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Unraveling Shock-Induced Chemistry Using Ultrafast Lasers[1]

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The exquisite time synchronicity between shock and diagnostics needed to unravel chemical events occurring in picoseconds has been achieved using a shaped ultrafast laser pulse to both drive the shocks and interrogate the sample via a multiplicity of optical diagnostics. The shaped laser drive pulse can produce well-controlled shock states of sub-ns duration with sub-10 ps risetimes, sufficient for investigation of fast reactions or phase transformations in a thin layer with picosecond time resolution. The shock state is characterized using ultrafast dynamic ellipsometry (UDE) in either planar or Gaussian spatial geometries, the latter allowing measurements of the equation of state of materials at a range of stresses in a single laser pulse. Time-resolved processes in materials are being interrogated using UDE, ultrafast infrared absorption, ultrafast UV/visible absorption, and femtosecond coherent Raman spectroscopies. Using these tools we showed that chemistry in an energetic thin film starts only after an induction time of a few tens of ps, an observation that allows differentiation between proposed shock-induced reaction mechanisms. These tools are presently being applied to a variety of energetic and reactive sample systems, from nitromethane and carbon disulfide, to micro-engineered interfaces in tunable energetic mixtures.

[1]In collaboration with Shawn McGrane, Cynthia Bolme, Dan Eakins, Margo Greenfield, Jason Scharff, and Von Whitley, Los Alamos National Laboratory.