Lead-Free Soldering Processes in the Electronic Industry - Extended Abstract:

Following the implementation of the new European environmental directives, Restriction of the Use of Certain Hazardous Substances (RoHS) and Waste Electrical and Electronic Equipment (WEEE), which involve the ban of lead from electrical and electronic products, this work presents process development, production and reliability testing of real products from electric and electronic European industrial assemblers using commercial lead-free solders. This work aims to help the implementation of the lead-free soldering processes at SME assemblers to assess the reliability of their products and processes.

The work carried out comprised different types of reliability tests, on boards produced by reflow and wave soldering, as high and low temperature storage, thermal cycling, thermal shock, vibration and shear testing; functionality tests; characterisation of the boards using visual inspection by optical and electronic microscopy.

Fig. 1 – Example of industrial electronic board.

The benchmarking of the process using PPM (Part Per Million) concept has been carried out in order to increase the process performance. Some defects like solder balls, bridging, incomplete barrel fill, voiding and blistering were found in the visual inspection before the reliability tests. After the reliability tests the following was observed:

- Most of the boards have passed the functionality tests without major defects after the low temperature storage, thermal shock and vibration tests.
- In the high temperature storage half of the tin/lead and about one third of the lead-free boards did not passed the functionality tests, mainly due to component failure.
- In the thermal cycling test more than 59% of the tin/lead and 49% of the lead-free boards did not passed the functionality tests, showing component damaging, joint degradation, pad lifting and cracks near the pads.

Fig. 2 - Defects found on the boards in study. a) Fillet tearing defect found in board with Sn/Cu/Ni (arrow); thermal cycling (3000 cycles; 0ºC to 100ºC). b) Optical micrograph of one sample: 96Sn/3.0Ag/0.7Cu; thermal cycling (3000 cycles; 0ºC to 100ºC) (100X). Crack propagation near the pad (arrow).

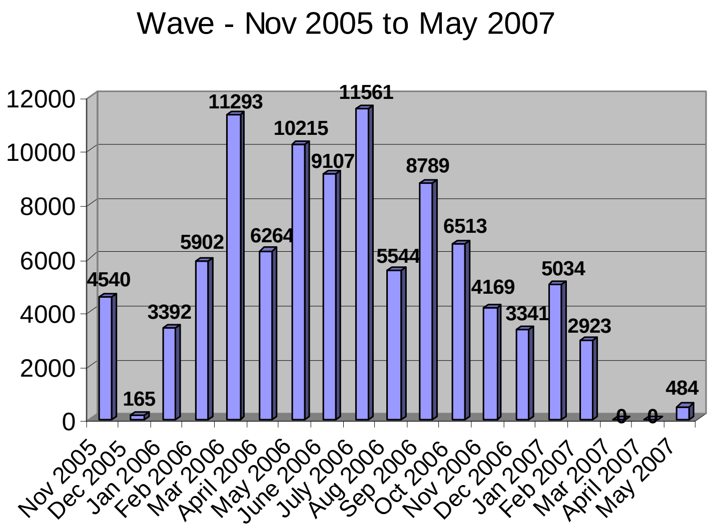

Fig.3 - Wave average PPM defect levels from both lead and lead-free companies.

This thesis also presents a defect level benchmarking for lead and lead-free soldering processes, this study of the level of the defects in the companies was compiled and plotted, allowing the companies to use it as tool to compare and evaluate the difficulties found by each of them during the transition to lead-free. Some economical facts are discussed in order to provide some recommendations as best practice lines for lead-free implementation in SMEs production.

In conclusion no major difficulties were found in the lead-free boards produced. Nevertheless, the wave soldering process showed some more complexity and defects. In terms of soldering paste performance all of them showed equal results.

The defects and abnormalities found (voiding and pad lifting) usually results from the lack of pre-heating and inadequate thermal profiling in the assembly process. After the reliability tests most of the boards have survived except the thermal cycle ones, which is the harshest test. The SMD (surface mount devices) showed less degradation than the through-hole components, this can be due to assembly process conditions and to expected performance of the through-hole joints under testing. The cracks found in the through-hole joints are always away from the interface and follows an intergranular fracture mode. The cracks did not propagate very far in the joint neither through the intermetallic layer, thus, indicating a good connection between materials, strong intermetallics, in both tin/lead and lead-free solders, and it should not compromise the integrity and functionality of the product.

The SMEs are engaged in taking this opportunity to reach a higher quality level in lead-free electric and electronic interconnections. Some of the companies embraced this “forced” transition to upgrade and improve their facilities, bringing better capabilities and opportunities in their businesses. This is reflected in the quality of the results obtained.

The objective of this work is to contribute to increase the knowledge of lead-free soldering processes applied to SMEs production and to act as a tool of information for the SMEs of the electrical and electronic sector, in order to help them in the transition to lead-free soldering.