NIF Polar-Direct-Drive Campaign: In ICF implosions, nonuniformities seeded by both laser-imprint and initial shell-mass perturbations can grow as a result of hydrodynamic instabilities, such as the Richtmyer–Meshkov (RM) and Rayleigh–Taylor (RT) instabilities. This potentially results in a severe degradation of the target compression and neutron yield, and accurate modeling and understanding of nonuniformity growth at ignition-scale conditions is key for confidence in ignition designs.

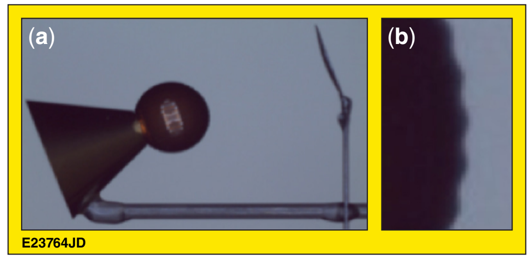

Figure 1. Photograph of a cone-in-shell target for studies of hydrodynamic instability growth in spherical, direct-drive geometry on the NIF. The target comprises a plastic capsule, a gold cone, and a backlighter. (b) Single-mode perturbations are machined onto the capsule surface to act as instability seeds.

As part of LLE's polar-direct-drive (PDD) campaign at the National Ignition Facility (NIF) to develop a direct-drive–ignition platform, recent experiments explored hydrodynamic instability growth in spherical, PDD implosion geometry. A photograph of one of the targets is shown in Fig. 1(a). These were spherical, 2.2-mm-diam plastic shells with a 100-μm wall thickness. For an unperturbed view onto a single capsule surface in the imploding target, a gold cone was attached to the capsule through a 1-mm opening in the shell. Machined onto the outer shell surface were sinusoidal, single-mode, single-amplitude perturbations with a wavelength of λ = 150 μm (~mode 50), and amplitudes of 1 μm or 7 μm [see Fig. 1(b)]. These perturbations acted as known sources for instability growth.

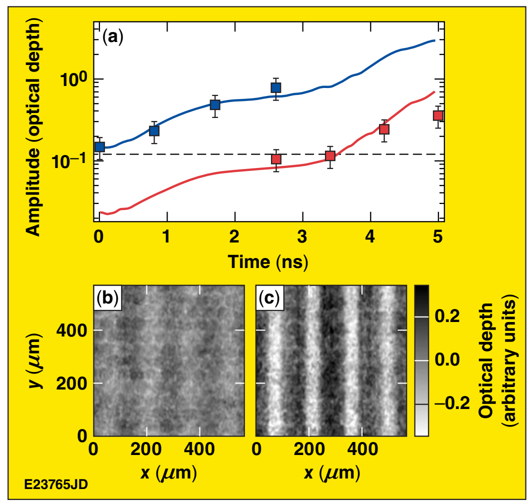

Figure 2. (a) Calculated (solid lines) and measured (squares) optical depth amplitudes for the 7-μm (blue) and 1-μm (red) initial modulation amplitude. The dashed black line is the instrument noise level. [(b) and (c)] Face-on x-ray images of the 7-μm target at 0.8 ns and 2.6 ns, respectively.

Upon irradiation of the capsule with the drive laser, the mass perturbation is amplified via shell compression and hydrodynamic instabilities. The perturbation amplitude as a function of time was measured in the form of optical-depth (OD) variations of the capsule wall using face-on, x-ray radiography with a $C_2H_2Cl_2$ (Saran) backlighter emitting at ~2.8 keV. The data were recorded with an x-ray framing camera over a 2.5-ns window for each shot. The two different amplitudes make it possible to track the mode-amplitude amplification at different times of the target implosion. Figure 2(a) shows 2-D *DRACO* calculations (lines) of the expected OD amplitude of the preimposed modulation for the two different targets. Notably, the 7-μm initial amplitude perturbation (blue line) introduces a sufficiently large OD modulation that it can be detected at time $t = 0$, without requiring additional amplification by the laser, thereby providing an *in-situ* characterization of the backlighter and imaging setup. The initial increase in OD amplitude up to ~2 ns is caused by shell compression and the Richtmyer–Meshkov instability, followed by the onset of amplification caused by the Rayleigh–Taylor instability after ~3 ns.

Radiography data obtained at different times with the 7-μm initial amplitude target are shown in Figs. 2(b) and 2(c). The optical depth amplitude increases in time, while the wavelength decreases slightly because of spherical convergence. Optical depth amplitudes extracted from the two experiments are plotted in Fig. 2(a) as solid squares. The initial analysis shows very good agreement with the pre-shot predictions, with more detailed analysis underway. Future experiments will investigate perturbation growth rates at shorter wavelengths, and growth from broadband, laser-imprinted surface perturbations in smooth targets.

Omega Facility Operations Summary: The Omega Facility conducted 141 target shots in November 2014 with an average experimental effectiveness of 89%. One-hundred six of these shots were taken on the OMEGA laser (experimental effectiveness of 92.5%) and 35 shots were taken on OMEGA EP (experimental effectiveness of 78.6%). The ICF program accounted for 66 target shots for experiments led by LLE and 64 target shots were taken for the HED program for experiments led by LANL, LLNL, and LLE. Eleven maintenance shots were also taken during this month.