THIN FILM CRACKING WITH THE EXTENDED FINITE ELEMENT METHOD

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The extended finite element method has been demonstrated to be robust and efficient in modeling discontinuities and singularities. In this study, we apply the method to simulate thin film cracking. First, the energy release rate of steady state channeling cracks is computed through a deduced two-dimensional problem. The asymptotic field near the crack tip at a bi-material interface, with a singularity intensity depending on the bi-material elastic mismatch, is used as the enriching functions. It is demonstrated that the method is applicable to model arbitrary singularities without sophisticated meshing requirements. Next, to simulate crack growth and crack pattern evolution, we implement the extended finite element method with a two-dimensional shear lag model and adopt subcritical decohesion for the crack velocity. The extended finite element method enables simulations of growth of multiple curved cracks using a coarse uniform mesh without remeshing. Starting from a random set of initial cracks, a mud crack pattern is generated. In the cases where the substrate creeps, the crack evolution is coupled to the substrate creep, and the crack velocity is modulated by the creep rate. We adopt a stepwise numerical procedure to simulate continuous crack growth, which incorporates the extended finite element method with a time-integration scheme. Our simulations show that the crack grows at a constant velocity after a transient stage. A dimensional consideration leads to a scaling law for the steady state growth velocity, and a numerical simulation determines the dimensionless pre-factor. Based on our analyses and simulations, the properties of thin film structures, such as fracture toughness, creep rate, and subcritical decohesion, can be determined by measuring crack velocities.

References

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