Coupled Problems and Multi-scale Computations of Shockwave Interaction with Strain Rate Sensitive Polymers

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Key words: Coupled Problems, Atomistic-to-Continuum Simulation, shockwave propagation, Polymers, High Strain Rate Sensitivity

ABSTRACT

Recent investigations into blast resistant properties of polymers with high rate sensitivity and multi-phase polymeric elastomers indicate that they can dissipate broad bands of frequencies such as those from blast events [1]. Polymers with underlying substrates, have been shown to absorb shock in quite a different manner than any ballistic material known to the armor community [2].

ONR is leading a Basic Research Challenge to develop polymers-by-design to divert and dissipate shockwaves from the head and thus prevent Traumatic Brain Injury (TBI) [3, 4]. Molecular dynamics--Coarse Grain modeling, are used to optimize the polymer properties and address directions in continuum high rate constitutive behavior. Coupled continuum modeling, high rate load, and multi-scale continuum XFEM modeling [3] feed the results to large scale coupled computations using bio-high fidelity models of the head and brain are used in this investigation (5). In this presentation we will focus on efforts related to designing new polymers (3, 4) using multi-scale modeling of coupled media associated with air blast shockwave propagation in strain rate sensitive polymers, composite materials/interfaces, air and the head/brain (helmet, skin, skull, voids, cerebral fluid and brain tissue) [5].

The polymers of interest are highly strain rate sensitive with complex constitutive behavior, and inclusions (particles, from the nano- to micro-scale) in order to divert and manage the shockwave. To understand interaction between materials and wave propagation at extreme high rate loading, coupled media with multi-scale computations have to be used, which address the interactions at different spatial and temporal scales. Different approaches are presented on the atomistic to continuum simulations of highly rate sensitive polymers in shockwave management, in order to divert or dissipate the shock [3, 4].

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