§54. Cu Wire Heated by Fast Electrons for Fast Ignition Study

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Cone-wire targets surrounded with imploded dense plasma have been studied as the fast electron transport in FI-relevant environment. The yield of Kα x-rays from the wire is clearly reduced when the cone-wire is surrounded with plasma, which can be explained with a divergence of the fast electrons after the cone. The results can be utilized as important database to benchmark simulation codes for the study of fast electron generation and transport in the full-scale fast ignition.

In the present experiment, the cone-wire target was surrounded with high-density plasma produced by a plastic shell implosion with GXII laser pulses at the Institute of Laser Engineering, Osaka University. An intense laser pulse from the LFEX laser was focused into the cone at various timings. The cone was made of 7 μm thick gold with an opening angle of 45° and an inner tip of 30 μm in diameter. A 50-μm-diameter copper wire was glued on the cone tip and its length was 250 μm, equivalent to the radius of the shell with a thickness of 7 μm. The implosion was performed with 9 beams of GXII with an energy of ~250 J/beam in 2ω with a pulse duration and a focused spot of 1.3 ns and 500 μm, respectively. The LFEX laser energy was varied from 0.5 to 0.9 kJ with a 2 ps pulse width. The fast electrons interact with the wire and produce the Cu Kα x-rays (8.05 keV). The spatial profile of the Kα x-rays along the wire was measured with a Bragg crystal imager. The x-ray energy spectrum was also measured with a spectrometer using a HOPG crystal. The energy spectra of fast electrons were measured on and off the wire axis, as well as various x-ray diagnostics including streak cameras to monitor the LFEX injection timing. Since the fast electron transport in the wire could be affected by the shock compression and/or heating of the wire due to the imploded plasma, the LFEX injection timing was carefully adjusted.

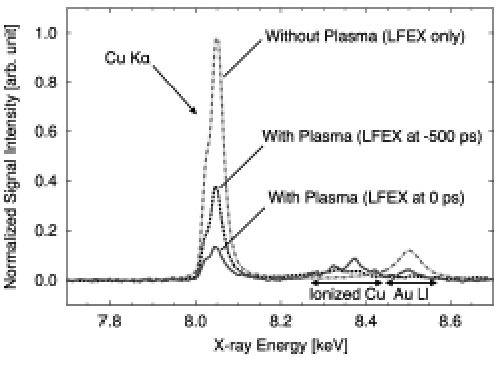

Fig. 1. X-ray spectra emitted from cone-wire targets.

Figure 1 shows the intensity of Kα x-rays observed under various LFEX injection timing. In the case when the LFEX was injected at the maximum compression timing (t = 0), the observed results and the hydrodynamics simulation results indicate; 1) the coupling efficiency into the wire was clearly reduced (down to ~20%) compared to the case without the surrounding plasma, 2) the wire was partially heated and could be disturbed because of the shock compression. To avoid the shock effects, the LFEX was injected at –500 ps since hydrodynamics simulation results show that the most part of wire remains cold with its solid density in the original shape but the cone-wire is surrounded by plasmas at ~500 ps prior to the maximum compression timing (i.e.–500 ps). In this case, the signal is increased compared to the case of 0 ps. However, signal reduction down to ~30% is observed. This signal reduction may be explained with the large electron beam divergence at the source. Results of hybrid particle-in-cell simulation shows that a significant number of fast electrons escape from the wire quickly when the wire is surrounded by plasma.

Cone wire target surrounded with imploded dense plasma have been studied to understand the fast electron energy transport. Kα x-rays from the wire has decrease substantially when surrounded by the implosion plasma. This is consistent with the increased divergence of fast electrons due to the existence of surrounding plasma. This work was performed under the auspices of the NIFS Collaboration Research program (NIFS11KUGK055).