Control of plasma shape with pulsed solenoid on laser ion source

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A laser ion source (LIS) can supply high-current ion beams with solid target. However, the LIS typically forms a sifted-Maxwell-Boltzmann distribution in their current output. This distribution has a peaked output that does not provide constant current over the pulse length. The ability to shape the current output of LIS would increase its versatility as an ion source. In our experiments, we used pulsed magnetic fields to alter the shape of the current output and change the sifted-Maxwell- Boltzmann distribution that is typically produced.

In our experiments, we assembled the test setup shown on the right in Fig. 1. We used a 1064 nm wavelength Nd:YAG laser of Q-switch delay 250 μs and pulse energy 600mJ. Laser pulses were fired into the target chamber at an iron target. The target then ablated into a plasma consisting of +1 iron ions and electrons. The plasma moved past 20 cm of empty space into a 12 cm long solenoid, the pulsed solenoid. The plasma then passed through drift tubes and into a Faraday cup 3.3 m away and of apearture 10 mm. We could control the time for which the pulse was fired relative to the laser's firing time t_p, and the peak of the magnetic field B_{max}. The solenoid had turns 50, its length was 12 cm, and its radius was 44 mm.

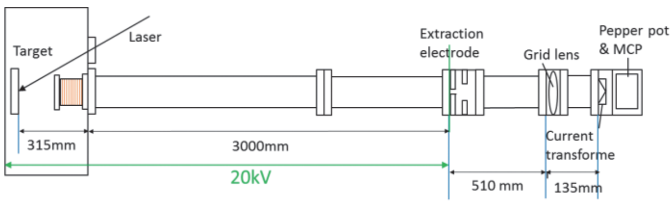

Fig. 1: Experimental setup

The pulsed solenoid was exposed to various magnetic fields ranging from 26 gauss to 510 gauss, as shown in Fig. 2. We altered the time for which the pulsed solenoid was fired from 1μs after the laser was fired to 20 μs after the laser was fired.

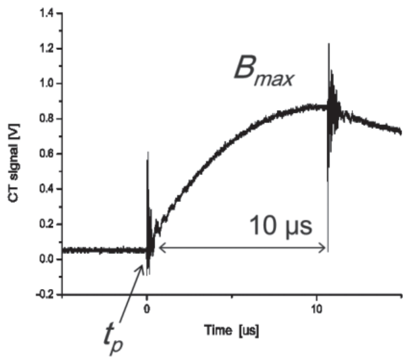

Fig. 2 Supplied magnetic shape by pulsed solenoid

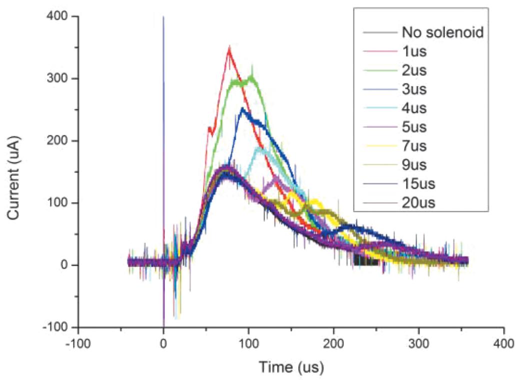

Fig. 3 current shapes for different delays

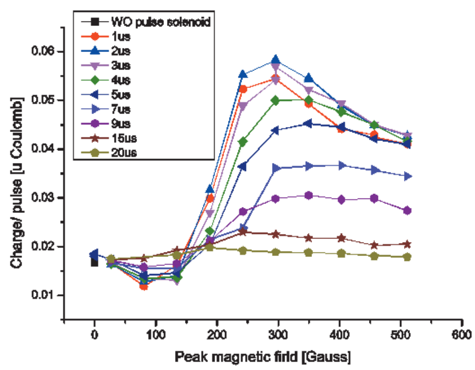

Fig. 4 Maximum current for different delays and magnetic fields

The obtained current shape for different delays is shown in Fig. 3. Magnetic pulses with delays ranging 15 μs and 20 μs range yielded results that appeared nearly identical to the results obtained without a pulsed solenoid. In all cases, the plasma followed the curvature of the pulsed solenoid's magnetic field lines into the pulsed solenoid. Fig. 4 shows the maximum current for different delays and magnetic fields in our experiments. Magnetic pulses with magnitudes lower than 188 gauss also had almost no effect on the shape of the plasma that we recorded. These results show that our technique can be effective in shaping the current of LIS.

We found that the solenoid field could change the beam shape. To control beam flexibility, we may need to control the pulsed field using multiple power supplies or multiple coils. Although the further studies are required, the pulsed solenoid is useful to control the beam current shape, which is a unique.

References

1)Kazumasa Takahashi, etc. AIP Conf. Proc. 1525, 241 (2013).

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