Application of finite difference method in solving phase-field models

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Phase-field modeling is a powerful tool in computational materials science, providing a useful framework for simulating microstructural evolution across various temporal and spatial scales. Unlike traditional sharp-interface approaches, phase-field modeling employs one or more continuous order parameters, or field variables, that vary smoothly across diffuse phase boundaries, thus eliminating the need to explicitly track interface positions. The phase-field model is valuable for simulating complex phenomena at the solder-substrate interface, particularly for implicitly tracking and predicting the growth and morphology of intermetallic compounds (IMCs), which are critical for understanding and optimizing solder joint reliability. In Phase-field model there are two main equations which drive this microstructural evolution: Allen-Cahn equation and Cahn-Hilliard equation. To numerically solve these complex phase-field equations, which are typically in the form of partial differential equations (PDEs), the Finite Difference Method (FDM) is applied. FDM approximates derivatives by finite differences on a discretized grid, transforming the continuous domain into a set of algebraic equations. The spatial derivatives in the governing equations are replaced by their finite difference approximations, converting the PDEs into a system of algebraic equations for the field variables at discrete grid points, which are then solved using numerical techniques to determine the approximate values of the field variables across the domain at each time step. In this work we present the numerical solution of phase-field model using finite difference method, specifically demonstrating its application to accurately simulate the complex intermetallic compound growth at the solder-substrate interface.

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