DEVELOPMENT OF 4.5 KEV MONOCHROMATIC X-RAY RADIGORAPHY USING THE HIGH-ENERGY, PICOSECOND LFEX LASER

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Fast Ignition (FI) [1, 2] is one of advanced Inertial Confinement Fusion (ICF) concepts that separate the compression of fusion fuel and rapid heating of the compressed core, leading to a potentially higher fusion gain than the conventional central hot spot ignition. In cone-guided FI, a deuterated plastic (CD) shell with a re-entrant cone is imploded by nanosecond lasers to form a high density core and an additional ultraintense, picoseconds ignition laser triggers the fusion reactions by rapidly heating the dense core at the peak compression. Because of the presence of the cone, a two-dimensional radiation-hydrodynamics code is required to design an asymmetrically compressed core close to the cone tip without destroying the cone. Experimental benchmarking of the code is therefore crucial for designing the FI target. The key parameters for the core formation are the core size, timing and value of peak areal density and the standoff distance between the core and the cone tip.

We report a development of a 2-D monochromatic x-ray radiograph technique in combination of a spherically bent crystal and 4.5 keV Ti K-alpha line emission produced by the kilo-Joule class, picosecond-short-pulse LFEX laser at Institute of Laser Engineering (ILE). The crystal imager was configured with a quartz crystal and operated at 1.0° off normal incidence at the 1st order reflection with the magnification of 11.5. The spectral bandwidth of the crystal (~ 10 eV) is narrower than the Ti K-alpha spectrum, producing a monochromatic x-ray image. The temporal resolution of the diagnostic is determined by the pulse duration of the 1.6 ps LFEX laser, enabling to capture the fast dynamics of the compressed core. A similar technique using 8.05 keV Cu K-alpha x-ray was developed and successfully applied for areal density measurements of a cone-in-shell target [3,4].

The monochromatic crystal imager was tested to radiograph a 200 μm diameter CD sphere irradiated by ~2 kJ, 9 GXII beams in 1.3 ns Gaussian pulse. A Ti backlighter foil was placed at 2 mm away from the implosion core. The core image was observed with the normalized peak transmission of ~ 0.2 and the spatial resolution of ~ 18 μm. The analysis shows that the measured core is estimated to be ~ 100 μm diameter and ~ 50 μm distance from the cone tip. A hydrodynamic simulation predicts the plasma condition of the core to be 40 mg/cm^2 and ~ 8 g/cm^3. The detail of the diagnostic design and analysis of the radiograph image will be presented. This work was performed under the auspices of the NIFS Collaboration Research program (NIFS13KUGK072 and NIFS12KUGK057).

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