Nanoparticle Stabilized Solder Materials for High Reliability Applications

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Nanoparticle additions to solder materials have been demonstrated to result in increased reliability of solder joints [1]. Increased reliability is of especial interest to the automotive, aerospace and oil and gas drilling industry as the electronics are required to withstand elevated temperatures for extended periods. Fatigue failure in the solder joints is a serious problem in these harsh environments. Hardening the solder with the addition of nanoparticles and stabilizing the grain structure should result in increased reliability, which may also be of interest to other manufacturers in niche high reliability markets, such as medical equipment manufacturers.

Two types of nanoparticles have typically been used to modify the solder. The first type of particle is composed of reactive, solder wettable elements such as Ni [2] or Ag [3]. However the drawback is that these will eventually react with the solder, especially at elevated temperatures, and solder stability will not be achieved. The second type of particle is composed of stable unreactive materials such as TiO_2 [4] or 'POSS' [5] which are stable even at elevated temperatures. However, dispersing the particles in the solder is a difficult problem, as they are typically not solder wettable. In the IeMRC funded study at KCL, we have used a third type of particle consisting of an inert core and solder wettable shell. We are using silica as the core and noble metals such as Au, Ag and Pd as the shell. However, dispersing the particles in the solder has proven to be difficult, with the majority of particles still expelled from the solder, and parameters such as the solder reflow profile, coating material and thickness all play a part, which are being quantified and modelled.

The interactions between the nanoparticles and the solder are also being investigated, together with appropriate production routes and the impact of the added particles on all aspects of solder technology. These include the impact of the nanoparticles on printability, reflow characteristics and on the flux residues which will inevitably contain some of the added particles. Building on the understanding of the nanoparticle-solder interactions at all stages of the soldering process, it will be possible to identify optimum core-shell particles, particle production routes and soldering parameters that will allow enhanced reliability joints.

The project partners include Henkel, Sondex and NPL. Henkel Corp. are manufacturers of the Multicore® brand of solders, and their main solder paste research group is based in Hemel Hempstead, UK. Henkel have proven to be an invaluable research partner, supplying pastes, solder powders and fluxes, and most importantly expertise to the original feasibility study. Sondex Ltd. are manufacturers of oil and gas drilling equipment, based in Hampshire, UK, and have a particular interest in reliable electronics for high temperature applications. Sondex will use the nanoparticle enhanced solder pastes on their assembly line and evaluate their performance. NPL, based in Teddington, UK, are experts in all aspects of soldering technology and are expected to play an important role in characterisation of the flux residues, and in characterizing the thermo-mechanical fatigue behaviour of the solders. In addition, NPL will help to disseminate the results of the project to the wider electronics manufacturing community through the activities of the SSTC.

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