Lead-Free Implications for Barcode Labels

James Williams, PhD

Some polyimide labels may withstand the new thermal requirements for lead-free electronics manufacturing.

Increasing worldwide interest in 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 and will have an effect on critical components. Even barcode labels may also be affected by thermal changes in the printed circuit board (PCB) manufacturing process. The polyimide label you may be using today may have trouble with tomorrow's lead-free manufacturing.

Current Soldering Processes

The current manufacturing processes for electronics products are well characterized and understood. Many solder blends of tin and lead are available to satisfy the different process requirements experienced today. In this relatively stable process world, cleaning processes and chemicals have often been optimized to achieve Six Sigma performance in manufacturing reliability. Process temperatures used for soldering operations today range between 180 and 240°C.

The environmental push for the "greening" of the globe has given impetus to lead-free soldering processes as the world economy exponentially consumes electronics products containing solder with lead. Ultimately, as new electronics obsolete older generations of equipment that are, subsequently, discarded, an exponential growth in lead-containing solid waste streams will occur.

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 of 260 to 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 to 200°C, are under development but are 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 shows a typical reflow profile.

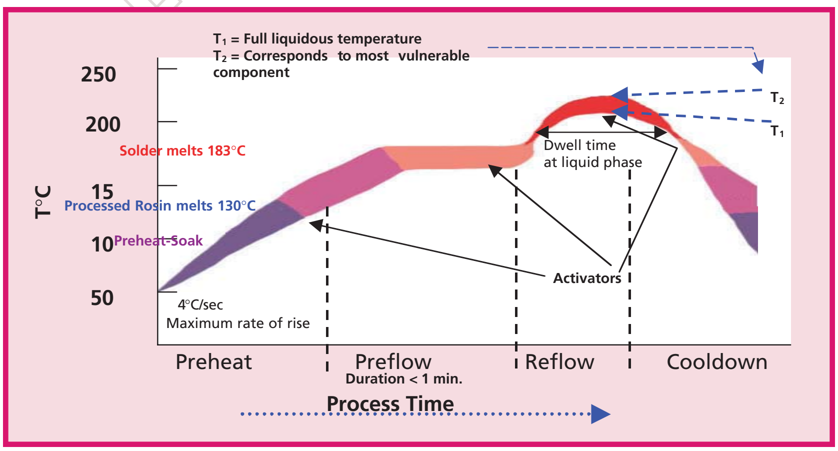

FIGURE 1: A typical reflow profile.

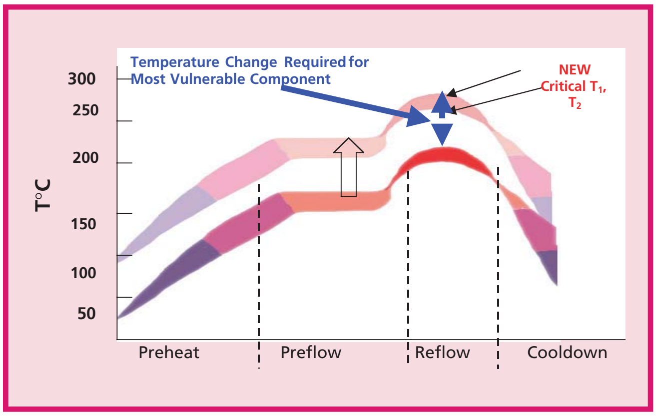

FIGURE 2: The new reflow profile required for lead-free manufacturing. Note the temperature change required for the MVC.

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 °C, while the x-axis shows progress in relative process time (seconds to minutes), as the PCB moves through the manufacturing process from preheat through preflow, reflow 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 preflow. As the product moves from preheat into reflow, various chemical activators allow 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 T_1 signifies the lowest temperature required to achieve the full liquid (molten solder) state. Temperature T_2 corresponds to the highest allowed temperature permitted for the MVC.

The next idealized profile shows the effects of an approximate 30 to 50°C shift, depicting the new temperatures required for lead-free soldering. The most significant thing to note is the upward temperature change required of the MVC, or the new critical T_1 and T_2 points (Figure 2).

Enter the Barcode Label

The barcode label, which has come to be viewed as an important component in electronics manufacturing, carries information that has high value. That value may be mandated by the end-user customer or by the manufacturer's own internal inventory control needs for managing stocking levels and production planning. Barcodes can be used for process control purposes to enable real-time status reports on process conditions and product flow. Barcode labels may even allow individual boards to control their own process environment by means of the information contained on them.

If the information is missing for any reason—it is unscannable or the label falls off, for example—then the products do not comply with customer specifications, the manufacturer does not gain the benefits of the barcode technology employed or both.

FIGURE 3: Polyimide label subjected to 300°C for 50 minutes.

Figure 3 shows a label that did not withstand an environmental thermal change. As can be seen, labels can discolor, curl, decompose and/or fall off of the circuit board or component to which they are attached.

Figure 4 depicts the continuum of thermal performance for labels produced and used in PCB manufacturing today.

A correlation does exist between price and performance—as the performance demands increase, so does the price. Although today's manufacturer might be using less expensive and, hence, less thermally resistant labels such as polyesters and polyetherimides satisfactorily, as the process' 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, as shown in Figure 5.

Polyimide labels are one cost-effective choice for manufacturers adapting to the new thermal environments of lead free. Surprisingly, though, all polyimide labels do not work in the new

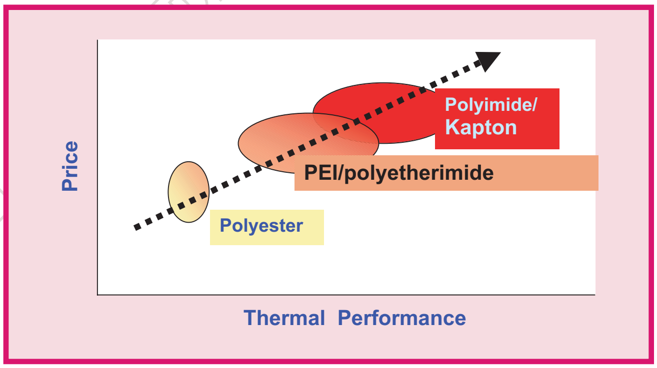

FIGURE 4: Thermal performance for labels used in PCB manufacturing currently.

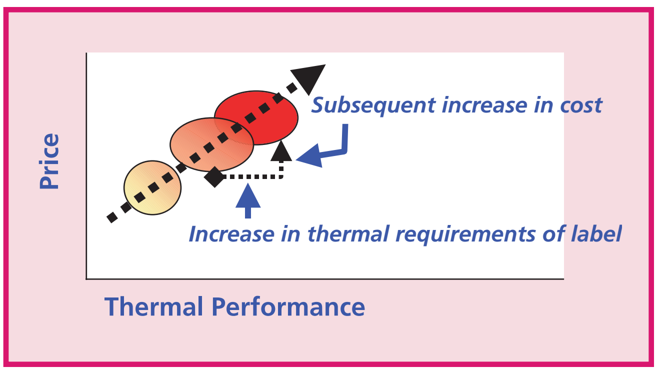

FIGURE 5: As thermal performance requirements increase for barcode labels, so does their price.

FIGURE 6: Two polyimide labels, exposed side-by-side at 600°F (312°C) for 50 minutes. The label at top performed satisfactorily, while the label at bottom became discolored.

thermal environment. Figure 6 shows two polyimide labels, exposed side-by-side at 600°F (312°C) for 50 minutes.

Another aspect to the new lead-free initiative is that the barcode labels themselves need to be clearly 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 manufacturing variables must be reevaluated, such as chemical cleaners, label materials and thermal transfer ribbons. New working relationships will be necessary, including:

- Label material suppliers will need to work closely with chemical cleaning companies for testing new cleaners as they evolve.
- Label material suppliers will also need to work more closely than before with ribbon and printer companies to ensure these products are compatible with the new requirements.
- The end users [original equipment manufacturers (OEMs) and electronics manufacturing services (EMS) providers] must be aware of the necessity of testing these label components rather than assuming 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.

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