Modeling the Effect of Constitutive Model on Reliability of Lead-Free Solder Joints

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Abstract

This paper will focus on the study of solder constitutive model effect on solder joint fatigue life prediction. Two loading conditions are considered, including thermal cycling and cyclic bending. In this study, four different solder constitutive models including elastic-plastic (EP), elastic-creep (Creep), elastic-plastic-creep (EPC) and viscoplastic Anand’s (Anand) models are implemented in FE modeling and simulation for comparison using ANSYS commercial FEA software. Two cases of Plastic-Ball-Grid-Array (PBGA) assembly subjected to thermal cycling and Very-thin-Quad-Flat-No-lead (VQFN) assembly subjected to cyclic bending are selected for investigating solder constitutive model effect on solder fatigue life and stress-strain behavior. Fatigue life prediction shows that the Creep, EPC and Anand’s models result in consistent fatigue life for PBGA assembly subjected to temperature cycling loading. When using EPC model, the creep deformation is dominant for PBGA assembly. In terms of cyclic bending study for VQFN assembly, the significant different simulation results can be found when using different constitutive models. Results show that EP and EPC models lead to similar result and accumulated strain energy density per cycle is easier to converge, while Creep model is equivalent to Anand’s model which results in lower strain energy density value for high temperature bending. The thermal cycling fatigue test data for PBGA is also presented for validating FE simulation results.