6 - 19 Development of Laser Ion Source at IMP in 2012

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Laser ion sources had been being developed at IMP since 2006 due to its enormous potential in the production of high-intensity and high charge state ion beams especially from refractory material. The experiments on the production of multiply charged ions on a laser ion source were carried out in 2012.

The charge state distribution of the laser plasma was measured for C, Al and Pb. The schematic diagram of the experimental set-up is shown in Fig. 1. A 3 J Nd : YAG laser with a pulse duration of 8 ns was used. The laser beam entering the target chamber through a BK7 window is reflected by a plat mirror and finally focused onto the target by a plano-convex lens at an incidence angel of 45 degree. The charge state distribution was measured with an electrostatic ion analyzer (EIA). The laser produced plasma drifted for 3.6 m to the entrance slit of the EIA. At a given voltage loaded on the electrostatic plate, only those ions with a certain energy-to-charge ratio could go through the EIA and arrive at the secondary electron multiplier located after the exit slit of the EIA. The charge state was determined by the time of flight (TOF). A typical TOF spectrum is shown in Fig. 2. With a series of such TOF measurements at a range of electrostatic fields, a composite plot of the charge state can be obtained, as shown in Fig. 3. In comparison with the presence of naked nuclei and H-like ions in the case of C and Al plasma respectively, the highest charge state of Pb was just Pb^{9+}. The reason for this could be the low electron temperature of the plasma since only a relatively low laser power density on the target (estimated as 10^{12} Wcm^{-2}) could be achieve with a 3 J Nd : YAG laser. Another possible reason would be ion recombination during the process of plasma drifting. To confirm this further investigations are needed.

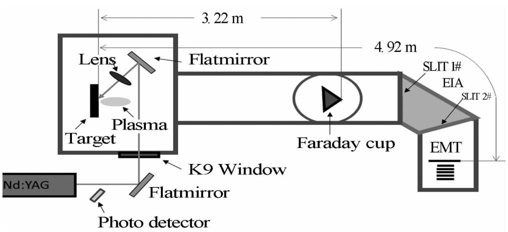

Fig. 1 Set-up for laser plasma experiment.

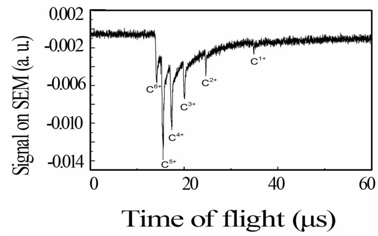

Fig. 2 Time-of-flight spectrum for C plasma.

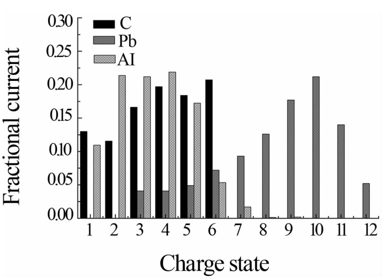

Fig. 3 Charge state distribution of C, Al and Pb plasma.

A preliminary experiment on the extraction of laser produced ion beams was carried out. For this purpose, the target chamber was potentializedwith a high positive voltage. And after drifting 50 cm or so and passing through an aperture at the same potential with the target, the laser ion beam would be extracted by an electrode held at ground potential and monitored by a fast current transformer (FCT). The peak current intensity increasedfrom 6 to 60 emA with the extraction voltage increasing from 0 to 52 kV. The further enhancement of the extraction voltage failed due to sparking.

In order to improve the yield of highly charged heavy ions, a new laser system supposed to deliver 10 J energy has been being developed by FJIRSM (Fujian Institute of Research on the Structure of Matter) since the end of 2011. The oscillators and first two amplifiers have been configured by the end of 2012, which resulted in 3 J of energy. The whole system is expected to be assembled and delivered to IMP in the middle of 2013.