§55. High Density Implosion with the High-Z Doped Target

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i) Introduction In order to achieve the high gain thermonuclear burn in the inertial confinement fusion, a high density plasma core should be formed by implosion process. When the shell is accelerated by the compression laser, the ablation surface of the shell is unstable due to the Rayleigh-Taylor instability. Growth of the Rayleigh-Taylor instability can easily reduce the implosion performances, and resultant imploded plasma density is significantly suppressed from that expected for the ideal spherically symmetrical implosion. Therefore, the reduction of Rayleigh-Taylor instability is critical issue of the inertial confinement fusion research. For the direct-drive implosion, we usually the plastic ablator (CH). If the high-Z material such as bromine (Br) is doped into the plastic target, the radiation emitted by high-Z material can efficiently conduct the thermal energy in to high dense region in addition to the electron thermal conduction. Finally, the double ablation takes place, where both electron ablation (EA) due to the electron thermal conduction, and radiative ablation (RA) due to the radiative energy transfer by the emission of doped high-Z material, are formed. The radiative ablation gives generally the high mass ablation ratio, and lower Rayleigh-Taylor growth rate, compared to that by the electron ablation. Thus, this high-Z doped target can reduce the Rayleigh-Taylor growth in the implosion process. In our research, we are going to achieve following goals; 1) experimental demonstration of reduction of Rayleigh-Taylor instability, by S. Fujioka (Osaka University), 2) fusibility demonstration of introduction for the fast-ignition experiment, by A. Sunahara (Institute for Laser Technology), 3) theoretical and simulation research on the double ablation. by A. Sunahara (institute for Laser Technology), N. Ohnishi (Tohoku University), Philippe Nicolai (CELIA) and Marina Olazabal(CELIA), 4) Target fabrication of CDBr for the current experiment by Y. Fujimoto (Osaka University), 5) Fundamental research on high-Z doped target by K. Nagai (Tokyo Institute of Technology), and T. Norimatsu(Osaka University). In this report, we described our achievements in 2013.

ii) Experimental demonstration of low-Rayleigh-Taylor growth in the implosion We have tested reduction of Rayleigh-Taylor instability by using Sphere CDBr target ($C_{500}H_{497}Br_3$) in the implosion by GXII laser. CDBr sphere was irradiated by GXII 0.53 μm wavelength 12 beams.

We observed the imploded shell by x-ray framing camera for CDBr and CD for the comparison shown in Figs.1(a) and (b) growth.

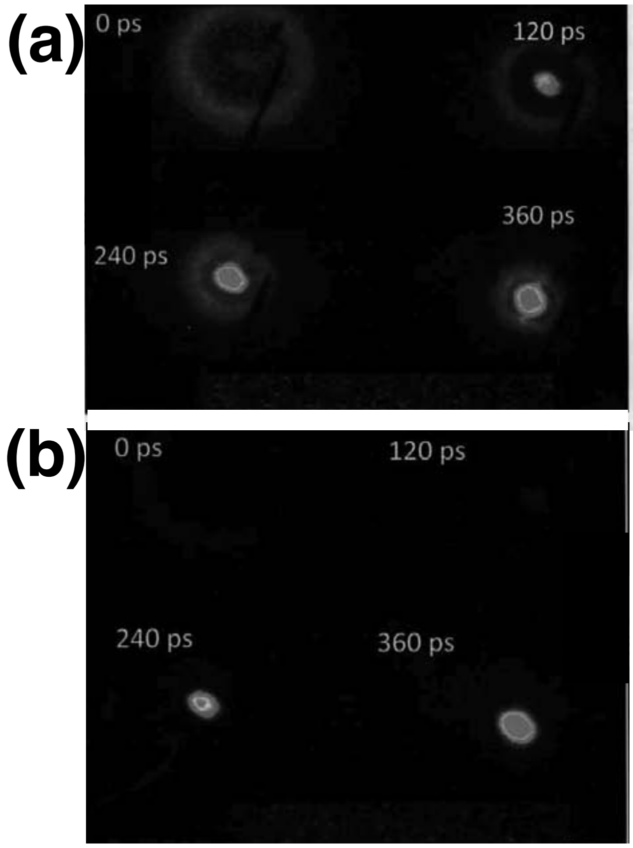

Fig. 1: X-ray framing images. (a) CDBr implosion (b) CD implosion.

iii) Radiation hydrodynamic simulation for the sphere implosion We conducted 2D radiation hydrodynamic simulation for the shell implosion. We compared CDBr and CD targets from the implosion density point of view. Simulated results show that CDBr with 0.3% Br dope can give higher implosion density for the higher number of Raylegh-Taylor perturbations. However, for the lower modes of perturbations, the core density of both targets is similar.

iv) Conclusion In 2013, we demonstrated that quite low doping amount of 0.3 atomic % to the plastic target is effective for reducing the Rayleigh-Taylor instability in the implosion by GXII laser system. However, the implosion velocity of CDBr is slower than that of CD, although both planar targets of CDBr and CD represent similar trajectories in the target acceleration experiment conducted in 2012. This means that optimization of amount of Br dope in the implosion is still not good. Optimum dope is less than 0.3% because the density profile of the in-flight shell in the implosion is higher than that for the planar one, and results in the larger radiation energy loss. Also, we evaluated the reduction of the Rayleigh-Taylor growth and final core density for both CDBr and CD targets by 2D hydrodynamic simulations.