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Use of Full-Field X- ray Imaging and Ptychographic X-ray Computed Tomography for the Investigation of 3D Morphology of Micro-Nano Silver Materials for Advanced Electronics Packaging Applications

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Modern Synchrotron-based X-ray 3D tomographic imaging techniques, such as Full-Field Imaging and Computed Ptychographic Imaging offer many new possibilities for non-destructive, submicron-scale investigation of a broad range of scientific and industrial materials. In this work we investigated the processing-structure-property relationship of silver-based material (namely, micron-sized powders with nano-sized features) for lead-free electronic die-attach applications.

Unlike lead-based solders, silver-based powders are able to satisfy increasingly demanding mechanical, thermal, electrical and environmental requirements. Sub-micron silver powders can be sintered under reduced temperature and in the absence of pressure, both being desirable features for modern semiconductor packaging industry. However, the 3D morphological submicron structure of sintered powders, and especially the structure of interfacial regions at and near the substrate have been difficult to investigate using conventional materials science techniques.

The specimens required for the X-ray tomography (cylindrical pillars ~15 microns in diameter and ~50 microns in length) were prepared using Dual-Beam SEM/FIB systems (Center for Functional Nanomaterials, Brookhaven National Lab, Upton, NY and Princeton University, Princeton, NJ) and mounted on the tips of tungsten needles using a nano-manipulator. For ptychography work, the specimens were mounted on OMNY pins. The work has been performed at NSLS synchrotron (X8C beamline), NSLS-II synchrotron (FXI beamline) (Brookhaven National Lab, Upton, NY, USA) and cSAXS beamline, Swiss Light Source synchrotron (Villigen, Switzerland).

Quantitative analysis of 3D X-ray tomograms helped to establish important correlations between processing conditions (thermal aging, pressure, substrate metallization), mechanical properties (adhesive peel force) and morphological parameters (feature size, constituent volume ratio, surface curvature, 3D microstructures). The work also helped to reveal the mechanisms of potential degradation mechanisms in sintered silver powders for die-attach applications, as well as demonstrated the potential of using Full-Field and Ptychographic Computed X-ray Tomography techniques as powerful 3D imaging tools for examining materials in many areas of science and technology.

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