Reproducibility of plasma generation in a laser ion source with liquid metal target using a rotating drum

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Ion beams have been increasingly applied in various fields such as cancer therapy and nuclear fusion, leading to a growing demand for higher beam intensities. Consequently, ion sources capable of producing high-current beams are also required. In particular, heavy ion inertial fusion needs the continuous delivery of ion beams with currents of about 500 mA[1]. To meet these demands, laser ion sources (LIS) have gathered significant attention.

A laser ion source generates plasma by irradiating a solid target with a high-intensity laser and inducing ablation. This method is suitable for the generation of high-current ion beams because it can produce high-density plasma. However, since each laser shot leaves a visible damage on the target surface due to the ablation, the target position must be moved after each pulse. As a result, the number of laser shots is limited by the surface area of the target, making periodic target replacement inevitable.

To achieve continuous and highly reproducible plasma generation, we have proposed a novel LIS system that employs liquid bismuth as the target material. In this system, a thin film of liquid bismuth is formed on the inner surface of a rotating drum, and the laser is irradiated onto this film. This approach allows the ablation spot to self-repair, enabling continuous laser irradiation at a fixed location without damage on the target and also continuous generation of high-current ion beams. An additional advantage of this setup is that the centrifugal force generated by the rotating drum suppresses the splashing of the liquid metal during laser irradiation.

In this study, we investigated plasma reproducibility as a function of the drum's rotational speed, ranging from 20 to 300 rpm. We also conducted single-shot and 1–10 Hz repetitive laser irradiations to evaluate reproducibility. This presentation discusses the dependencies of plasma reproducibility on drum rotation speed and laser irradiation frequency.

References

[1] Joe W. Kwan, IEEE Transactions on Plasma Science, **33**, 1901 (2005)