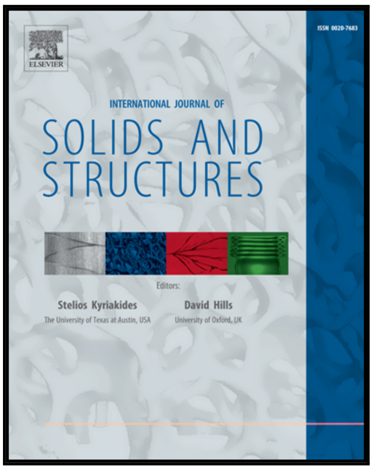

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A dislocation density based viscoplastic constitutive model for lead free solder under drop impact

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Abstract: A dislocation density based constitutive model is developed to describe the viscoplastic behavior of lead free solder joints in microelectronic packages under drop impact. Averaged dislocation density is assigned as an internal state variable to address the microstructural slip, which is the critical mechanism in inelastic deformation of polycrystalline metals and alloys. The dislocation density is divided into mobile and immobile parts. The inelastic deformation is predicted based on the mobile dislocation density, and the immobile dislocation density is adopted to predict the evolution of yield surface. Dislocation annihilation induced by dynamic recovery is considered by calculating the decreasing rate of immobile dislocation density. An implicit algorithm is employed to determine the stress evolution for arbitrary paths. The model is validated by comparing with experiment data from literature. It shows that the proposed model can describe the inelastic deformation of Sn-3.0Ag-0.5Cu solder alloy at different temperatures and strain rates with reasonable accuracy. Furthermore, the reliability of solder joints in a representative 3D microelectronic package under drop impact is numerically studied, and the developed constitutive model is programmed into the finite element analysis to simulate the viscoplastic deformation of solder joints. Three impact cases were analyzed to investigate the reliability of solder joints with different drop angles. The simulation result shows that more joints are prone to failure when a package edge is parallel impacted to the ground. The deformation and reliability of the critical joints is predicted by sub-model analyses.

Keywords: dislocations; viscoplasticity; rate-dependent; dynamic recovery;