§31. Design Study on Foam-cryogenic Targets by Integrated Simulations

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The purpose of this study is to analyze the recent fast ignition experiments with cone-guided targets and carry forwards a design of form-cryogenic targets, on the basis of the integrated code system, FI^3. In FY2008, the following simulations were conducted.

1. Cone-Tip Effects

On the basis of one-dimensional coupled PIC and Fokker–Planck simulations, the core heating properties of different cone materials for sub-ignition class experiments of the cone-guiding fast ignition have been studied.

The results of 1D PIC simulations for Au and CH cones are shown in **Fig.1**. When Au is used as a cone tip material, the Au atoms are ionized to a high charge state during the interaction with a heating pulse in a few hundreds of femtoseconds. Because of the extreme photon pressure, the pulse starts to interact directly with a solid-density cone tip after the density slope is steepened. In addition, the electrons in the return current are strongly scattered by the highly ionized Au ions. In such a situation, the energy coupling of the heating laser to the fast electrons could drop drastically. For the CH cone case, the beam intensity keeps high after density steepening occurs since the collisional effects are small. Thus, the energy coupling of heating laser to fast electron becomes twice as high as that for the Au cone case.

The following core heating process was simulated with FP transport code using the fast electron profiles obtained in PIC simulations as the source term. The temporal evolution of core temperature obtained for the Au and CH cones are plotted in **Fig.2**. In the Au cone case, during the transport in the cone tip, the quality of the generated fast electron beam deteriorates due to the collisional and resistive drags and the scattering by the Au ions. As a result, the core heating gets saturated quickly and the energy coupling efficiency of the heating laser to the core decreases. It is found that in comparison with the Au cone tip, a twice higher rise in temperature of a compressed CD core has been achieved with the CH cone tip after 1 ps heating by a 10^{20} W/cm^2 intensity pulse. Therefore, we proposed CH as an alternative material of cone tip to reduce the collisional effects.

2. Cone Tip Deformation Due To Plasma Jet

In the final phase of implosion of cone-guided shell targets, the cone tip is attacked by the jet-like plasma flow from the imploded core. If the cone tip is breached before heating laser injection, the cone inner region is fulfilled by low-density plasma, which will strongly affect the fast electron generation and the following core heating. To evaluate the required cone tip thickness to keep the cone inner region clean until the maximum compression, 2D implosion simulations were carried out for cone-guiding CD shell targets, where the cone inner region is filled with Au or CD.

In **Fig.3**, temporal evolution of core average density and front position of the shock wave propagating from the cone tip. The shock propagation velocity is higher when the cone is filled with low-density CD. This indicates that the thicker cone tip is required for CD or CH cone tip compared with conventional Au cone tip to prevent the cone tip from being breached.

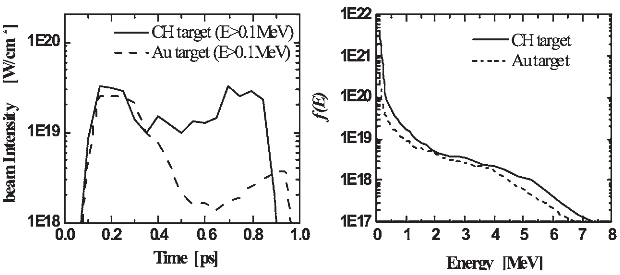

Fig.1 Results of 1D PIC simulations; the left one is the temporal evolution of fast electron beam intensity and the right one the time integrated fast electron spectra for Au and CH cone

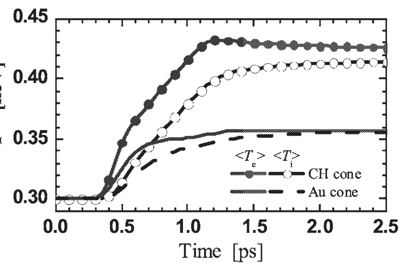

Fig.2 Temporal evolution of averaged core temperature ($<T_e>$;:electron, $<T_i>$: ions).

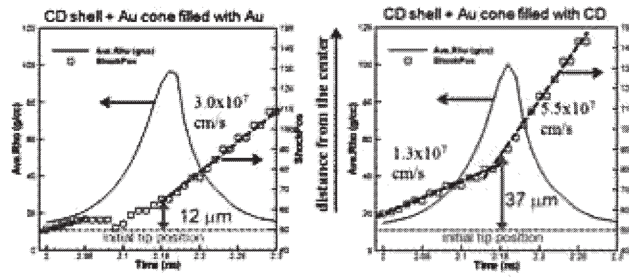

Fig.3 Temporal evolution of core average density and front position of the shock wave propagating from the cone tip when the cone inner region is filled with Au and CD.

Major publications

1.T. Nakamura, et al., *Laser Part. Beams* **26**, (2008) 207.
2.K. Mima, *J. Physics: Conf. Series* **112**, (2008) 022005.
3.T. Nakamura, et al., *J. Physics: Conf. Series* **112**, (2008) 022049.
4.H. Nagatomo, et al., *J. Physics: Conf. Series* **112**, (2008) 022053.
5.T. Johzaki, et al., *J. Physics: Conf. Series* **112**, (2008) 022054.
6.H. Sakagami, et al., *J. Physics: Conf. Series* **112**, (2008) 022070.
7.T. Johzaki, et al., *Plasma Phys. Control. Fusion* **51**, (2009) 014002.