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Present status of direct-heating of imploded spherical shell target toward inertial fusion energy
球殻ターゲットを用いた直接加熱レーザー核融合実験の進捗

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We have been conducted high-rep. inertial fusion experiments on the basis of counter-irradiating direct heating scheme. We report the present status of experiments that tailored pulses with 2.5 J/25 ns foot and 0.5 J/0.3 ns peak implode a spherical shell target of 500 μm in diameter and 7 μm in thickness and sequence pulses with 0.4 J/150 fs direct heat this imploded core. In the series of shot, we have succeeded in energy deposition into the imploded core center.

1. Introduction

The burning of inertial confinement fusion (ICF) is achieved in National Ignition Facility (NIF) in 2014 [1]. To realize inertial fusion energy (IFE), we required an improvement of the energy coupling efficiency from laser to fuel core plasma, which was limited to 0.8 % in the NIF experiments. Present NIF experiments have been adopted so-called indirect scheme [2] to produce a central hot spot. In contrast, direct scheme with advanced ignition such as fast ignition [3-6] is considered attractive for IFE because we can expect higher coupling efficiency with lower laser energy.

We are involved in counter irradiating direct heating scheme [7], in which tailed pulses implode a spherical shell target to compose core plasma at first then heating pulses in sequence direct heat this core. This paper represents the present status of direct heating experiments those including the evidence of energy deposition of heating pulses into the imploded core in series shots.

2. Experimental Results

Figure 1 represents the laser block-diagram of HAMA [8] and the schematics of laser irradiation on the spherical shell target. Each counter beam includes three pulses in sequence; “K: 2.4 J/25 ns”, ”L: 0.5 J/300 ps”, and “S: 0.4 J/150 fs”, respectively. The peak laser intensitie was 2 x 10^{13} W/cm^2 for “L” and 6 x 10^{18} W/cm^2 for “S”, respectively. The shell target is consists of deuterated polystyrene with 500 μm in diameter and 7 μm in thickness. This target has two apertures of ϕ 400 μm in perpendicular to the laser axis for making diagnoses of photon emission from a plasma core by using a X-ray streak camera.

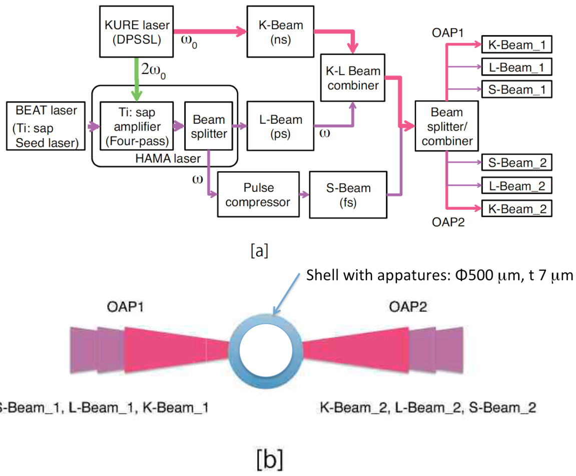

Fig.1. [a] The laser block-diagram of HAMA and [b] laser-target irradiation schematics for counter-irradiating fast heating scheme.

Figure 2 shows X-ray streak images (a) w/o heating and (b) w/ heating pulses. X-ray emission profiles both in time and in space are shown in (c) and (d), respectively. From Fig.2 (a), the broad emission at central region indicates the formation of imploded core by irradiation of “K” and “L” pulses. From Fig.2 (b) and (d), by irradiating heating pulses in addition, the intensity of X-ray emission was increased at the spatial region of 50 μm in center. These figures indicate that we can deposit energy of heating pulses into the imploded core central rather than core edge where heating lasers were irradiated.

Figure 3 shows X-ray streak images for several shots in series. Shot#44 was w/o heating pulses and the other were w/ heating pulses. From Fig.3, we observed central core heating for every shot when heating pulses were irradiated. These results indicate that the direct heating scheme is a promising candidate for improvement of energy coupling efficiency into the plasma core.

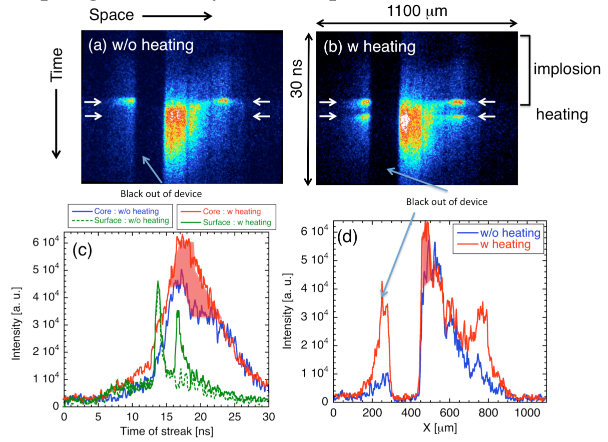

Fig.2. X-ray streak images for (a) w/o heating and (b) w/ heating. (c) X-ray emission profiled in time regions for w/ and w/o heating. (d) X-ray emission profile in space regions for w/ and w/o heating.

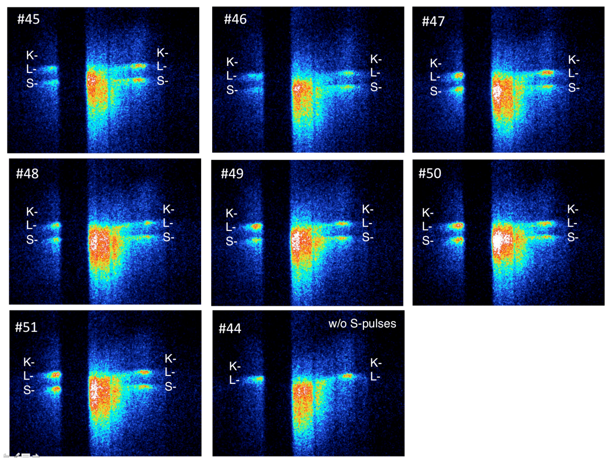

Fig.3. X-ray streak images for several shots in series (#44 ~ #51). Shot #44 is w/o heating and the others are w/ heating

3. Conclusions

Tailored pulses with 25 ns foot and 0.3 ns peak implode a spherical shell target of 500 mm in diameter and 7 mm in thickness and sequence pulses with 150 fs duration direct heat this imploded core. We have succeeded in energy deposition into the imploded core center for every shots in repetitive experiments.

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