Further study needed on backward compatibility

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At APEX in February, I was honored with the IPC President's Award for 'numerous contributions to IPC technical conferences, standards and testing programs.' It was great to see so many friends in Anaheim and to learn from so many industry colleagues at the conference. There was great excitement on the show floor as well. As I was quoted as saying in the IPC Press Release, "APEX 2006 was a huge success. It gets better every year and shows the hard work that goes into it."

One of the intriguing topics under discussion in the industry is 'backward compatibility'. The industry is moving towards the elimination of Pb, using SAC alloys for the BGA/CSP balls. However, Sn-Pb soldering still exists during the transition period and beyond, as several product categories may take advantage of the exemptions. The compatibility of SAC CSP and BGA with the Sn-Pb soldering process is very much questionable. This is primarily due to the fact that the SAC alloy (melting temperature 217°ΔC) will not always completely melt during reflow with the Sn-Pb solder, typically at reflow peak temperatures between 205-225°C. As such, there will be little or no self-alignment, which is critical especially for finer pitch area array packages. Coplanarity issues further aggravate the situation due to the lack of collapse. Further, as the contribution of solder balls to the solder joint material is very high (typically 70% to 80%), if very little mixing takes place, leading to grossly segregated microstructures, solder joint metallurgical uniformity and reliability become matters of concern. Poor interfacial bonding and increased voids are some of the other issues which have been observed leading to poor solder interconnect reliability, which, in combination with the process issues, render the SAC area array packages 'incompatible'with the Sn-Pb soldering process.

Based on these considerations, iNEMI has called for "continued availability of Sn-Pb compatible components for exempted products". Companies that manufacture high-reliability, long-service life systems must be assured of the availability of components that are compatible with Sn-Pb assembly, not only to provide continued quality and performance in new products but to maintain products already in use". Pb-free BGAs are designed to be assembled with SAC solder paste, not Sn-Pb solder paste. We need a continued supply of Sn-Pb ball BGAs. We cannot take Pb-free BGAs and attach them to boards using Sn-Pb solder with today's typical assembly process. Industry experience has shown that doing so can produce lower assembly yields and less reliable interconnects."

Although Pb-free area array packages assembled with Sn-Pb solder paste are not recommended, such assemblies will continue to exist for some time. Efforts have been on-going in the industry to investigate what process conditions are needed in order to minimize the risk. Our recent study has shown that the solder paste amount and the reflow temperature play critical roles in the mixed alloy assembly, both in terms of compositional homogeneity and voiding. During reflow, when the temperature reaches 183°C and above, the eutectic Sn-Pb solder paste melts and is in the liquid state. The Sn-Pb liquid dissolves some solder (Sn) from the SAC ball until the equilibrium concentration is reached. More Sn-Pb solder paste dissolves more Sn from the SAC ball at the same temperature, and the dissolution increases as the temperature increases. This suggests that the mass of the Sn-Pb solder relative to the mass of the SAC ball, as well as the temperature, determines the degree of dissolution and mixing. Homogeneous solder joints were seen at various reflow temperatures ranging from 210°C to 230°C, depending on the Sn percentage in the mixed solder alloy. Samples with higher Sn content and reflow temperatures appeared to exhibit smaller and more finely dispersed Pb-rich phases than samples with lower Sn content and reflow temperatures.

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The complete mixing of Sn-Pb solder with the SAC ball is critical to forming uniform and homogeneous microstructures.

For area array packages, the reliability of such an interconnect is generally considered to be no more inferior than one using the Sn-Pb solder paste and Sn-Pb balls. The questions still remain: How should we characterize the degree of homogeneity? What degree of homogeneity is needed for reliability? Is this different for different loading conditions (for example, thermomechanical vs. dynamic mechanical)?

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