Feasibility Project

Design tools for the manufacture and implementation (DfM) of Pb-free solder joints: Materials Modelling Challenges

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Electronics products are complex assemblies of components and circuit boards. These components are joined to the circuit boards by solders which connect a metal pad on the circuit board (metallisation) with the metal leads of the components. These solders have traditionally been alloys of a mixture of tin and lead. In July 2006 the European Commission banned the use of lead, and therefore new lead free solders are being used. These new materials are not well understood and behave differently to the tin-lead materials during manufacturing and during their service life. This project hopes to create an understanding of how these materials behave by modelling interactions between the solders and the substrate materials. These interactions include the formation of interfacial compounds, called intermetallics, which can help wetting, but are often brittle and may ultimately result in the failure of the solder joint. The size, shape and distribution of these intermetallics are extremely important, but are difficult to predict. The difficulty mainly comes from the complex interface evolution as a result of nucleation, grain growth and grain coarsening. This study will use a phase-field (PF) method, which is seen as one of the most powerful modeling techniques, to simulate the formation and growth of intermetallics during soldering processes. Such a model will be useful to the electronics manufacturing industry in complying with environmental legislation, whilst ensuring the integrity of their products.

Despite the rapid progress of the PF simulation technique in recent years, simulating the behaviour of intermetallics on a metallisation/solder interface is not easy. Take the commonly used Cu/Sn interface as an example - at least two different kinds of intermetallics have been observed. Taking into consideration the copper phase and the liquid phase, very rapidly this becomes a significant multi-phase phenomenon involving at least three reactions. Moreover, each of the phases is a cluster of multiple grains. These grains and grain boundaries must be fully modelled in a PF simulation because short circuit diffusion along grain boundaries is known to play an important role in growth of intermetallics.

The development of a multiphase, multicomponent PF model involving diffusional interactions is therefore a challenging task, and will also challenge even today’s computer power. Therefore, in order to overcome these difficulties, new PF simulation techniques will be employed in this work and combined together in one code for the first time. It will also be important to obtain accurate material parameters such as interfacial energies and mobilities, and diffusion coefficients, either through collaboration or direct measurement.

Predictions concerning the size, distribution and shape of intermetallics, in addition to the effects of processing parameters, will provide basic underpinning information in order to provide design tools for the manufacture and implementation of Pb-free solder joints.