§48. Mitigation of Laser Imprinting with Diamond Ablator

Shigemori, K., Kato, H., Sakaiya, T., Hosogi, R., Terasaki, H., Hironaka, Y., Nagatomo, S., Shimizu, K., Azechi, H. (Osaka Univ.)

Laser imprinting is one of the most important issues on hydrodynamic instabilities in direct drive inertial confinement fusion (ICF) targets because it gives the initial condition for Rayleigh-Taylor instability (RTI) and related hydrodynamic mixing. In past two years, we focused on experiments about mitigation of imprinting with diamond which has very low compressibility and high melting point. The experimental results showed reduction of the imprinting, and strange non-sinusoidal shape by the laser imprinting.

Here we report new additional experimental results of laser imprinting of diamond targets. The targets comprised single-crystal diamond foils (Type-Ib, density: 3.51 g/cm^3) with a thickness of 12–20 μm. A polystyrene (PS) foil (density: 1.06 g/cm^2) with a thickness of 25 μm was employed as a reference material. The experiments were conducted using the GEKKO-XII Nd:glass laser facility at the Institute of Laser Engineering, Osaka University. The diamond and PS foils were irradiated with the second harmonic light (λ: 0.527 μm) from the Nd:glass laser. The pulse shape was Gaussian with a 1.3 ns duration (full width at half maximum), using one beam for the foot pulse stacked with two beams for the drive pulse, with time delays between the beams. We define the time origin (t = 0) at the onset of the main drive pulse. Perturbations were observed on the target via amplification due to RTI growth using the drive beams because the imprinted perturbations were typically too small for visible detection. A schematic of the experimental setup and the typical stacked pulse shape are shown in Fig. 1. The intensity modulation of the foot pulse was achieved using a grid mask placed immediately in front of the focusing lens. In the last experiments, the modulation amplitude on the target foil was 100 μm with a 40% intensity perturbation ($\delta I/I_0$). In this year, we put a random phase plate (RPP) between the focusing lens and the grid mask. The intensity perturbation was 10% for the present experiment. The intensity of the foot pulse was 4 ×10^{12} W/cm^2 or 5 ×10^{13} W/cm^2.

The areal-density perturbation growth was measured using a face-on x-ray backlighting technique. A zinc (Zn) target was irradiated to generate ~1.5 keV quasi-monochromatic x-rays coupled with a 10-μm-thick aluminum filter. Temporal evolution of the transmitted x-rays from the Zn backlighter through a diamond or PS foil was imaged through a slit onto the photocathode of an x-ray streak camera.

Examples of raw streaked backlit images of the diamond and PS targets are shown in Fig. 2. The time origin (t = 0) was set as the half maximum of the onset of the drive pulse. Time-integrated lineouts were obtained for each temporal resolution duration. Figure 2 also shows the lineouts for both two targets at t = 1.6 ns. The areal-density perturbations were obtained by fitting the convolutions of the resolution functions and the sinusoidal perturbation functions to the raw lineouts. In the past experiments with intensity modulation of 40%, we found a spiked dip structure on the diamond surface. However, the present data with intensity modulation of 10% shows sinusoidal perturbation on the diamond surface.

We have been trying to figure out the difference in the shape of the perturbation with modified incompressible model as well as two dimensional radiation hydrodynamics code calculations.

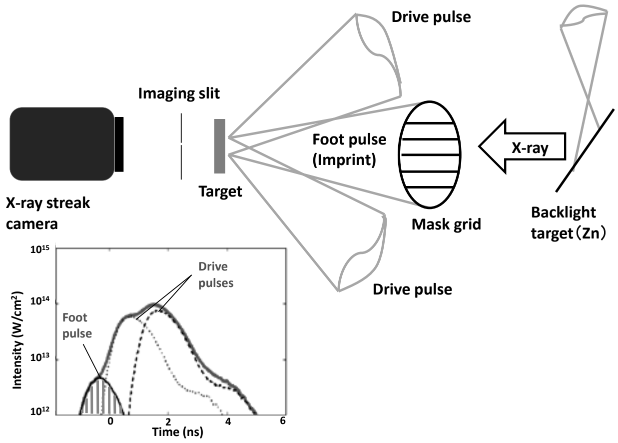

Fig. 1. Experimental setup for measurement of areal-density perturbations seeded by nonuniform irradiation. The pulse shapes for the irradiation laser are also shown.

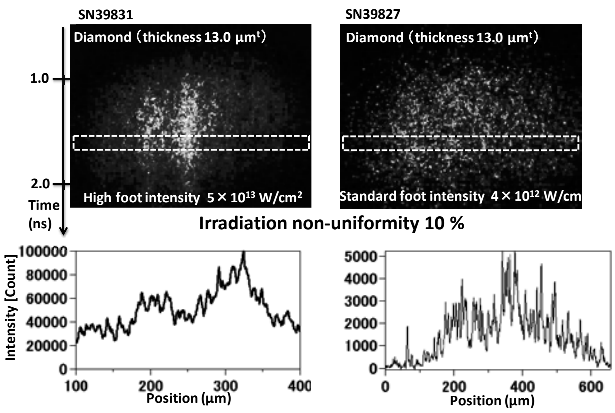

Fig. 2. Raw streaked images of the backlit diamond with foot pulse intensity of 4 ×10^{12} W/cm^2 or 5 ×10^{13} W/cm^2. The lineouts were taken at 1.6 ns after onset of the main drive pulse.