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Quarterly Report

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Contents

In Brief

This volume of LLE Review, covering January–March 2001, includes a report on the characterization of direct-drive implosion core conditions using time-resolved Ar *K*-shell spectroscopy. This work was carried out by a team that included S. P. Regan, J. A. Delettrez, P. A. Jaanimagi, B. Yaakobi, V. A. Smalyuk, F. J. Marshall, D. D. Meyerhofer, and W. Seka of the Laboratory for Laser Energetics (LLE), University of Rochester; D. A. Haynes, Jr. of the Department of Engineering Physics, University of Wisconsin; and C. F. Hooper, Jr. of the Department of Physics, University of Florida. The experiments involved the implosion of polymer shells filled with Ar-doped deuterium gas driven with up to 24-kJ, 1-ns square laser pulses smoothed with 1-THz, 2-D smoothing by spectral dispersion (SSD) and polarization smoothing (PS). The emissivity-averaged core electron temperature and density were inferred from the measured time-dependent Ar *K*-shell spectral line shapes. Electron densities in excess of 2.5×10^{24} cm^{-3} and electron temperatures ~2.5 keV were measured in these experiments. This represents the highest combination of electron temperature and density measured for these types of implosions in laser-driven inertial fusion experiments.

Additional research highlights reported in this issue include the following:

- C. K. Li, F. H. Séguin, D. G. Hicks, J. A. Frenje, K. M. Greene, S. Kurebayashi, and R. D. Petrasso of the Massachusetts Institute of Technology (MIT) Plasma Science and Fusion Center (PSFC); D. D. Meyerhofer, J. M. Soures, V. Yu. Glebov, R. L. Keck, P. B. Radha, S. Roberts, S. Skupsky, and C. Stoeckl of LLE; and T. C. Sangster of Lawrence Livermore National Laboratory (LLNL) report on studies of the implosions of direct-drive, DT-gas-filled polymer capsules using nuclear diagnostics. In addition to traditional neutron measurements, a comprehensive array of knock-on deuteron, triton, and proton spectra were used to compare the performance of capsules irradiated with full beam smoothing on OMEGA (1-THz, 2-D SSD and PS) versus implosions of similar targets carried out with reduced beam smoothing (0.35-THz, 2-D SSD without PS). With full beam smoothing, implosions with moderate radial convergence (~10 to 20) are shown to produce neutron yields, fuel areal densities, and shell areal densities approximately 80%, 60%, and 35% higher, respectively, than those with the reduced level of beam smoothing.

- To improve the understanding of the moderate-convergence-ratio (~10 to 20), direct-drive implosions carried out on OMEGA, P. B. Radha, V. Yu. Glebov, D. D. Meyerhofer, C. Stoeckl, and J. M. Soures of LLE in collaboration with C. K. Li, R. D. Petrasso, and F. H. Séguin of MIT-PSFC developed a consistent measurement-based static model of the stagnated core and fuel–pusher mix. The model, presented in this issue, assumes that the imploded core is comprised of a clean fuel region and a "mix" region where the shell material is mixed into the fuel. Excellent agreement with a suite of neutron and particle diagnostics is obtained through the use of this model. The model suggests that approximately 1 μm of shell material is mixed into the fuel during the thermonuclear burn. It also suggests that the fuel areal density is distributed equally between the clean core and the fuel–shell mix region.

- L. Disdier, A. Rouyer, J-P Garconnet, A. Fedotoff, and J.-L. Bourgade of the Commissariat à L'Énergie Atomique (CEA) of France; V. Yu. Glebov, C. Stoeckl, and W. Seka of LLE; and D. C. Wilson of the Los Alamos National Laboratory (LANL) discuss high-resolution neutron imaging of capsules imploded on the OMEGA laser. Their diagnostic is based on penumbral imaging using a

biconical aperture. The CEA-designed diagnostic demonstrated the highest spatial resolution yet achieved on ICF implosions (45 to 60 μm) on direct-drive implosions carried out on the OMEGA facility. Modifications that are expected to improve the resolution to 13 μm for OMEGA implosions have recently been carried out on this diagnostic.

- Ultrafast picket-fence pulses have been proposed by an LLNL scientist as a means to maximize the frequency-conversion efficiency and minimize beam-power imbalance on the National Ignition Facility (NIF). In this issue J. A. Marozas and J. D. Zuegel of LLE report on the results of an analysis of the beam-smoothing performance of ultrafast picket-fence pulses for direct-drive targets on the NIF. They found that beam smoothing achieved with ultrafast picket-fence pulses is equivalent to the smoothing attained with the NIF's base-line 2-D SSD design if the applied bandwidth and divergence used for the picket-fence-configuration SSD is close to that of the base-line-design SSD system. Furthermore, it is shown that the diffraction-limited far-field pattern produced by chirped picket-fence pulses can reduce the pinhole loading, potentially leading to a larger permissible beam divergence for the NIF with 2-D SSD.

- B. Yaakobi, F. J. Marshall, T. R. Boehly, R. P. J. Town, D. D. Meyerhofer, and W. Seka report on a test of the feasibility of using extended x-ray absorption spectrum (EXAFS) to characterize the properties of solid materials shocked at moderately high pressures (up to a few Mbar). This work is part of LLE's participation in the Department of Energy's Stewardship Science Program (SSP). The initial results presented in this issue show very-high-contrast EXAFS modulations when a thick, undriven Ti foil is backlighted by the x-ray radiation from an imploded CH shell.

- KDP is an important electro-optic tetragonal crystal used widely in high-power laser systems. In this issue, T. Fang of Crystal Technologies and J. C. Lambropoulos of the UR's Department of Mechanical Engineering and LLE report on studies of the microhardness and indentation fracture of KDP. They develop an approximate model for analyzing crack-load micro-indentation data in tetragonal crystals. The model uses the minimum elastic modulus of the material.

John M. Soures
Editor