Thermomigration in SnPb solders

Stefan Schuß[*], Christian Hesch[†] and Kerstin Weinberg[‡]

[*†] Chair of Computational Mechanics,
University of Siegen
Paul-Bonatz-Straße 9-11, 57068 Siegen, Germany
e-mail: [stefan.schuß, christian.hesch]@uni-siegen.de

[‡] Chair of Solid Mechanics,
University of Siegen
Paul-Bonatz-Straße 9-11, 57068 Siegen, Germany
e-mail: kerstin.weinberg@uni-siegen.de

ABSTRACT

Solders are used to connect suitable metals and alloys such as copper, bronze, silver, aluminum but also iron, by combining their surfaces as a melt and solidifying after cooling. In flip chip modules arrays of solder bumps are used to interconnect semiconductor devices, such as IC chips and microelectromechanical systems to external circuity. With the trend toward higher integration and further miniaturization in the microelectronic industry the cross sectional area of the conductive lines within electronic packages has decreased drastically. Due to different electrical resistances of the conducting paths on the chip and on the circuit board the temperature on the chip side can be significantly larger than the temperature on the board side. This inevitably leads to a considerable temperature gradient across the solder bumps providing a driving force to cause thermomigration. Thermomigration can produce significant redistribution of elements and constituent phases in single and two-phase alloys. Microstructural changes such as phase decomposition and coarsening may, of course, affect the overall properties of the alloy which degrade the stability and performance of components.

In our contribution we present a model describing the evolution of the composition profile and microstructure in two phase alloys in the present of a temperature gradient caused by the Joule-heating effect. The model takes into account both, the Soret effect and his counterpart the Dufour effect which is an energy flux due to a mass concentration gradient. There are three important parameter used in the model: the Gibbs free energy density, the mobility of atoms presented and their heat of transport. Here we will focus on a Sn-Pb alloy and outline the modelling of these parameters as sufficiently smooth functions in mole fraction and temperature.

The model consists of two nonlinear fourth order partial differential equations. Consequently, the variational formulation of the problem mandates approximation functions which are at least C^1-continuous. In order to fulfill this requirement a B-Spline based finite element scheme is provided. One of the main advantages of B-Splines is the possibility to represent complex geometries exactly. However, since B-Spline bases are non-interpolatory boundary conditions can not be treated in a straight forward manner. For this reason we finally discuss the implementation of boundary conditions in the presented framework. Concluding computational studies of two and three dimensional thermomigration events within Sn-Pb alloys will corroborate the quality of our model.

REFERENCES

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