THE HIGH DENSITY CARBON ABLATOR IMPLOSION CAMPAIGN ON THE NATIONAL IGNITION FACILITY

N. B. Meezan1, A. J. MacKinnon1, L. F. Berzak Hopkins1, S. Le Pape1, L. Divol1, D. D. Ho1, J. S. Ross1, T. Ma1, A. E. Pak1, T. Döppner1, S. F. Khan1, D. T. Casey1, G. N. Hall1, M. B. Schneider1, A. S. Moore1, O. S. Jones1, J. L. Milovich1, J. L. Peterson1, C. R. Weber1, D. S. Clark1, C. A. Thomas1, R. C. Nora1, B. K. Spears1, B. A. Hammel1, A. B. Zylstra2, H. G. Rinderknecht2, H. Sio2, R. D. Petraso2, M. Stadermann1, J. Biener1, A. V. Hamza1, W. Requiron3, D. E. Hoover3, A. Nikroo3, C. Wild4, D. A. Callahan1, O. L. Landen1, O. A. Hurricane1, W. W. Hsing1, R. P. J. Town1, M. J. Edwards1

1Lawrence Livermore National Laboratory, Livermore, California, USA
2Massachusetts Institute of Technology Cambridge, Massachusetts, USA
3General Atomics, San Diego, California, USA
4Diamond Materials GmbH, Freiburg, Germany
meezan1@llnl.gov

The goal of the high-density carbon (HDC, or diamond) ablator campaign on the National Ignition Facility (NIF) is to assess HDC as an ablator for achieving alpha-heating and ignition [1]. Testing HDC as an ablator requires designing and developing a platform that drives high convergence ($\rho R \approx 1$ g/cm$^2$) implosions to ignition-relevant velocity ($v_{\text{fuel}} \geq 350$ km/s) while maintaining suitable drive symmetry and hydrodynamic stability. HDC’s high density ($\rho \approx 3.5$ g/cm$^3$) results in a thinner ablator than in plastic (CH) or beryllium designs, resulting in multi-shock laser pulses with durations $\leq 9$ ns, compared to $\approx 15$ ns for CH and Be. Short pulses enable the use of near-vacuum ($\rho < 0.1$ mg/cm$^3$) hohlraums, which are up to 40 % more efficient than hohlraums filled with high density ($\rho \geq 0.9$ mg/cm$^3$) helium gas. Implosion velocities equivalent to $v_{\text{fuel}} \geq 400$ km/s have been demonstrated in these hohlraums [1]. In addition, laser backscatter and hot-electron generation are negligible [2]. Recently, the HDC campaign has driven implosions with thermonuclear yields of $2-3 \times 10^{15}$ neutrons, DT fuel $\rho R \approx 0.5-0.6$ g/cm$^2$, and no measurable ablator mix in the hot spot.

In this talk, we summarize the campaign’s progress in two efforts:
1. Develop a platform (hohlraum + capsule + laser) with suitable symmetry control
2. Find a combination of capsule dopant and hohlraum drive spectrum with suitable stability at the ablation front and the fuel-ablator interface

Symmetry has been difficult: the highest performing implosions have been prolate, with hot-spot shape $P_2/P_0 \approx 20-40\%$ [2]. To fix this, the campaign has explored several hohlraum sizes and laser pulse durations. Good control of $P_2$ asymmetry has been achieved in a 5.75 mm diameter hohlraum with an 844 µm radius capsule and laser energy $< 1$ MJ. Uranium hohlraums without a thin gold liner have also been tested, demonstrating M-band x-ray intensities ($hv > 1.8$ keV) 33 % lower than in gold-lined hohlraums. Future plans include incorporating unlined uranium hohlraums into the promising 5.75 mm platform and testing this platform with cryogenic DT layer implosions.


*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344.