집속된 레이저빔에 의한 레이저 유도 플라즈마 채널의 형성 및 팽창에 관한 연구

Plasma Channel Expansion in a Laser-Induced Plasma (LIP) Using a Focused Laser Beam

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Propagation of an intense laser pulse through fully ionized plasma has been an interesting topic in many fields. It includes laser-driven electron accelerators,(1) generation of high harmonics,(2) soft x-ray laser development (3) and so on. Specifically, in the application of laser-driven electron accelerators a large laser-plasma interaction length is required to get sufficient acceleration energy of electron. The plasma wave-guide has made possible one of the major goals in intense laser-matter interaction physics. Important to this application is detailed knowledge of the evolution of the shock wave in the plasma, which leads the electron density profiles forming the wave-guide. In the current work, we present time resolved shadowgraphs as well as Mach-Zehnder interferograms of the plasma and shock wave produced by a focused laser beam in a gas jet or in a gas chamber.

The present study reports both the Mach-Zehnder and optical shadowgraphs measurements of plasma channels in underdense plasmas of nitrogen produced by a gas breakdown at the focal spot of a laser. Temporal evolution of the plasma as well as shock wave were measured to interpret their thermodynamic behavior (i.e., shock velocity and electron number densities in the plasma), which are closely related to the formation of the plasma channel in the laser-induced plasma. Fig. 1 shows a typical time-dependent radial (r) electron density profiles obtained in a gas chamber filled with 100 torr of N_2 gas. As shown in the figure, the on-axis electron density was increased by 5 ns with approximately 3.8×10^{18} cm^{-3} giving the ionization level of $Z^{*}\sim1$. At time t $\geq$ 7 ns, the on-axis electron density was decreased. Fig. 2 shows the radial (r) electron density in a gas jet with backfill pressure of 30 bars. The density profiles shows slowing of the expansion and flattening of the central density. The peak on-axis electron density of 3×10^{18} cm^{-3} was observed at 3 ns. Experimental results showed that the shock wave decoupled from the hot plasma core at early time, $t \geq 1$ ns, and the shock expansion speed was increased faster and further with increasing the laser energy as well as applied gas pressure. In addition, electron density minimum on-axis was observed in a gas jet with initial shock expansion speed of 1.0×10^{6} cm/sec and corresponding electron temperature of 1.0×10^{2} eV.

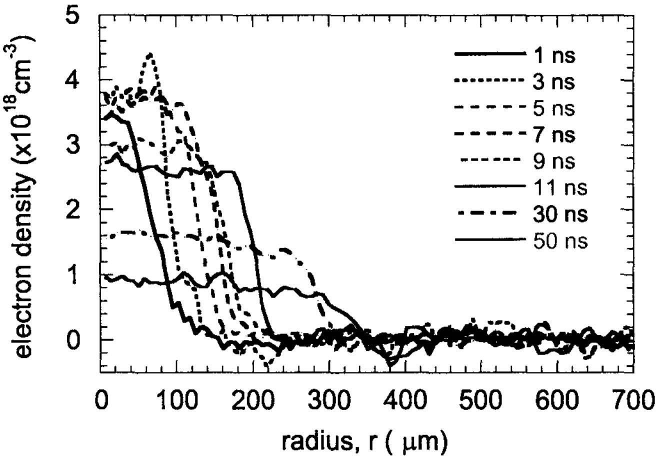

Fig. 1. Time dependent electron density of N_2 gas in a gas chamber. The gas chamber was filled with 100 torr of N_2 gas. An Nd:YAG (532 nm) laser was employed as a radiation source (450 mJ, 38 μm focal spot size) using a focusing lens (f =150 mm).

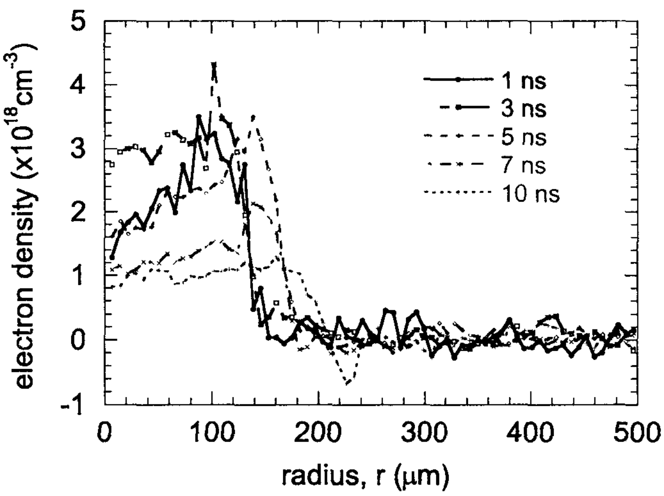

Fig. 2. Electron density vs. elapsed time of the gas jet. The backfill pressure of the gas jet was 30 bars and energy of the laser was 900 mJ. N_2 gas was used.

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