

## MATERIALS ENGINEERING SEMINAR

“DYNAMIC FAILURE OF POLYMER BONDED EXPLOSIVE SYSTEMS: FROM IDEALIZED SINGLE CRYSTAL TO VARIATIONS OF THE TRADITIONAL PARTICULATE REINFORCED COMPOSITE”

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### ABSTRACT

Polymer bonded explosives (PBX) are a particle reinforced composite containing a high solids loading of explosive particulates bound in a polymer matrix. Commercially produced energetic particulates contain some percentage of flaws in the form of contaminants, porosity, and preexisting fractures. Additional large-scale porosity within the composite is generated during PBX formulation. The introduction of novel additive manufacturing techniques to the energetics field alters the known composite structure and introduces a porosity variable that has not been fully characterized. Porosity collapse during deformation is believed to be a predominant mechanism for hotspot formation, which dominates shock initiation behaviors. These phenomena are difficult to experimentally characterize due to inherent small spatial and temporal scales, and as such numerical and computational models are relied upon to inform fundamental physics. Experimental characterization of the behaviors of energetic materials during deformation is necessary to better inform computational studies and improve our understanding of hotspot formation mechanisms.

This dissertation experimentally evaluates the high-rate deformation of porosity in individual explosive particulates and within the overall composite structure. This has included the development of a novel micromachining technique for pore generation in energetic single crystals using the focused ion beam (FIB), resulting in precise and controllable porosity generation that is easily reproducible in collaboration with computational studies. FIB was shown to be an effective pore generation technique, verified by assessing surface roughness and pore quality compared to contemporary manufacturing methods. Three experimental subsets are evaluated: surface cracks in HMX single crystals, polygonal pores in HMX single crystals, and large-scale porosity variations in mock vibration assisted print (VAP) produced composites of borosilicate glass beads and Sylgard 184® binder. A single stage light gas gun was used to impact the samples at 400 m/s and the impact event and resultant material response were observed in real time using x-ray phase contrast imaging (PCI). Machined surface cracks were shown to have little effect on the final fracture behaviors of HMX crystals. In polygonal pores, fractures were shown to originate due to stress concentration during impact followed by otherwise expected brittle fracture behaviors. Additively manufactured PBX deformation behaviors were observed to be dominated by the collapse of the existing ordered porosity in the bulk which occurred at an increased rate relative to the bulk material compression. Future work includes exploration of further FIB produced pore effects on dynamic fractures, evaluation of printed material deformation behaviors at additional rates, as well as application and evaluation of additional VAP printed material formulations.

**Date: Monday, June 12, 2023**

**Time: 11:30 A.M.**

**Place: ARMS 1021, in person only.**