Abstract Submitted
for the SHOCK15 Meeting of
The American Physical Society

Simple Scaling Laws for the Role of Pre-existing and Shock-induced Microstructure on Spall Strength JUSTIN WILKERSON, University of Texas at San Antonio — Failure of ductile metals has long been attributed to void nucleation, growth, and finally coalescence leading to fracture. Under extreme loading conditions, experimental investigations have demonstrated a strong rate-dependence in the dynamic tensile strength of such metals, which may be attributed to the fact that voids are constrained to grow at finite rates. Here we show that bounds on these void growth rates may be derived analytically by considering the constraints imposed by micro-inertia and relativistic dislocation drag. We then make use of these bounds to derive simple scaling laws for predicting the role of pre-existing microstructure, e.g. second-phase particle spacing and grain size, on the rate-dependent spall strength of metals. Under typical loading conditions, we find that the spall is governed by this pre-existing microstructure with void growth governed primarily by micro-inertia. However, under the most extreme loading conditions, we find that the spall strength is governed instead by the shock-induced microstructure with growth mediated by dislocation emission. Lastly, we demonstrate how the scaling laws may be utilized to optimize the pre-existing microstructure, e.g. grain size considering the Hall-Petch effect, of a material for a particular application.

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Date submitted: 16 Jun 2015 Electronic form version 1.4