§52. Areal Density Measurements of Imploded Cone-in-shell Targets with High-energy K-alpha X-ray Backlighters

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Fast Ignition (FI)[1),2)] Laser fusion is an advanced inertial confinement fusion (ICF) concept that independently achieve a high density fuel compression and a rapid heating of the core to ignition using intense high-power lasers. The separation of the compression and ignition phases provides several advantages such as relaxing constraint on implosion symmetry that is severely distorted by hydrodynamic instability, and less required compression laser energy, leading to a potentially higher fusion gain than the conventional hot-spot ignition. In cone-guided FI, a deuterated plastic (CD) shell with a re-entrant cone is compressed by nanosecond long pulse lasers to create a high density core. The compressed core is rapidly heated with an additional ultraintense, picoseconds ignition laser near the peak compression to the ignition temperature. The presence of the cone maintains the clear path for the ignition laser during the implosion, but it breaks the symmetry of the implosion. Thus, development and benchmarking of a simulation capability with a two-dimensional radiation hydrodynamics code is important for designing and optimizing fast ignition targets.

Following a success of the development of the spherical crystal imaging system in the previous year[3)], the goal of this project is to measure a temporal evolution of areal densities of laser-driven cone-sphere target. The experiment was carried out at Institute of Laser Engineering, Osaka University. Figure 1 shows a schematic of the experimental overview. A cone-sphere target consisted of a 200 μm diameter CD sphere and a Au re-entrant cone was irradiated by 9 GXII beams with 2 kJ of the total beam energy in a Gaussian pulse. 4.5 keV Kα x-rays were produced by irradiating ~1000 J, 1.6 ps LFEX laser on a Ti foil near the peak compression. The backlighter x-ray, reflected off with the spherically bent crystal, was recorded with an imaging plate (IP) detector.

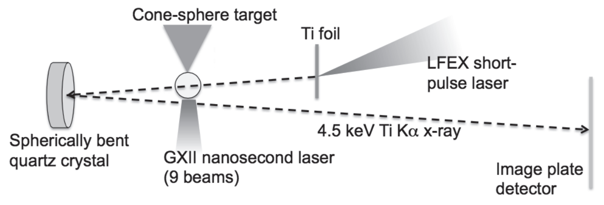

Fig. 1. A schematic of the Ti Ka radiography at ILE

Figure 2 shows a sequence of the radiographic images of compressed CD sphere. At all backlighter timing, high density plasmas are clearly observed in front of the cone. The position of the cores is well separated from the cone tip, indicating formation of high density CD plasma assembly. By analyzing the images, the information of the core sizes, positions with respect to the cone tip and core areal densities can be obtained. Here, the raw transmitted x-ray images were analyzed to obtain the transmission profiles by extrapolating the initial intensity profiles (I_0). The relative timing of the recorded images was estimated from the measurements with an x-ray streak camera. The peak of the laser pulse is set to 4.0 ns. The recorded images were at 4.11 ns, 4.17 and 4.38 ns. The optical depth of the vertical lineouts of the images were compared in Figure 3. Qualitatively, the size of the cores is similar (~ 50 μm in radius) at all three times. The optical depth profile peaks at 4.17 ns. The analyses of the radial profiles in order to estimate the areal densities and densities of the cores are being performed. The experimental areal densities will be compared with a 2-D radiation hydrodynamics code.

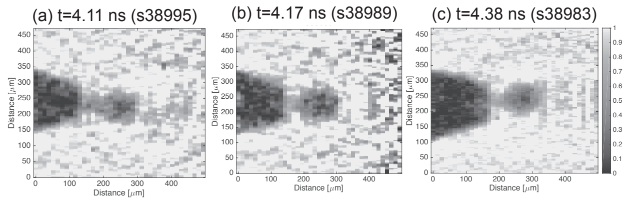

Fig. 2. A temporal evolution of the experimental transmission profiles at (a) 4.11 ns (s38995), (b) 4.17 ns (s38989), and (c) 4.38 ns (s38983).

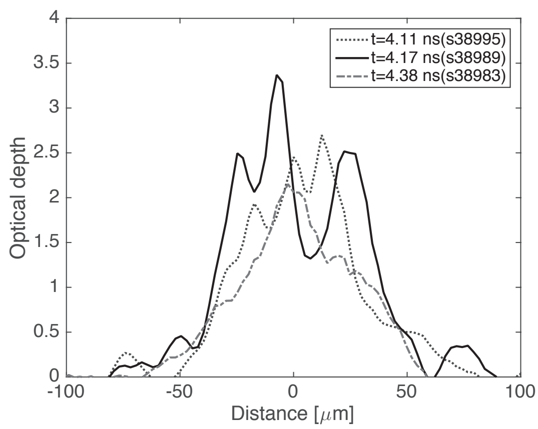

Fig. 3. Comparison of the experimental optical depth (optical depth, τ = -log (I/I_0)).

1) Tabak M. *et al*., Phys. Plasmas **1**, 1626 (1994)
2) Kodama R. *et al*., Nature **412**, 798 (2001)
3) Sawada H. et al., IFSA2014 proceeding (2016)