§49. Plasma Channel Formation in Imploded Plasmas

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As the basic research of "super-penetration" fast ignition[1)], we conducted an experiment to investigate the ultra intense laser propagation in an imploded plasma at GXII and LFEX facility in ILE, Osaka University. The propagation in a dense plasma was observed via Cu-Kα emission inside the plasma by using a small amount of dopant of copper ions in the CD shell. The LFEX is focused at the positions corresponding to the critical density of imploded plasma based on the previous experimental results. The Cu-Kα emission image was observed with a crystal imager with 6.2 times magnifications and the absolute emission intensity was detected with the calibrated HOPG spectrometer. In the last year's campaign, we observe the enhancement of Cu-Kα emission at the core region by optimizing the focusing position, which exhibits the fast electron propagation toward the core.

However the target used in the previous experiment has a uniform copper doping in the shell wall, leading to a high background noise due to strong emission during the implosion. In addition, the implosion speed and maximum core density became significantly reduced because of energy loss via emission. So we developed a new target with a thick CH overcoat onto the inner Cu-doped CD layer. The thickness of the coating layer is determined by the ablated shell thickness from a 1-D MHD calculation. Also, in order to keep the copper ion number in the core, the dopant ratio increases as twice compared to the last year's shell.

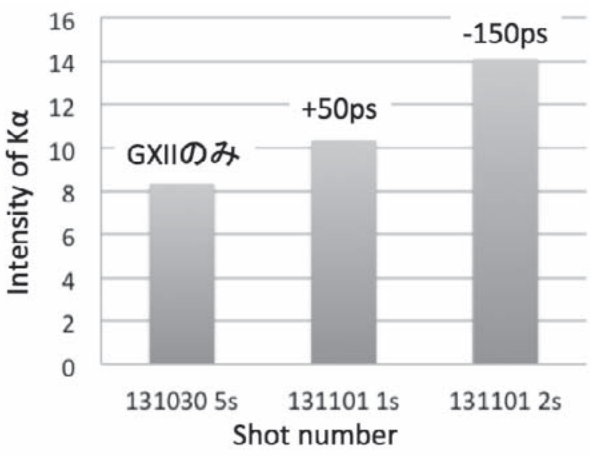

Fig. 1. Cu-Kα intensities for GXII only (131030-5s), LFEX injection at +50ps (131101-1s) and -150ps (131101-2s) detected with HOPG spectrometer.

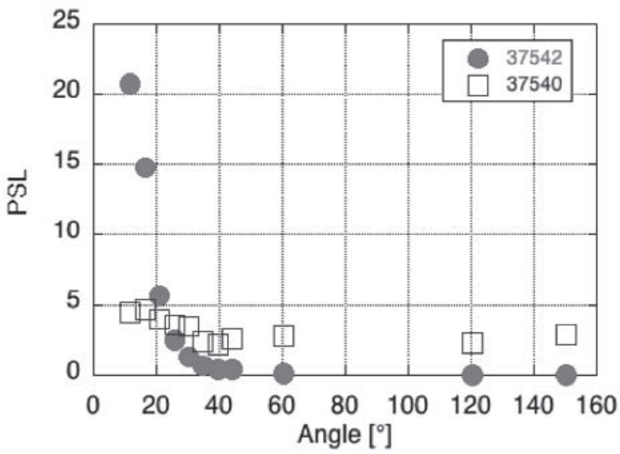

Fig. 2. Angular distribution of Bremsstrahlung X-rays for cone-in-shell experiment (#37540) and super-penetration experiment (#37542).

As the results, the implosion speed becomes recovered as about 0.9 times of that of pure CD shell implosion. The MHD calculation also shows the similar core density to the pure CD shell. Although the Cu-Kα measurements shows the reduction of background noise created in the implosion process, the total amount of signal itself is also small compared to the direct light backgound, which makes difficult a qualitative analysis of the image. On the other hand, HOPG spectrum clearly indicates the enhancement of Cu-Kα emission by injection of LFEX. Fig. 1 represents the total counts of Cu-Kα emission for different shots; GXII only (131030-5s), LFEX injection at +50ps (131101-1s) and -150ps (131101-2s) in respect to the maximum compression timing of the imploded core. Because the cupper ions are concentrated on the core region, the enhancement strongly indicates the fact that the amount of fast electrons passes the core region. This is also confirmed by the results of spatial distribution of electron emission. Figure 2 shows the spatial distribution of Bremsstrahlung X-rays created when the fast electrons hit the target vacuum chamber wall for super-panetration (#37542) and cone-in-shell FI experiment (#37540). The emission obtained at cone-in-shell target shows relatively isotropic emission. On the other hand, the emission in super-penetration significantly collimated toward the laser direction, showing an effective heating to the core.

In summary, intense laser propagation in imploded plasma was investigated for super-penetration fast ignition. Unfortunately, there were miss-shots of GXII laser in the experiment, so that the core density may be smaller than that expected. However we can confirm the validity of CH coating and observe a significantly collimated electron beam. These results imply the feasibility of the effective heating to the core.

1) Lei, A.L et al.: Phys. Rev. E **76** (2007) 066403; ibid, Phys. Plasmas **16** (2009) 056307.