Void formation due to vacancy supersaturation and plastic deformation in intermetallics

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Abstract. In this contribution we present a model for the simulation of KIRKENDALL-void nucleation in intermetallic materials and subsequent void growth induced by mechanical loading. After a brief explanation of the phenomena and its consequences on the reliability of microelectronic components we introduce a constitutive model for void nucleation which is based on a thermodynamic consistent approach to vacancy diffusion. In opposite to former works we account here for the temporal evolution of voids with sources and sinks of vacancies in the surrounding material, cf. [1, 2]. It turns out that nano-voids collapse, whereas voids which are small but exceed a critical radius (of a few vacancies) grow driven by diffusion effects. On the other hand the growth of bigger voids is primarily driven by elastic-plastic deformation of the void surrounding material. We found that work hardening plays a minor role and, as expected, creep decelerates the void growth.

The resulting constitutive equations for void growth can be used to predict the temporal development of ensembles of voids in solder joints during thermal cycling and/or impact loading. By means of numerical studies on the material point level we provide inside into the (not yet completely understood) mechanisms of failure by formation and growth of KIRKENDALL voids. Here we found that the evolving distribution initially resembles the ones known from LSW theories, whereas the distribution during proceeded loading evolves such that the amount of large voids drastically increases. Such behavior correlates to experimental studies and shows the potential of the model for the failure analysis of joints.

References

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