Creation of cocktail beam from alloy target with laser†

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Lasers can create many types of heavy ions from a solid target. Therefore, with the use of a laser and an alloy target, an ion beam composed of several elements can be easily created. The cocktail beam can be used to simulate cosmic rays in a laboratory. A recent paper reported the enhancement of a plasma flux by mixing a few different types of species with an original target.[1)] However, the charge state distribution of each ion was not studied. To create a controllable cocktail beam, we investigated the charge state distributions of laser plasma from an alloy composed of Al and Fe.

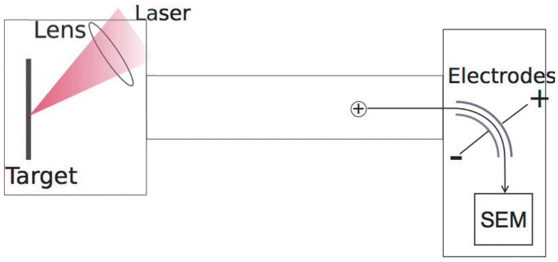

Fig. 1. Schematic of experimental setup.

Figure 1 shows a schematic of the experimental setup. We used a Nd:YAG laser (1064 nm, 6 ns, 615 mJ, and 7.9×10^{-3} cm^2 spot size) for ablation. As the targets, we used pure Al, Fe sheets, and an alloy of Al and Fe (AL-FE-01-F.ALLY) with Al:Fe = 10:19 (number). The chamber was evacuated to 5×10^{-4} Pa. The charge state distribution was measured through a time-of-flight (TOF) method using a cylindrical electrostatic ion energy analyzer. The device was composed of two coaxial electrodes, with a slit in front of the electrodes, and a secondary-electron-multiplier detector (SEM) placed at 3.3 m from the targets. Only the particles with a specific velocity and ratio of charge to mass could pass through the electrode. In addition, we could determine the velocity of particle reaching the SEM from the time of flight. Consequently, we could obtain the ratio of chare to mass and identify the ion.

Figure 2 shows the experimentally obtained results ratios of peak ion flux from the alloy target to the peak ion flux from the pure targets. As shown in the figure, they were Al 1^+: 0.5, Al 2^+: 0.68, Al 3^+: 0.58, Al 4^+: 0.27, Al 5^+: 0.27, Al 6^+: 0.65, Al 7^+: 0.84, Al 8^+: 0.89, Al 9^+: 0.34, Fe 1^+: 0.72, Fe 2^+: 0.60, Fe 3^+: 0.51, Fe 4^+: 0.65, Fe5^+: 3.5, Fe 6^+: 15. Total peaks up to a 4^+ charge state of the Al and Fe ions from the alloy targets were around half those from the pure targets. Hence, the ratios of the peak value were close to the stoichiometric ratio in the target material (Al:Fe =10:19). On the other hand, the ratios of highly charged states were larger than the composition ratio; in particular, Fe 5^+ and Fe 6^+ were much larger than those of the other ions.

The results showed that we can control the ratio of the flux of the Al to Fe ions, except for Fe 5^+ and Fe 6^+, as a function of composition ratio of alloy. A large increase in Fe 5^+ and Fe 6^+ indicates that we can substantially increase the charge state of a specific ion using an alloy.

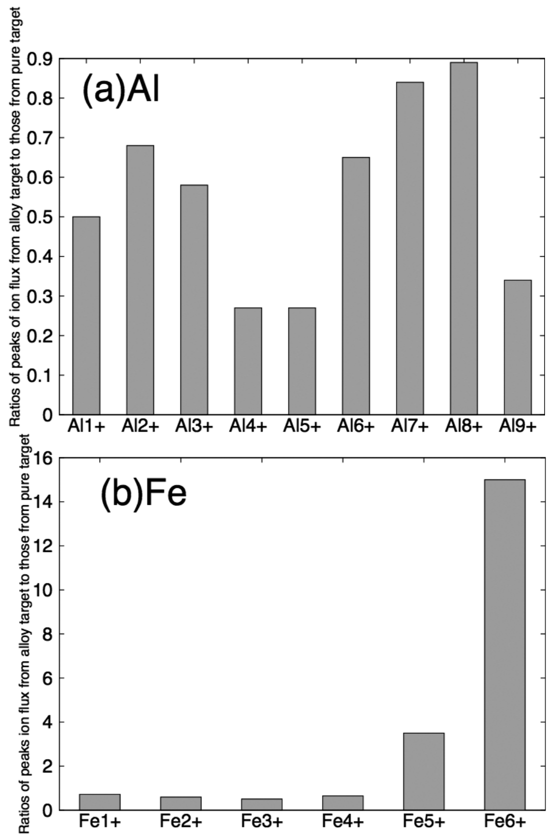

Fig. 2. Ratios of peaks value of Al and Fe ion flux from alloy target to those from pure targets

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References

1) A. Velyhan, J. Krasa, E.Krousky, L. Laska, D. Margarone, M.Pfeifer, K. Rohlena, J. Skala, J. Ulischmied, A. Lorusso, L. Velardi and V. Nassisi : 4th workshop on PPLA2009, Messina, Italy, 165, 6-10 (2010), p488-494