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First demonstration of a layered direct-drive inertial confinement fusion target on the National Ignition Facility

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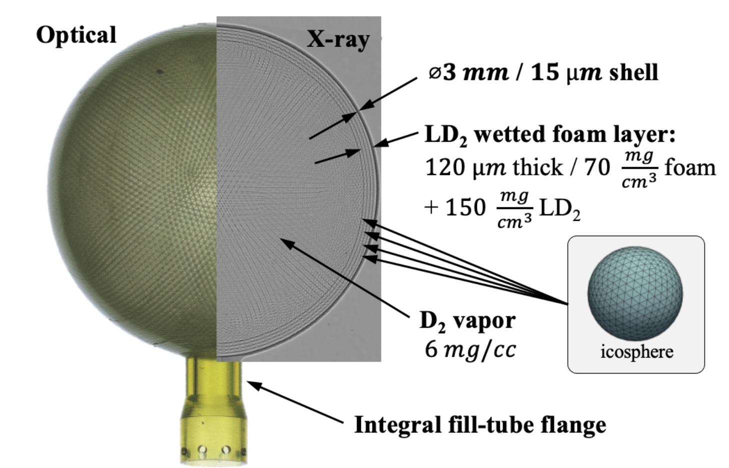
Experiment N250316-001 marked the first demonstration of a layered direct-drive inertial confinement fusion (ICF) target on the National Ignition Facility (NIF) laser. The target consisted of a $\varnothing 3\ mm$ plastic capsule with a $15\ \mu m$ thick shell and a $120\ \mu m$ thick foam layer ($70\ mg/cc$), both of which were additively manufactured using two-photon polymerization (2PP). The shell and foam were fabricated concurrently in a single print, representing the fourth such target fielded at NIF. The foam layer was constructed as four concentric icosphere surfaces composed of solid-density struts (approximately $\varnothing 6\ \mu m \times 30\ \mu m$ in length), designed to wick liquid deuterium throughout the structure. This formed a wetted foam (WF) layer on the interior surface of the capsule, surrounding a central vapor region that served as the hot spot. Cryogenic cooling of the target was achieved via conduction through a $\varnothing 250\ \mu m$ copper fill-tube, which was integrated into a flange printed with the capsule. The target was cooled to $\sim 28\ K$, resulting in coexisting liquid and vapor deuterium phases with densities of $\sim 150\ mg/cc$ and $\sim 6\ mg/cc$, respectively. The capsule was irradiated with an $850\ kJ$, $300\ TW$, $4\ ns$ laser drive using a polar direct drive (PDD) pointing configuration. Preliminary nuclear performance data aligned with preshot radiation-hydrodynamics predictions from HYDRA simulations, providing validation for early modeling studies that suggested robust ignition could be achievable with such designs on the NIF platform. Additively manufactured PDD-WF targets are being developed as next-generation, igniting, low-mass neutron sources for survivability experiments as part of NIF's National Security Applications Program. These targets offer advantages in fieldability compared to current laser indirect drive (LID) beta-layered ice designs. Furthermore through LLNL's LDRD support, this work is advancing capsule manufacturing technologies under consideration for liquid-layered LID ICF and inertial fusion energy (IFE) concepts, providing valuable insights into scalable production techniques for future applications.



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