Ballistic Impact Damage in Ceramics

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Abstract

Observations and analysis of damage generated within commercially-available boron carbide, silicon carbide, titanium diboride, and tungsten carbide due to the ballistic impact (non-penetrating) with either tungsten carbide spheres or sub-scale tungsten alloy long-rod penetrators is presented. In general, damage types and mechanisms include those driven by shear (compressive) and tensile stresses. Tensile damage within each ceramic was qualitatively similar, while significant differences in damage due to shear stresses were observed. For the case of an impacting long-rod penetrator (normal incidence), a simple physically-based analytical model for the dwell/penetration transition (i.e. penetration onset) velocity was derived. The model utilizes the full stress-field distributions from Hertz's theory of elastic contact coupled with a micromechanical description of the shear-driven damage mechanism. The model connects the dwell/penetration transition velocity to several ceramic attributes. These include Poisson's ratio, average flaw size, short-crack fracture toughness, and atomic-level static friction coefficient. The damage observations and implications will be presented and discussed.