Materials Science & Engineering Doctoral Defense

Characterization of Thermo-Mechanical Damage in Tin and Sintered Nano-Silver Solders

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abstract

Increasing density of microelectronic packages, results in an increase in thermal and mechanical stresses within the various layers of the package. To accommodate the high-performance demands, the materials used in the electronic package would also require improvement. Specifically, the damage that often occurs in solders that function as die-attachment and thermal interfaces need to be addressed. This work evaluates and characterizes thermo-mechanical damage in two material systems – Electroplated Tin and Sintered Nano-Silver solder. Tin plated electrical contacts are prone to formation of single crystalline tin whiskers which can cause short circuiting. A mechanistic model of their formation, evolution and microstructural influence is still not fully understood. In this work, growth of mechanically induced tin whiskers/hillocks is studied using in situ Nano-indentation and Electron Backscatter Diffraction (EBSD). Electroplated tin was indented and monitored in vacuum to study growth of hillocks without the influence of atmosphere. Thermal aging was done to study the effect of intermetallic compounds. Grain orientation of the hillocks and the plastically deformed region surrounding the indent was studied using Focused Ion Beam (FIB) lift-out technique. In addition, micropillars were milled on the surface of electroplated Sn using FIB to evaluate the yield strength and its relation to Sn grain size. High operating temperature power electronics use wide band-gap semiconductor devices (Silicon Carbide/Gallium Nitride). The operating temperature of these devices can exceed 250oC, preventing use of traditional Sn-solders as Thermal Interface materials (TIM). At high temperature, the thermomechanical stresses can severely degrade the reliability and life of the device. In this light, new non-destructive approach is needed to understand the damage mechanism when subjected to reliability tests such as thermal cycling. In this work, sintered nano-Silver was identified as a promising high temperature TIM. Sintered nano-Silver samples were fabricated and their shear strength was evaluated. Thermal cycling tests were conducted and damage evolution was characterized using a lab scale 3D X-ray system to periodically assess changes in the microstructure such as cracks, voids, and porosity in the TIM layer. The evolution of microstructure and the effect of cycling temperature during thermal cycling are discussed.

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