Challenges in understanding meso-scale heterogeneity under shock compression

Manny Gonzales

Materials and Manufacturing Directorate, Air Force Research Laboratory, Wright Patterson, OH, US

The bulk response of heterogeneous materials to high-strain-rate loading conditions depends strongly on meso-scale processes, mediated by the complexity of the microstructure. Multi-component, multi-phase reactive powder mixtures in particular can exhibit disparate size, shape, and morphology distributions. These compacted mixtures are porous in nature, which further complicates the deformation phenomena. Shock compression of these mixtures can lead to localization, complex transport and mixing, and compaction phenomena which can manifest measurable signals capturable by conventional sensors such as PVDF stress gauges. However, these signals are difficult to interpret due to the combined effect of multiple physical processes affecting the signal, especially if interpreting the signals to assess the shock-induced reactivity of the mixture.

This talk provides an overview of the challenges in probing the shock response of reactive powder mixtures, and draws examples from the author’s work on Ti+B+Al mixtures. The compaction response of the mixture was found to be a critical variable in the shock-induced reactivity of the mixture. The effect of extrinsic microstructural variables and the microstructural configuration on the shock-induced reactivity will be discussed. The compaction and deformation phenomena are captured by meso-scale simulations, and are compared with in-situ PVDF and VISAR measurements. A methodology is proposed to describe the uncertainties in the equation of state predicted from shock speed and interfacial material velocity measurements from PVDF stress gauges and VISAR probes. A review of current literature is also provided and suggestions of future experiments/simulation strategies to assess shock-induced reactivity are discussed.