Materials in Extreme Dynamic Environments

Georgia Tech has a unique combination of experimental facilities and modeling and simulation capabilities to explore the behavior of materials subjected to high strain rate loading conditions.

The Georgia Tech High-Strain-Rate Laboratory is equipped with interferometric, stress-gauge measurement, and high-speed digital data acquisition instrumentation, permitting material testing at strain rates up to $10^5$ s$^{-1}$, under a range of multiaxial states of stress through normal and pressure-shear (inclined) plate impact experiments. The facility consists of a single-stage gas gun with an 80 mm diameter, 8 m long barrel connected to a 28.5 liter inert-gas chamber on the breech side and to a large soft-recovery catcher tank on the muzzle side. A 0.3-calibre gas-gun is also available for impact experiments at velocities up to 400 m/s. Time-resolved instrumentation includes use of in-situ stress measurements performed using piezoelectric PVDF as well as piezoresistive manganin stress gauges, and particle velocity measurements using the state-of-the-art four-beam VISAR (Velocity Interferometer System for Any Reflector) interferometry.

The Georgia Tech Dynamic Properties Research Lab facilities consist of a set of split Hopkinson bars, Gas Gun Facility, and Computational Resources. The split Hopkinson bars provide material testing capabilities in compression, tension, torsion, torsion/compression and torsion/tension at strain rates of the order of $10^2$ to $10^4$ s$^{-1}$. This facility is equipped with two Polytec OFV-3001 laser vibrometer systems and two OFV-512 optical fiber laser heads for measurement of surface velocities between 0 to 10 m/s. A set of Tektronix high speed digital oscilloscopes are available for data acquisition at sampling rates up to 50 nanoseconds per point.

Research to understand dynamic response of materials at various critical length and time scales emphasizes both high-performance computational finite element and molecular dynamics simulations and experimental characterizations using laser interferometry and novel digital diagnostics. A variety of quasistatic and dynamic deformation and loading conditions encountered in engineering applications are considered. The computational and experiments techniques allow for explicit account of material mesoscopic, microscopic, and nanoscopic structures. The objectives are to outline factors, mechanisms and conditions that enhance material performance under given conditions, to provide guidance for the enhancement of performance, and to facilitate the design of materials with specified functionalities.

Research in this area concerns the often consistent, and sometimes competing, requirements on responses of materials for armor and anti-armor. For example, balances between high impedance and lightweight, strength and toughness, and material removal and energy absorbency place challenges on both the design of materials and the design of structures. In particular, design of the material in addition to the structural armor geometry is important in the development of advanced materials for meeting specific performance objectives. Research in this area focuses on the characterization of structure-performance relations in ceramic and metallic composites. Combined computational and experimental methods are used, emphasizing an explicit account of microstructures, microstructure deformation, and failure processes. The computational analyses integrate deterministic tracking of fracture processes and stochastic quantification of the variability of material behavior. The experimental
analyses emphasize digital high-speed photography and laser interferometry for the quantification of material response. The figure below shows an explicit combined deterministic and stochastic finite element model of a reconstructed composite microstructure using a cohesive finite element framework by the group of Min Zhou.

http://dprl.me.gatech.edu/
http://www.hsrlab.gatech.edu/
http://mprl.me.gatech.edu/facilities/high-strain.php
http://mprl.me.gatech.edu/facilities/split-hopkins.php