Kinetic model of whisker growth in Sn films

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The spontaneous growth of whiskers from Pb-free Sn solder films on Cu substrates poses a serious threat to the reliability of electronic circuits.

Researchers at Brown are using experiments and computer simulations to understand the mechanisms for the formation of Sn whiskers. As part of this effort, a new computer model has been developed that couples stress-driven grain boundary diffusion with elastic and plastic deformation in a 3-dimensional polycrystalline microstructure. This model has been used to show how stresses develop in the Sn film due to reactions with the Cu substrate, and how these stresses lead to deformation and whisker formation in the film.

Figure 1 shows a simulation of whisker formation. Cu diffuses into the Sn film and reacts to form an intermetallic compound, resulting in volumetric expansion within the film. The volumetric expansion is accommodated in much of the film by dislocation plasticity (red). A few grains, however, are assumed to have a flow stress slightly lower than their neighbors. This relaxes the stress near the soft grain, and the resulting stress gradient drives Sn to diffuse towards the soft grain. The soft grain is extruded from the film, forming a whisker.

Based on results of these simulations, an analytical model has been developed that predicts whisker growth rates which are in good agreement with representative experiments (see Figure 2).

These and future results will be used to guide efforts to develop Sn films with whisker-resistant microstructures.

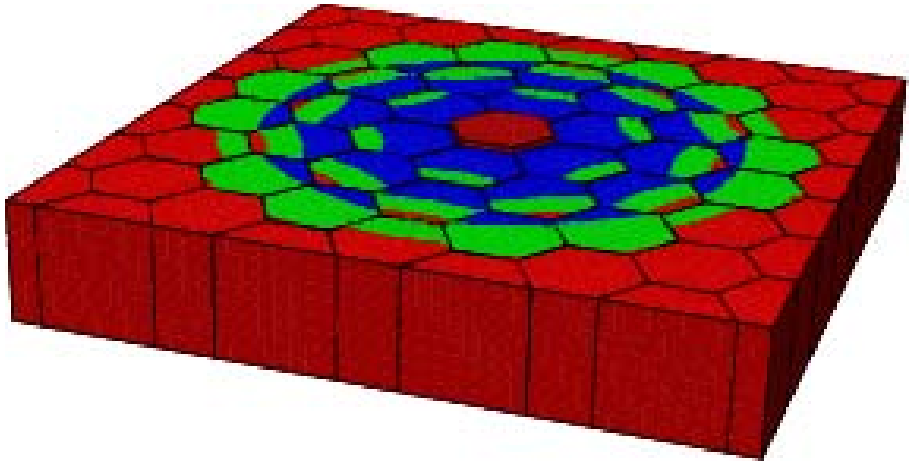

Figure 1

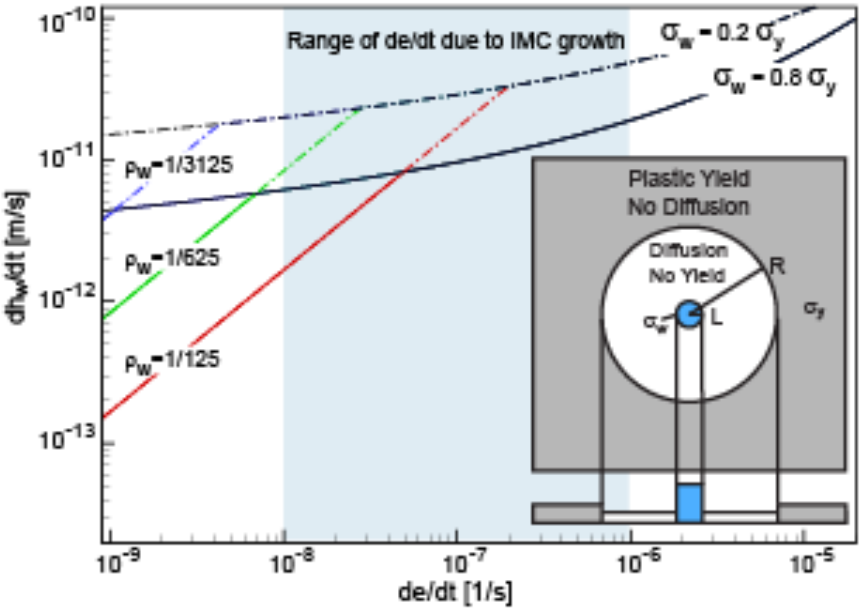

Figure 2