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Dynamic rupture propagation in extremely heterogeneous media

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Fracture experiments of monolithic brittle materials usually show the maximum speed of smooth rupture at some 30% of the relevant shear wave speed. This experimental maximum rupture speed is by far lower than those predicted by theories and inferred from inversions of seismograms, and some seismic inversions (e.g., the 1979 Imperial Valley, 1992 Landers, 1999 Izmit, 2001 the central Kunlunshan and 2002 Denali earthquakes) even suggest the existence of supershear rupture speeds (i.e., rupture propagating faster than the relevant shear wave). Exceptionally, a few laboratory experiments of dynamic rupture on pre-cut interfaces do indicate that such high rupture speeds can be achieved (e.g. Uenishi *et al.*, *Bull. Seism. Soc. Am.*, 1999; Rosakis, *Adv. Phys.*, 2002), but the exact mechanism for rupture nucleation and the transition of a nucleated rupture from sub-Rayleigh to supershear rupture speed has not been clarified yet: The question of whether natural earthquake ruptures can propagate at such extraordinary high speeds is still under active debate (see e.g. Uenishi and Rossmanith, *Acta Mech.*, 2002; Das, *J. Mech. Phys. Solids*, 2003; Xia *et al.*, *Science*, 2004). In this contribution, we consider dynamic fracture in extremely heterogeneous media that consist of thin fluid and solid films: Inside a wire frame of 50mm high and 50mm wide, a flat soap film contacts a flat thin plastic film (30mm high, 20mm wide), under static mode I loading conditions with crack-parallel (T-) stresses. The rupture (crack), initiated at a point in the fluid film, propagates perpendicularly to the contacting interface. When the subsonically propagating circular rupture front reaches the interface, the rupture advances along the interface and then it is 'diffracted' at the corner (kink) of the interface. We change the kink angle of the interface and record the rupture propagation process utilizing a high-speed digital video camera at a frame rate of some microseconds. The results show that interface rupture propagation may accelerate (or even decelerate) and the dynamic crack behavior is very sensitive to the geometry (corner [kink] angle) of the interface between the two films: (1) If the corner angle is obtuse (with respect to the solid film), the interface rupture speed is subsonic while the rupture in the bulk may be supersonic; (2) If the interface corner angle is acute, the rupture speed at the interface may become supersonic and the rupture in the bulk is guided by this supersonic interface rupture. This latter result is in contrast to the subsonic crack propagation in monolithic thin fluid films. The observed sensitivity to the interface corner (kink) angle might give a new hint on the question of whether natural earthquake ruptures can really accelerate to such extraordinary high speeds as have been inferred from seismological inversions.