UNIVERSITY OF RHODE ISLAND

Department of Chemistry Ph.D. Seminar

2:00 PM, Friday, March 10, 2023
Beaupre Room 105

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Simulation and Fabrication of Reactive Metamaterials to Control Shock to Detonation Transition

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Energetic materials undergo chemical reactions at time scales spanning hours to tens of nanoseconds and pressures ranging from atmospheric to tens of gigapascals. These extreme ranges require a wide breadth of experimentation and simulations to capture both safety and design concerns. To probe chemical mechanisms at the microsecond to nanosecond time scale simulations and experiments were conducted to control the shock to detonation transition (SDT) by energy trapping within reactive metamaterials. Simulations carried out in ALE3D were used as a framework for designing high impedance tantalum arrays within nominally homogeneous energetic materials. High explosive ignition and growth reactive flow modeling demonstrated enhanced reactivity under shock loading conditions that would not induce a detonation. Localized reactions and hot spots were observed within regions of constructive interference that markedly affected the system's SDT. Reactive metamaterials were fabricated by utilizing additive manufacturing to engineer structures within the homogeneous energetic material nitromethane. Fritz cast-cure plane wave lenses were designed and calibrated to provide planar (< 50 nanosecond) input shocks. Photon doppler velocimetry was the primary diagnostic to measure particle velocity at various points in the metamaterial. Samples that normally would not detonate underwent SDT with the inclusion of high impedance tantalum pins. Particle velocity traces suggest that even when a complete shock to detonation transition was not achieved, partial reactions occurred to a greater extent in systems with arrays.