

Thermo-mechanical Stress And Fatigue life Prediction Of Microelectronics Interconnects

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A thermo-mechanical analysis has been performed to predict stresses within the interconnect structure of a multichip module substrate induced by temperature cycling. The resulting fatigue life was then estimated, and sensitivity studies were performed to assess the sensitivity of the prediction methodology to various key parameters. In particular, an MCM-D structure, implementing aluminum-silicon (Al-Si) metallization layers separated with a silicon dioxide (SiO₂) interlayer dielectric, was examined using a two-dimensional, plane-strain finite element model (FEM).

Developed with PDA/PATRAN, the FEM was configured to simulate a cross-section through a typical interconnection between metallized signal layers. A total stack-up thickness of 17 microns was modeled, representing a 7 micron SiO₂ base, a 2 micron thick Al-Si signal layer, a 2 micron thick SiO₂ dielectric layer, a second Al-Si layer and a 4 micron SiO₂ passivation. The interconnecting via was given a slope of 26 degrees and a sharp corner at the signal plane transitions, as indicated in electron photomicrographs.

The finalized FEM incorporated 702 plane strain, two-dimensional elements, connecting a total of 760 space coordinates. A vertical constraint boundary condition was placed on nodes of the base silicon dioxide layer, while a symmetry argument was invoked on the two sides. The top of the passivation layer was allowed to expand without restraint.

The model was used to simulate repeated temperature cycling. The resulting non-linear, elasto-plastic stress-strain response was obtained, under the assumption of a von Mises constitutive model, using P3/Advanced FEA as implemented on a SUN computer.

The strain-based fatigue life can be estimated from the finite element results using a Coffin-Manson relationship. Key material fatigue parameters were obtained from the available literature. A sensitivity study was performed in order to evaluate the effect of these parameters on the predicted fatigue life. The results have been compared to available test results from the ARPA-sponsored RELTEC program.

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