Lead-Free Solders and Processing Issues in Microelectronics

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Recent legislation in the European Union (EU) is expected to result in a full transition to lead-free soldering technology in the near future. Waste Electrical and Electronic Equipment (WEEE) and Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directives became European law on February 13, 2003, and the member states now have 18 months from this date to implement them.[1] The WEEE directive seeks to increase recycling and recovery of waste equipment, while RoHS bans lead, mercury, cadmium, chromium (VI), polybrominated biphenyls, and polybrominated diphenyl ethers by January 7, 2006.[2] Although there are a few exemptions, the bulk of electronic products are affected by the lead ban in RoHS. Accordingly, R&D activities will have to be intensified to meet the deadline set by the EU directives and the pressure from environmentally conscious consumers. To address questions on lead-free solders and soldering technologies, TMS has been active over the last several years in organizing a series of symposia on lead-free and lead-bearing solders at its annual and fall meetings and publishing their results.[3–7]

At the 2003 TMS Annual Meeting in San Diego, California, a technical symposium on "Pb-Free Solders and Processing Issues Relevant to Microelectronic Packaging" (organized by J. Lucas, S. Chada, S. Kang, C. Kao, K. Lin, J. Ready, and J. Yu), sponsored by the Electronic Packaging and Interconnection Materials Committee of EMPMD, was another successful forum for presenting and discussing recent findings on various aspects of lead-free solders R&D. Over 50 papers were presented dealing with fundamental studies, microstructure, alloy development, interfacial reactions, mechanical properties, physical metallurgy, solder joint reliability of lead-free solders, and solder joints. One unique trend of this symposium was a major emphasis on the leading lead-free candidates, namely, Sn-Ag-Cu alloy systems, and their use in microelectronic soldering. Of the papers presented, four were chosen for this issue of *JOM* to provide an update on the issues, especially on the characterization of mechanical properties, solidification behavior, and intermetallics.

The first paper by P. Vianco et al. (Sandia National Laboratory) discusses the mechanical properties of Sn-Ag-Cu solders as a function of copper content. Compression stress-strain tests are performed to measure the yield stress of the solders as a function of test temperature and strain rate. The microstructure of as-cast and annealed alloys are correlated with the mechanical behavior of the Sn-Ag-Cu solders.

The second paper by F. Ochoa et al. (Arizona State University) describes the mechanical behavior and microstructure of bulk Sn-3.5Ag solders as a function of cooling rate in solidification. Cooling rate is found to significantly affect the tin dendrite microstructure as well as Ag_3Sn aspect ratio. Creep deformation of the solders solidified at a different rate is also reported in terms of the creep stress exponent and the solder microstructure.

The third paper by S. Kang et al. (IBM) reports on the formation of large Ag_3Sn plates in the solidification of near-ternary eutectic Sn-Ag-Cu solder joints and their effects on the mechanical behavior and implications on reliability. It is also demonstrated that the Ag_3Sn plate formation can be controlled kinetically by utilizing elevated cooling rates or suppressed thermodynamically by using reduced silver and/or copper compositions.

The last paper by R. Chromik et al. (Lehigh University) discusses the characterization of mechanical properties of tin-based intermetallics commonly found in lead-free solder joints. Nanoindentation techniques are employed to measure elastic and plastic behavior of many intermetallics, such as Ag_3Sn, Cu_6Sn_5, Ni_3Sn_4, and $AuSn_4$.

The remaining papers presented at the 2003 TMS Annual Meeting will be published in the *Journal of Electronic Materials* later this year as a special issue on lead-free solders.

References

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