Peridynamics for failure prediction in electronic packages

Erdogan Madenci
Aerospace and Mechanical Engineering Department
University of Arizona, Tucson, AZ, USA
madenci@email.arizona.edu

Simulation of damage initiation and its subsequent propagation in electronic packages is still a major challenge despite the development of many important concepts. The main difficulty arises from the mathematical formulation of the classical continuum mechanics. It breaks down whenever a discontinuity appears in the material. Also, there is no internal length parameter distinguishing different length scales. Although the classical continuum theory is incapable of distinguishing among different scales, it can capture certain failure processes, and can be applied to a wide range of engineering problems, especially by employing the Finite Element Method (FEM). The FEM is robust in particular for determining stress fields, and it is also exceptionally suitable for modeling structures possessing complex geometries and different materials under general loading conditions. However, its governing equations are derived based on the classical continuum mechanics, and it also suffers from the presence of undefined spatial derivatives of displacements at crack tips or along crack surfaces.

Alternatively, a nonlocal continuum theory referred to as peridynamic theory eliminates these shortcomings, and provides the ability to address multiphysics and multiscale failure prediction in a common framework. The theory uses spatial integral equations that can be applied to a discontinuity. The peridynamic governing equations are defined at fracture surfaces; additionally, material damage is part of the peridynamic constitutive laws. These attributes permit damage initiation and propagation to be modeled, with arbitrary paths, without the need for an external criteria. This presentation will describe the peridynamic theory and demonstrate its predictive capability by considering electronic packages subjected to complex loading conditions in the presence of coupled fields. It will also include a brief description of ongoing work for further advancement and different applications of peridynamics.