CASE STUDY CORNER

NEW SERIES!

Screen Printing Partners

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An electronics assembler and its supplier eliminated tombstoning and solder balling associated with lead-free processes.

As the changeover to lead free enters the mainstream of electronics assembly, manufacturing businesses are coming to grips with the practicalities of volume production using the new solder alloys and component terminations. Many of the issues that challenged surface-mount assembly with tin-lead (SnPb) solders must be solved once more to enable lead-free solder joints to achieve comparable end-of-line yield, electrical performance and reliability.

As an example, DELTEC Automotive GmbH of Germany switched to lead free in 2001. Working with its engineering division, as well as with DEK International process specialists, DELTEC Automotive learned some important lessons about board and stencil design, solder alloy selection and reflow.

Keeping Ahead of Legislation

DELTEC Automotive has manufacturing plants in Germany and the Czech Republic and supplies assemblies such as door control equipment and ignition electronics to German car brands. Besides the automotive sector, the company also produces high reliability assemblies for industrial application. These include explosion-proof electronic switching gear for oilrigs and general petrochemical applications, as well as consumer electronics products.

As a player in the German automotive electronics market, the company is certified to VDA 6.1 (Verband der Automobilindustrie e.V), the German automotive quality standard similar to QS-9000, as well as ISO 9001:2000. The company is also in the process of meeting the new ISO/TS 16949:2002 quality standard that major carmakers are planning to adopt within the next three years.

At its plant in Eastern Bavaria, DELTEC operates four double-sided surface-mount production lines. Driven by the impending European legislation on lead-free electronic assembly such as the WEEE Directive, and the demands of its customers to lead the industry transition to lead free, DELTEC introduced its first lead-free processes in six weeks during 2001.

Tombstoning Attempts a Comeback

DELTEC's lead-free project achieved success during this timeframe, but tombstoning and solder balling remained stubbornly persistent. These phenomena are rare with lead-based solders but may enjoy a brief renaissance as lead free enters volume production. The problem was most acute with passive 0402 components. After investigating all the potential causes, DELTEC focused its attention on the stencil.

Determined by DEK, the most effective approach to solving this problem was, first, systematically checking the placement, the paste, the printer and the paste stencil. The next step was to test the oven and the reflow profile. The focus, initially, was on images of the loaded board, as well as the Gerber data of the copper layer, the solder resist and the paste pattern. Immediately noticeable was that the Gerber data implied identical pad sizes at the copper, solder resist and paste layers. Clearly, the paste layer needed modification, including optimizing the shape and size of paste deposits to suit the components and the copper layer. After discussion, the two companies changed the pad layout to comply with design rules that DEK suggested.

Welcome to Case Study Corner, a new series of articles *Circuits Assembly*'s readers have requested! This series features a technology problem solved by the collaboration of an electronics assembler and its supplier.

If you have solved a technical challenge with your customer or supplier, contact Editor-in-Chief Lisa Hamburg Bastin at lhbastin@upmediagroup.com for more information about highlighting your story. We're looking for articles on successfully implementing lead free, reflow profiling, reworking micro components, placing today's smallest components and choosing the right test/inspection strategy for your application.

PHOTO: After tombstoning and solder balling became problematic with their lead-free process, DELTEC engineers focused their attention on the stencil.

As a first pass at resolving the problems, changing the pad layout significantly reduced bead formation by decreasing the volume of paste deposited. Tombstoning was also reduced. At the end of line, this first stencil revision resulted in a 50% reduction in the number of defects. However, at some metal electrode leadless face (MELF) sites, now too little paste ensured adequate adhesion during placement. This outcome occurred because the automatic placement machine in use at DELTEC Automotive moves the board beneath a fixed placement head. As a result, placement tolerance values are in the order of ± 0.07 mm.

Further Enhancement

In the next phase, DEK recut the stencil apertures for the MELF pads in question by laser. By adjusting the paste volume at specific sites in this way, adequate adhesion between the component and the deposited paste was ensured, regardless of placement variations. Although this modified stencil delivered significant improvement, the objective had still not yet been achieved in full. For example, excessive paste volume was still present on the pads of particular components despite reduction of the paste layer. Pattern displacement was also observed over the entire multiple pattern area.

To gain a deeper understanding, DELTEC produced an original blank board. All the pads could then be measured and the results could be compared with the original copper layer data. A reduction from the solder mask to the copper layer of approximately 70 µm was found that was not contained in the original data. As a result, most of the apertures in the early stencil designs had been cut to the same size as the copper pads. In some cases they were larger such as with the 0402 components. With this mismatch between aperture and pad, the volume of paste applied would always have been too high.

Following discussion with DELTEC, DEK redesigned the copper and paste layer on the printed wiring board (PWB). In addition, reducing the thickness of the paste deposit from 150 µm to 125 µm helped to further reduce the volume of paste applied. Next, DEK investigated the possible displacement with a complete PWB set and followed this investigation up with a series of tests using two different pastes. DEK then sent accurate photos of the prints to DELTEC for evaluation. In this context, DELTEC checked the pattern tolerances with the manufacturer of the boards and was surprised to learn of deviations of ±100 µm!

For further improvements, DELTEC focused on assessing various paste formulations and reflow profiles. On its paste optimization process, the company discussed its needs with a number of paste suppliers. A high-melting lead-free paste was important as the component group on which it was used is required to reliably withstand relatively high temperatures in the vehicle over the longer term.

Further work on the placement process resolved some remaining adhesion problems with a number of large MELFs. With the second DEK stencil subsequently sent to DELTEC, specific MELF pads had once again been recut to prevent this. Following the paste printing, placement and reflow processes, cooling the assembly from 250°C down to 100°C required a temperature gradient of 1 to 1.5°C/sec.

Technology Partners

The technology partnership between the two companies helped DELTEC to solve lead-free soldering issues such as tombstoning and solder balling. As a result, the company is now manufacturing 50% of all its subassemblies with lead-free solder. The process is successful with components down to a size of 0201, as well as advanced packages like micro-ball grid arrays (microBGAs) and flip chips. Typical pitch rasters on the boards are in the fine-pitch zone of 0.5 mm. ■

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