NONLINEAR CONTINUUM AND ATOMISTIC MODELING OF DYNAMIC FRACTURE INSTABILITIES

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ABSTRACT

Recent theoretical studies [1,2] have been aimed to explain some of the existing discrepancies between theory and experiments on dynamic fracture, and to develop a nonlinear theory of dynamic fracture that explicitly takes into account the large elastic deformation associated with the breaking of atomic bonds near a crack tip. This development is motivated by the fact that the conventional linear elastodynamic fracture mechanics has not provided an unequivocal explanation of many experimental findings such as the occurrence of mirror-mist-hackle patterns along fracture surfaces and the onset of local crack branching at velocities relatively low compared with the elastic wave speeds. A non-linear continuum analysis is developed to show that stable, steady-state crack motion is limited not only by the macroscopic Rayleigh wave speed as asserted by the established theory of dynamic fracture, but also by a local wave speed governed by the elastic response near the crack tip. The local limiting speed ensures that a subsonic deformation field can be established in highly nonlinear material regions prior to rupture. A two-dimensional triangular lattice with nearest-neighbour interatomic bonding is studied as a model nonlinear elastic solid which is isotropic under infinitesimal strains, but becomes anisotropic and nonlinear when the lattice is heavily stretched. The local limiting speed is determined by considering the most critical state of deformation on the verge of bond rupture. It is also shown that lattice dispersion in front of a crack tip can further reduce the speed of bond-breaking stress waves with wavelength of on the order of a few atomic spacing. The viewpoint emerging from these studies is that high speed dynamic fracture involves a competition between a high inertia local crack-tip field and the surrounding low inertia apparent crack field. Further nonlinear calculations of dynamic crack tip field will also be discussed in this talk.

REFERENCES

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