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The Stability of Cu_6Sn_5 in the Formation and Performance of Lead-free Solder Joints

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It is generally recognized that the intermetallic that forms at the interface between a high tin solder and a copper substrate plays a significant role in determining the properties of a solder joint and its long term reliability. This is particularly the case with the very small joint volumes in microelectronics A distinguishing feature of lead-free solders is that the Cu_6Sn_5 is also a component of the bulk solder and can occur as a primary phase in hypoeutectic compositions or as a constituent of pseudobinary or ternary eutectic phases. It has recently been determined that the long-recognized transformation of this intermetallic from a close packed hexagonal to a monoclinic crystal form can be a real phenomenon in soldering processes but the kinetics of the transformation under non-equilibrium conditions have not been known. In the experiments reported in this paper the Cu_6Sn_5 was subject to a regime of cooling at rates and isothermal ageing similar to those experienced in practical electronic assembly and the resulting phases identified. On the basis of this data it has been possible to generate a first approximation of a diagram that makes it possible to predict the form in which the Cu_6Sn_5 will occur in solder joints. The instability arising from this transformation provides a case for the use of a nickel addition that has been shown to stabilize permanently the hexagonal form of the Cu_6Sn_5.