Length Scale Dependent Creep Deformation of Dissimilar Metallic Joints: Case Study on Sn-Cu Joints

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Abstract
Dissimilar metallic joints are used in a variety of applications, such as solder joints, MEMs devices, thin films, etc. Size of the characteristic dimension of the compliant metal in joints can vary from several hundreds to a few tens of micrometers and even lesser. The present study investigates the effect of reduction in the length scale of such metallic joints on creep deformation in the mesoscopic size range. Sn-Cu joints, which are widely used in microelectronics industry, were used as the model system. Tensile creep tests were performed on multiple Sn-Cu joints, wherein the thickness of the creep compliant Sn was decreased from 1.4 mm to 170 μm. At a given stress, the minimum creep rate reduced dramatically with reduction in joint thickness. Furthermore, orientation imaging revealed a change in the number and orientation of Sn grains with decrease in the length scale. The experimental observations were explained by a synergistic approach involving continuum based finite element analysis with microstructure based crystal plasticity modeling, which captured the effects of dimensional constraints on the macroscopic stress state as well as microstructural constraints due to crystal anisotropy and dislocation motion on the creep strengthening in thin joints. Based on these insights a unified length scale sensitive model was developed which can predict the creep rate of a given joint and deconvolute the individual role of geometrical and microstructural effects.

Keywords: Metallic joints, creep strengthening, crystal plasticity, finite element analysis, geometrical constraints, microstructural constraints