MML Develops a Peridynamics Model of Electromigration in Microelectronic Interconnects

Researchers from NIST and the University of New Mexico have developed a peridynamics approach to modeling electromigration. Electromigration, the damage to metallic conductors produced by the flow of electrical current, is an important mechanism in advanced electronics chips because the very fine-scale interconnect structures in these products must support current densities up to 1 million amperes per square centimeter at present. The desired current density is continually increasing as the size of the devices is scaled down with Moore’s Law.

In electromigration, an “electron wind” displaces atoms, leaving voids and other deformations in the original conductor, eventually causing electrical failure. The modeling challenge is that phenomena both at and beyond the time and size scales that can be treated by atomistic modeling methods are important. The popular atomistic modeling approach molecular dynamics (MD) cannot effectively treat the diffusion processes important for electromigration because the effects occur over milliseconds; the MD approach is practical only up to a few nanoseconds. Peridynamics, developed at Sandia National Laboratories, treats deformation and fracture during high-rate loading. The key advantage of peridynamics is that the paths of the cracks are predicted by the model, rather than needing to be built into the design of the mathematical model.

The peridynamics approach allows treatment of small volume elements of metal that: a) are larger than individual atoms; b) behave according to specified interaction laws; c) can be made small enough to treat the nanometer-scale geometries in microelectronic interconnects; and d) can form voids and other deformations characteristic of electromigration. A book chapter demonstrates the modeling of the motion of voids as driven by electric current. This phenomenon has been observed in the laboratory and can contribute to electrical failures if too many voids accumulate at, for example, a bend or a narrow point in a conductor.

See: Read, D. T., W. H. Gerstle, and V. K. Tewary. 2011. Modeling Electromigration Using the Peridynamics Approach. In Kim, Choong-Un, editor. Electromigration in Thin Films and Electronic Devices: Materials and Reliability. Cambridge, UK: Woodhead Publishing.

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