JP0055458

Computational Study of Laser Imprint Mitigation with X-Ray Radiation Using an Integrated Code

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Abstract. The initial imprint of density perturbation due to spatial nonuniformity of laser intensity is one of the most important issues in laser fusion research. The imprint mitigation scheme by use of soft x-ray radiation has been proposed to reduce the laser nonuniformity through the thermal conduction region. We present the results of two-dimensional simulation concerning this issue using our integrated code.

1 Introduction

In laser fusion, the initial imprint of perturbation to a target due to spatial nonuniformity of laser intensity is critical issue, since it becomes a seed of hydrodynamic instability which will prevent the spherical implosion. The laser energy is absorbed in the vicinity of the cut-off density and the absorbed energy is transported to the ablation surface by the electron thermal conduction. Therefore, a nonuniformity of the absorbed energy is expected to be suppressed through the thermal conduction region[1]. The width of this region is so called a stand-off distance, D_{AC}.

The external x-ray preirradiation scheme[2] has been proposed to suppression the laser imprint with x-ray radiation. In this scheme, the target is irradiated by x-ray before laser incidence, so that the preformed plasma is uniform. This preformed plasma forms a stand-off distance before laser irradiation.

2 Numerical Methods

We have been developing the integrated code ILESTA-2D[3] for laser fusion and related physics, numerical scheme of which is based on two-dimensional arbitrary Lagrangian Eulerian (ALE). This code includes the various physical processes of laser fusion to simulate the implosion. In our calculations, hydrodynamics, laser absorption, thermal conduction, radiation energy transport, opacity, and realistic EOS are consistently treated.

The radiation energy transport is calculated by the multi-group diffusion approximation with an Eddington factor. A tabulated opacity based on the averaged ion model is used.

3 Results and Discussion

As schematically shown in Fig. 1, the x-ray source is emitted from Au foil located at a distance of 1.8mm from the target and the foil is irradiated by the laser of 0.53μm wavelength and intensity 5.3×10^{13}W/cm^2. Time evolution of the radiation is calculated

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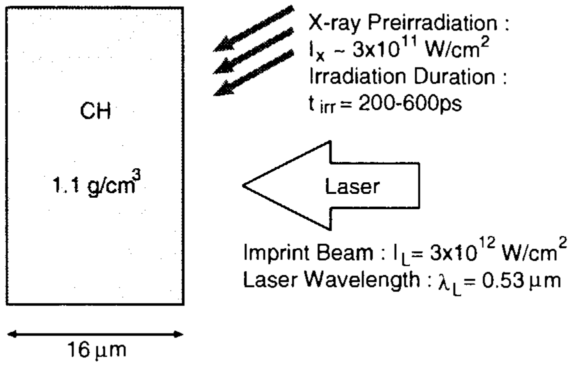

Figure 1: Simulation condition of the x-ray preirradiation scheme.

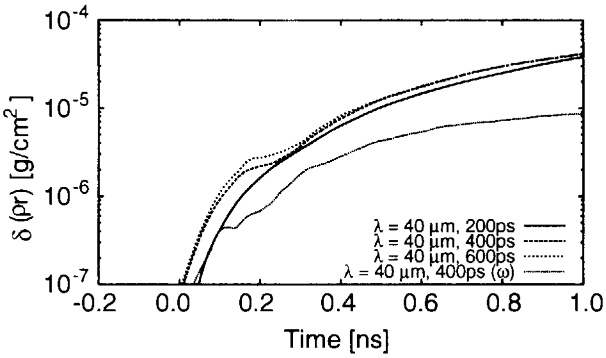

Figure 2: Time evolution of the areal density perturbation $\delta(\rho r)$ of the target

by one-dimensional code ILESTA-1D[4] and is used as the input for the outer boundary of two-dimensional calculation.

The spatial nonuniformity is assumed to be sinusoidal with $\delta I/I = 10\%$ and its wavelength, $\lambda = 40\mu$m. We can see that the dependency of the areal density perturbation on the x-ray irradiation duration is weak as shown in Fig. 2. This is because the stand-off distance is rather independent of the irradiation duration. On the other hand, the stand-off distance is enhanced when longer wavelength laser of $\lambda_L = 1.06\mu$m is used, and the imprint mitigation is seen in the two-dimensional calculation.

In the corresponding experiments at ILE[2], the nonuniform irradiance mitigation has been found more clearly. One of the reasons of the disagreement is that the emission spectra from Au foil are not sufficiently accurate in ILESTA-1D code[5]. Since the opacity calculations by non-LTE treatment for the emission spectra from high-Z material depend on the atomic model, we should improve them for detailed calculation.

4 Conclusion

We present the results of two-dimensional simulation of laser imprint mitigation scheme by use of x-ray radiation. It is found that the preformed plasma created by the x-ray source cannot directly suppress density perturbation due to laser nonuniformity. It is important that we seek the condition of keeping the long stand-off distance during nonuniform laser irradiation.

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