improvement of the laser beam profile of the multi-lens array using edge shaped plates

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in the direct driven laser fusion, uniform illumination of the spherical target is required. The laser intensity nonuniformity causes the increase of required laser energy for the ignition condition. Recently, various efforts to improve the illumination uniformity on the target have been proposed. However, the elimination of the spatially long wavelength modulation and the control of the intensity distribution on the target are difficult in previous approaches.

An alternative approach for eliminating the long wavelength modulation is the multi-lens array proposed by X. Deng. However, the spherical multi-lens array has fatal disadvantages such as the diffraction fringes due to the lenslet aperture.

We have already proposed a new scheme for eliminating the diffraction fringes from the single lenslet pattern using the edge-shaped plate. The diffraction fringes can be removed from the near field pattern on the target (radius: 500 μm) by shaping the edge structure of the edge-shaped plate. The phase of the beam inside the clear aperture is controlled to eliminate the interference due to the diffraction. The edge-shaped plate is made of a plane parallel glass plate having a continuously increasing curvature at the edge.

The experimental set up is shown in Fig. 1. The lens array of 7 spherical lenses is placed in front of the main focusing lens, which has 380 mm aperture, focal length of 1 m and aspherical surface profile. Each element lens of the 1-D array has 50 mm aperture and focal length of 40 m. The beam spot size on the target is 1 mm. The edge-shaped plate has 40 mm aperture and surface profile of super gaussian function (y/r) = Exp[-ln²(r)/m²], m = 20 mm, n = 88.

The measurement of the beam pattern was made with TV camera. The beam pattern was digitized and analyzed by the image processing device. The intensity distribution of single beamlet with and without the edge-shaped plate is shown in Fig. 2(a), (b). These intensity distribution include the intensity modulation due to the original beam modulation.

One dimensional intensity distributions of beam patterns of lens array on the observation plane are shown in Fig. 3. Figure 3(a) shows the intensity distribution without out the edge-shaped plate. The interference fringe between the individual beamlet is incompletely shown in small scale intensity modulation. In Fig. 3(a), the intensity distribution is modulated due to the Fresnel diffraction rings. In this case, the diffraction rings are incompletely overlapped due to the alignment error of each element lens. Figure 3(b) shows the intensity distribution with the edge-shaped plate. The beam profile does not include diffraction rings, and the intensity modulation have been improved significantly.

This work has demonstrated the effectiveness of the edge-shaped plate in the multi-lens array for obtaining a uniform beam profile (in this case, the flat top) on a small size target. One of the largest advantage of our method is the elimination of defocusing of the target which is necessary in the previous approach. Further investigation will be made on two-dimensional lens array and on the aspherical multi-lens array to control the beam shape on the target.


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Fig. 1. Experimental set up for evaluating 1-D lens array.

CtuK85 Fig. 2. Intensity distribution of the single lens beam pattern with and without the edge-shaped plate.

CtuK85 Fig. 3. Intensity distribution of 1-D lens array of 7 spherical lenses with and without the edge-shaped plate.

CtuK86

Apodization by color centres apertures on the Dolphin laser

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Among different types of apodizers which minimize diffraction rings, the most widespread in inertial confinement fusion systems for our knowledge are: serrated, sandblasted, liquid crystal, and sintered glasses apertures.

In papers in refs. 1–3 two techniques for fabrication of transparent layers with variable absorption for 1.06 μm apodizers in MeF₂-Tr and MeF₂-A crystals (where Me = Ca, Sr, Tr = Pr, Er; A = Li, Na, K) have been described: (1) electron beam coevaporation of the edges of transparent crystal, and after that bleaching of small parasitic absorption in the centre by UV light; (2) additive coloration in visible spectral region of the whole bulk of crystal, and after that formation of near-IR absorption bands at the edges of crystal by irradiation of UV-light at elevated temperatures.

Flat-topped transmission profile apodized apertures made by both these techniques of 45 mm and 12 mm in diameter correspondingly have been investigated in the 1.06 μm Dolphin ICF laser installation of P. N. Lebedev Physical Institute.

The transmission profiles of electron beam colored CaF₂-Pr apodizers are shown
apodizer (Fig. 3c, top part) with transmission profile of curve 1 (Fig. 1) and crystal diameter of 45 mm, and in the same place without any additional apertures (Fig. 3c, bottom part). Output apodizer beam passed through three amplifiers with rod dimensions of 45 mm × 630 mm.

We observed the significant improvement of beam homogeneity by suppressing Fresnel diffraction rings with apodizers. Apodized apertures at 45 mm in diameter CaF2 were not damaged at −3 J/cm² (3 ns pulse duration) in 1.86 μm large beams.

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CThK86

Transmission profile of CaF2:Pr apodizers fabricated by electron beam coloration.

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Transmission profile of CaF2:Li apodizers fabricated by additive coloration and UV irradiation at elevated temperatures.

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The burn patterns on photoplates of beam cross-sections of Dolphin laser. Top set of beam spots—

in Fig. 1, and additive colored CaF2:Li in Fig. 2.

Figure 3 illustrates the results of using apodizers in the Dolphin laser beam. Beam spots are compared at 8 m from the additive colored CaF2:Li apodizer (Fig. 3a, top part), and same diameter hard-edge apertures (Fig. 3a, bottom part) after beam passing through two amplifiers with 30 mm × 630 mm rods.

Figure 3b shows beam spots at 16 m from the output of the same apodizer (Fig. 3b, top part) and without any additional apertures (Fig. 3b, bottom part). In difference with Fig. 3a, the apodizer was placed at the early stage of amplifier system, and in addition to two amplifiers of Fig. 3a case, beam after apodizer passes through two amplifiers with 20 mm × 630 mm rods.

Figure 3c shows beam spots at 16 m from the electron beam colored CaF2:Pr apodizer (Fig. 3c, top part) with transmission profile of curve 1 (Fig. 1) and crystal diameter of 45 mm, and in the same place without any additional apertures (Fig. 3c, bottom part). Output apodizer beam passed through three amplifiers with rod dimensions of 45 mm × 630 mm.

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CThK87

Chirped pulse amplification using a dye-converter-free, flashlamp-pumped Tisapphire amplifier.

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Because of its large stimulated emission cross-section, high saturation energy and wide gain bandwidth, Ti:sapphire is an important amplification medium for terawatt-level laser systems based on chirped pulse amplification (CPA). Additionally, superior thermal properties and well-developed crystal growth technology of Ti:sapphire make scalability to higher energy system possible without sacrificing repetitive operation. Since its short upper state lifetime (3 μs) makes flashlamp pumping difficult, most Ti:sapphire-based CPA laser systems use laser-pumped amplifiers. However, flashlamp-pumping of Ti:sapphire amplifiers has advantages over laser-pumping in terms of simplicity of configuration and scalability to higher output energy. Although 500-mJ output has been successfully demonstrated from a flashlamp-pumped Ti:sapphire amplifier in a CPA laser system, a dye converter was used in the amplifier, increasing the complexity and required maintenance of the device.

In this paper, we report on measurements of small and large signal gain of a flashlamp-pumped Ti:sapphire amplifier without any dye converter in a CPA system and confirm that this amplifier will deliver >0.5 J output.

The seed pulses for this experiment are derived from a Ti:sapphire laser system which produces 50-mJ, 125-fs pulses at a wavelength of 810 nm and a repetition rate of 5 Hz. Pulses from a mode-locked Ti:sapphire oscillator are stretched to 380 ps in a grating pulse stretcher and amplified to the 7-mJ level in a regenerative amplifier. Further amplification up to the 100-mJ level occurs in two Ti:sapphire amplifiers separated by a vacuum spatial filter. All amplifiers to this point are pumped by the second harmonic of Q-switched Nd:glass oscillator/Nd:YAG amplifier system. The crystal used in the flashlamp-pumped am-