Synthesis and Characterization of the Lead-Free Solders with Sn-3.5Ag-xCu (x = 0.2, 0.5, 1.0) Alloy Nanoparticles by Chemical Reduction Method

Li-Yin Hsiao, Jenq-Gong Duh*,
Department of Material Science and Engineering
National Tsing Hua University
Hsin-Chu, Taiwan 300, R.O.C.

Solders provide the electrical and mechanical connections between the silicon die and the bonding pad in electronic packaging, and the material selections for solder alloys are thus critical. SnPb-based solder alloys are the most common materials in electronic industry. However, due to the concern of human health and natural environment, the investigation of alternative Pb-free solder is necessary. Near-eutectic SnAgCu alloys are being developed to be used as the lead-free solder.

The lead-free solders with Sn-3.5Ag-xCu (x = 0.2, 0.5, 1.0) nanoparticles were synthesized by chemical precipitation with $NaBH_4$ in this study. The nanopowders were prepared by the precursor reacting with $NaBH_4$ in aqueous solutions. A solution of the appropriate metal-precursors was rapidly added to a $NaBH_4$/NaOH solution under strong stirring. After mixing these two solutions, black precipitates were immediately observed, which were washed with distilled water and then dried at room temperature. The structures of the particles were characterized by X-ray diffraction (XRD), as shown in Fig.1. The XRD patterns reveal that the Ag_3Sn was formed due to the alloying process. From the XRD patterns shown in Fig. 1(c), Cu_6Sn_5 was only formed when Cu concentration was as high as 1.0 wt% in the derived nanopowders. The formation of Ag_3Sn and Cu_6Sn_5 gives strong evidence that the nanoparticles were mixed homogeneously. FE-SEM morphology of Sn3.5Ag0.2Cu nanoparticles is presented in Fig. 2. It indicates that the particle size of Sn3.5Ag0.2Cu nanoparticles is majority in the range of 40 nm. From the DSC profile in Fig. 3, the Sn3.5Ag0.2Cu nanoparticles derived by chemical reduction method could be melted successfully. In the wettability test, good metallurgical bonding was revealed between solders and substrates after reflow. Thus, the nanoparticles derived by chemical reduction method in this study can be used as an appropriate solder powders in electronic packaging.

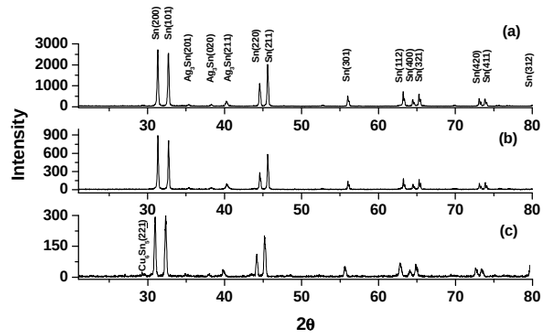

Fig. 1. XRD patterns of derived powders: (a) Sn3.5Ag0.2Cu, (b) Sn3.5Ag0.5Cu, and (c) Sn3.5Ag1.0Cu.

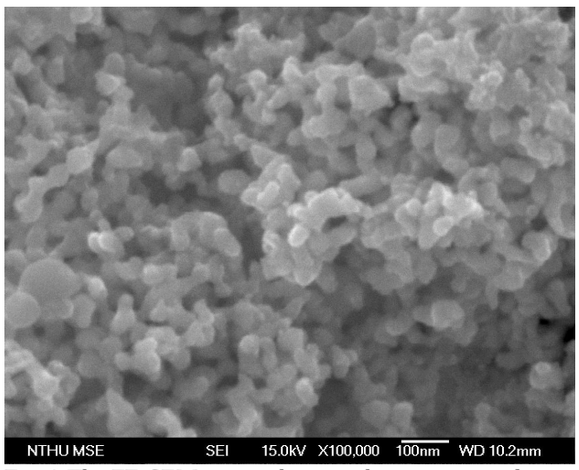

Fig. 2 The FE-SEM image showing the structure and morphology of Sn3.5Ag0.2Cu nanoparticles.

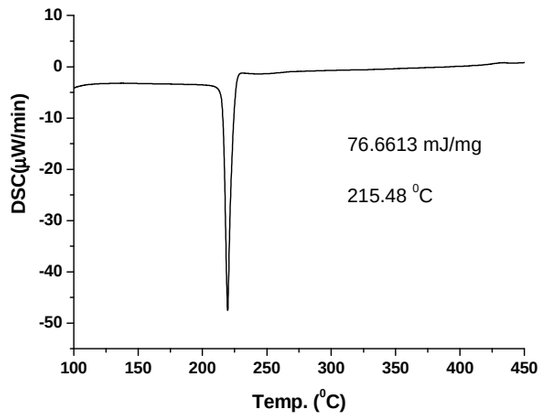

Fig. 3 The DSC profile of Sn3.5Ag0.2Cu nanoparticles

*Corresponding author
Telephone: 886-3-5712686
Fax: 886-3-5712686
E-mail:jgd@mx.nthu.edu.tw