Mechanical Engineering Colloquium, ME794:

Dynamic Deformation & Fracture of Non-classical Composites

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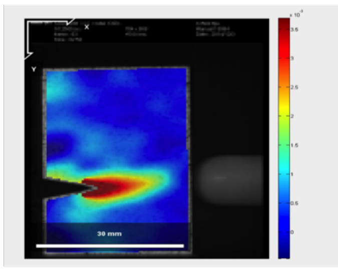
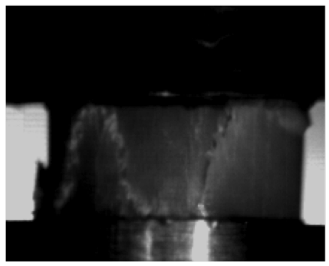
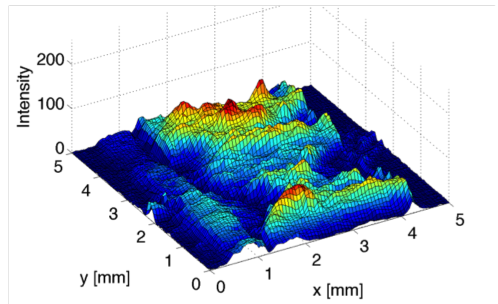
221 MEC, 1:00pm







Beyond classical laminate composites, woven composites and emerging ceramic-metal nanolaminates have improved properties making them viable next-generation materials for energy, communication and transportation systems. One major concern in their widespread use is the ability to withstand extreme loading conditions.

This talk will present the dynamic behavior of two non-classical composites: woven polymer matrix composites and a nanolaminate MAX phase (Ti_3SiC_2). Strain-rate effects of three woven fiberglass composites, each varying in thermosetting resin matrix material are presented from 10^{-3} to 10^{5} s^{-1} and compared to uniaxial carbon fiber epoxy composite. Under uniform loading conditions, the woven composites exhibited localized shear band formation with characteristic geometry. These results are analyzed in the context of Mohr-Coulomb failure theory to explore the coefficient of internal friction and cohesive shear strength per microstructure. The silicon and epoxy matrix composites exhibited a 50% decrease in the coefficient of internal friction from quasi-static to dynamic conditions, whereas the melamine matrix composite remained nominally the same. Next, a MAX phase ceramic-matrix nanolaminate, Ti_3SiC_2, is presented in the context of both dynamic compression and dynamic fracture experiments. The deformation response of MAX phases is unique in the formation of kink bands between layers that allow for improved energy absorption under impact, but are not well understood. Their compressive constitutive response is presented experimentally and matched by a simple nonlinear damage accumulation model. The results indicate that the compressive strength does not appear to be rate-dependent, but the average strain at failure increases by 1% from quasi-static to dynamic. The mixed-mode dynamic fracture initiation of Ti_3SiC_2 is also investigated where mode I (opening) and II (shearing) stress intensity factors (SIFs) are determined from digital image correlation (DIC) deformation maps around the crack tip using an overdeterministic least squares approach. With future requirements for structural materials to be lighter, stronger, and more resistant to complex loading environments, these non-classical composites are promising candidates to meet such demands.

Leslie Lamberson is a currently an Assistant Professor jointly in Mechanical Engineering & Mechanics and Materials Science and Engineering at Drexel University. In 2013, she was a NASA Glenn summer faculty fellow in the Materials and Structures for Extreme Environments core. Leslie received her B.S. in Aerospace Engineering from the University of Michigan, her M.S. in Aerospace Engineering with a thesis on thin foil fatigue with George Kardomateas at the Georgia Institute of Technology, and her Ph.D. with Ares Rosakis working on hypervelocity induced dynamic fracture at the California Institute of Technology. Prior to her faculty appointment, she was a postdoctoral research scholar with K.T. Ramesh at the Johns Hopkins University working on the dynamic electromechanical behavior of multifunctional ceramics.

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