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Laser-shocked energetic materials for laboratory-scale characterization and model validation

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The development of laboratory-scale methods for characterizing the properties of energetic materials, i.e., using only milligram quantities of material, is essential for the development of new types of explosives and propellants for use in military applications. Laser-based excitation methods for initiating or exciting the energetic material offer several advantages for investigating the response of energetic materials to various stimuli: 1) very small quantities of material can be studied prior to scale-up synthesis, 2) no detonation of bulk energetic material is required, eliminating the need for expensive safety precautions, and 3) extensive diagnostics can be incorporated into the experimental setup to provide as much information as possible per shot. In this presentation, progress in our laboratory developing three laser-based methods for characterizing energetic materials will be discussed. Direct excitation of a sample residue using a focused nanosecond laser pulse enables estimation of the performance of the energetic material based on the measured shock wave velocity with a technique called laser-induced air shock from energetic materials (LASEM); recent LASEM results on novel energetic materials will be presented. Impact ignition of energetic materials has also been investigated using laser-driven flyer plates. High-speed schlieren imaging of the flyer plate launch has demonstrated that late-time emission from the impacted energetic material is caused by the reaction of particles ejected off the sample surface with the flyer plate launch products. Finally, the role of a rapid temperature jump (10^{14} K/s) in the initiation of the explosive cyclotrimethylenetrinitramine (RDX) has been investigated by indirect ultrafast laser heating. Although the temperature jump was insufficient to decompose the RDX, it did induce a temporary electronic excitation of the heated explosive molecules. These results are being used to validate multiscale models in order to understand initiation mechanisms for explosives.