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High-Precision Measurements of the Equation of State of Polymers at 100 to 1000 GPa Using Laser-Driven Shock Waves

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The equation of state (EOS) of materials at extreme temperatures and pressures is of interest to astrophysics, high-energy-density physics, and inertial confinement fusion (ICF). The high-pressure (>100 GPa) behavior of polymer materials is essential to the understanding of ablator materials for ignition targets. EOS measurements on CH_x provide benchmarks on the behavior of polymers under extreme conditions and the effect of stoichiometry (i.e., the C:H ratio) on that behavior. High-power lasers produce shock pressures greater than 100 GPa, and recent advances in diagnostics and analysis have made it possible to perform highly accurate measurements of shock velocity. This improves upon the impedance-matching technique for laser-driven shock experiments, producing $\sim$1% precision at extreme pressures. The OMEGA laser is used to produce principal (single-shock) Hugoniot EOS measurements on polystyrene (CH), polypropylene (CH_2), GDP ($C_{43}H_{56}O$), and Ge-doped GDP at shock pressures of $\sim$100 to 1000 GPa. We also present a novel target design that provides double-shock (re-shock) data together with the above data. These data are pertinent to ICF target designs that use multiple shocks to approximate an isentropic compression. Results of the single- and double-shock experiments on these polymers are presented and compared to various EOS models. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC52-08NA28302. In collaboration with T.R. Boehly, D.E. Fratanduono, D.D. Meyerhofer (LLE), D.G. Hicks, P.M. Celliers, and G.W. Collins (LLNL).