A unified phase field damage model for modeling the brittle-ductile dynamic failure mode transition in metals
Dongyang Chu, Xiang Li, Zhanli Liu*, Zhuo Zhuang
Applied Mechanics Lab., Dept. of Engineering Mechanics, School of Aerospace, Tsinghua University, Beijing 100084 China

Abstract
Dynamic brittle fracture and shear banding are typical failure modes in metals under high strain rate loading. In this paper, a unified phase field damage model is developed to capture the above two failure modes transition naturally by allowing the critical energy release rate to vary with the stress triaxiality to distinguish the material failure properties of tensile fracture and shear banding. Besides this, compared with the existing elastic-plastic phase field fracture models, the plastic dissipation energy before the damage evolution is excluded in the failure energy to model ductile failure more physically, and the degradation function of the yield stress is introduced which not only provides a damage softening mechanism for the ductile failure but also ensures a proper simulation of the brittle fracture. The unified phase field damage model is applied to study the brittle-ductile failure mode transition in Kalthoff test. The results show that stress wave propagation plays an important role in the brittle-ductile failure mode transition. The shear banding requires more energy for initiation and will be activated straightly as the plastic wave pass the notch tip for high impact velocity. While for low impact velocity, the energy will be released by selecting the brittle fracture mode which requires less energy when the reflected tensile wave superimposes at the notch tip. For our simulation, the damage softening contributes considerably more to the shear banding than the thermal softening. This model can be used to simulate the complex dynamic failure of metal under impact loading.

Keywords: brittle-ductile failure mode transition; phase field model; dynamic fracture; shear band

* Corresponding author. Tel.: +86-10-62771114; Fax: +86-10-62771114.
Email: liuzhanli@tsinghua.edu.cn (ZL Liu)