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Interferometric measurement of a laser produced plasma using Nomarski interferometer

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1. INTRODUCTION

Research on laser-induced plasma has received much attention by virtue of its their numerous applications. [1-3] Laser-produced plasmas, which is driven by focusing an intense laser pulse onto target, rapidly expands into the ambient gas. Because the laser-produced plasma has a transient nature, it is important to understand its temporal and spatial dynamics for obtaining plasma conditions in each application.

Laser interferometry tool has a capability for determining the spatial distribution of electron density at early stages of plume expansion. In this study, the interferometric analysis was carried out with the aim of investigating the characteristics of laser-induced plasma on the surface of titanium (Ti) metal target. We employed the Nomarski interferometry tool to obtain interference fringe patterns from the plasma. The Nomarski interferometry tool [4] can be convenient approach to other common tools such as Michelson and Mach-Zehnder interferometers because it has intrinsic advantages of its compact size and easy alignment. Nomarski interferometry tool is based on the concept that the probe beam passing the laser-produced plasmas is divided by the bi-prism and recombined to generate interference patterns.

2. BODY

2.1 EXPERIMENT

The schematic diagram of the experimental setup is shown in Fig. 1. A Nd:YAG laser (1064nm; pulse duration: ~10 ns) was used as excitation source. The plasma was drove on the sample surface by focusing 1064-nm radiation onto a flat target via a plano-convex lens of a focal length 125-mm. In this study, the certified titanium (Ti) target obtained from LTS chemical Inc. was used as target material.

We employed frequency-doubled, Q-switched, Nd:YAG laser (Laser-Spectra, Quanta ray) as an inteferometric probe beam to generate interference patterns. A 532-nm laser beam (pulse duration: ~5 ns) is expanded by a couple of concave lens of focal length 25-mm and plano-convex lens of focal length 250-mm. The expanded 532-nm laser beam passing through a 30-mm pinhole is then feed into a Nomarski interferometer to generate the interference pattern. The interfered beam is fed into a 656 × 488 CCD array. The triggering signal of a pulse generator synchronizes the probe laser beam and the laser beam for plasma ignition.

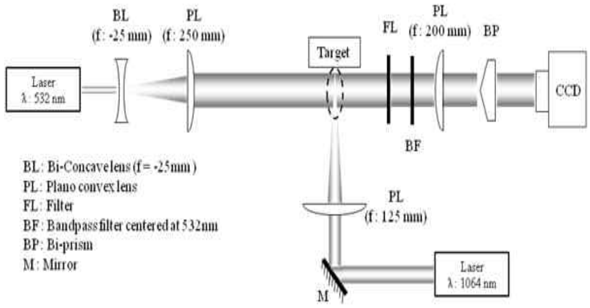

FIG. 1. Schematic of experimental setup.

2.2 RESULTS AND DISCUSSION

The interferometric images were recorded after the arrival time of the laser pulse on target. The (a) and (b) of Fig. 2 show typical fringe patterns in the presence and absence of the plasma, respectively. It is seen that there is clear fringe shifts in Fig 2 (a), which is ascribed to the high density of free electrons and neutral atoms in laser-produced plasma. Figure 2 (c) presents the electron density profiles calculated using Abel inversion equation. [5]

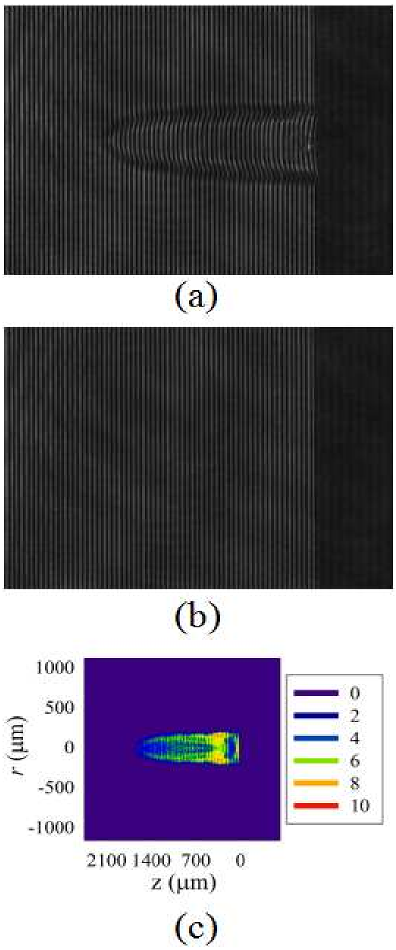

FIG. 2. (a) Interferogram measured at gate delay t = 40 ns after the onset of laser induced breakdown (b) Background interferogram in absence of laser induced breakdown. (c) Spatial distribution of electron density measured at gate delay t = 40 ns. The values in Fig 5. are in unit of $10^{19}/cm^3$.

3. CONCLUSION

The spatial and temporal behavior of laser-produced plasma was investigated on the basis of interferometric analysis using Nomarski interferometer. Electron density profile was calculated using Abel inversion equation via Fast Fourier-transformation method.

4. ACKNOWLEDGEMENT

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