchlordecone)	Not used
	Other chlorinated organic compounds	Not used
Brominated Organic Compounds	Tetrabromobisphenol-A-bis-(2, 3-dibromopropylether) (TBBP-A-bis)	Not used
	Polybrominated diphenylethers (PBDE)	Not used
	Polybrominated biphenyls (PBB)	Not used
	Compounds	Not used
	Other brominated organic compounds	Not used
Organic tin compounds (Tributyl tin compounds, Triphenyl tin compounds)		Not used
Asbestos		Not used
Azo compounds		Not used
Formaldehyde		Not used
Polyvinyl chloride (PVC) and PVC blends	Not used	