PL-5
THERMODYNAMIC PROPERTIES AND PHASE EQUILIBRIA OF ALLOY SYSTEMS RELEVANT FOR LEAD-FREE SOLDERING

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According to the RoHS[1] and WEEE[2] Directives of the European Union, most electrical and electronic equipment sold in the European Union after July 1, 2006, will have to be free of a number of toxic elements, among them also lead. Since lead has been a main component in the traditional tin-lead solders for a long time, new lead-free solder materials have to be developed, and their properties should at least be comparable to those of the traditional materials: they should have similar melting temperatures, adequate chemical, physical, and mechanical properties, and, of course, they must not be toxic. But it is not only the solder material itself but also the solder joints obtained with various contact materials like copper, nickel, gold, palladium, and others, that need attention because they are eventually responsible for the quality and reliability of the final product.

Most manufacturers rely currently on tin-rich Sn-Ag or Sn-Ag-Cu alloys for lead-free soldering. However, due to the rather high melting temperatures of eutectic Sn-Ag (221°C) or Sn-Ag-Cu (217°C) compared to eutectic Sn-Pb (183°C), other alloy systems are under consideration: Sn-Ag-In, Sn-Zn based alloys, but also Sn-Bi based alloy systems.

The European COST Action 531 on "Lead-free Solder Materials" brings together scientist from 22 European countries, and one of the several goals of this joint research action is the development of a Thermodynamic Database. This Database will contain the thermodynamic parameters for all binary systems and the relevant ternary systems consisting of the elements Ag, Au, Bi, Cu, In, Ni(P), Pb, Pd, Sb, Sn, and Zn, and with these parameters it will be possible, based on the so-called CALPHAD approach, to calculate their thermodynamic properties and the corresponding phase diagrams using any commercially available software.

Of course, in order to optimize the parameters in the Database, the CALPHAD method needs reliable experimental data, both for thermodynamic properties and phase equilibria. Therefore one Working Group in COST 531 is responsible for providing the necessary experimental data. A number of examples will be given of the measurement of integral and partial thermodynamic properties as well as of phase equilibria in various relevant ternary and even quaternary systems, for example, describing the interaction of Sn-Ag-Cu solders with Ni substrates or of Sn-Ag-In solders with Pd substrates.

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[1] RoHS-Directive 2002/95/EC, Official Journal of the European Union 37 (2003) p.19-23
[2] WEEE-Directive 2002/96/EC, Official Journal of the European Union 37 (2003) p.24-38