EUV 리소그라피 광원용 레이저 생성 Xe 가스 플라즈마의 가시화

Visualization of Laser-Produced, Xe Gas Plasma in EUV Light Sources for the Lithography

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Extreme ultraviolet (EUV) radiation of wavelength $\lambda \sim 10$ nm or photon energy $h\nu \sim 100$ eV is presently a blank region in the electromagnetic spectrum where applications are concerned. This is because no powerful sources were available until when intense-laser-produced plasmas are available. Both a new laboratory-sized source of EUV radiation and its new applications in lithography of semiconductor devices have been developed[1, 2]. The EUV lithography is the most promising candidate for the lithography below 70 nm technology. High wafer throughput EUV lithography requires a radiation source emitting more than 100 W EUV power. The key to achieve such a high EUV power is to have a powerful laser and a high conversion efficiency EUV generator mainly consisted of a target system and laser optics.

In the present study, the Xe gas target system of laser-produced plasma EUV light sources has been developed. Xe gas was flowed at pressure of several tens bar in a serpentine pipe immersed in low temperature liquid nitrogen inside of a copper container and injected in a form of gas cluster through a submillimeter-diameter hole into a vacuum chamber by a magnetically coupled valve. A high-energy Nd:YAG laser with energy of 2 J, pulse width of 7 ns, and frequency of 10 Hz was used to irradiate the target. Its second harmonic in the green was used in order to reach a higher critical plasma density, which is expected to result in a higher absorption of laser energy into the plasma.

At present, the plasma in the Xe gas injected with high pressure were studied and visualized by means of a laser interferometer, where a small fraction of laser light emitted is bypassed to give rise to time delay. Using this visualizing method, we obtained a number of useful images for the Xe gas plasmas so that both plasma form and density distribution may be analyzed in details. Also, sooner or later, the plasma in the clustered Xe gas for the higher EUV radiation intensity will be investigated using the same imaging method.

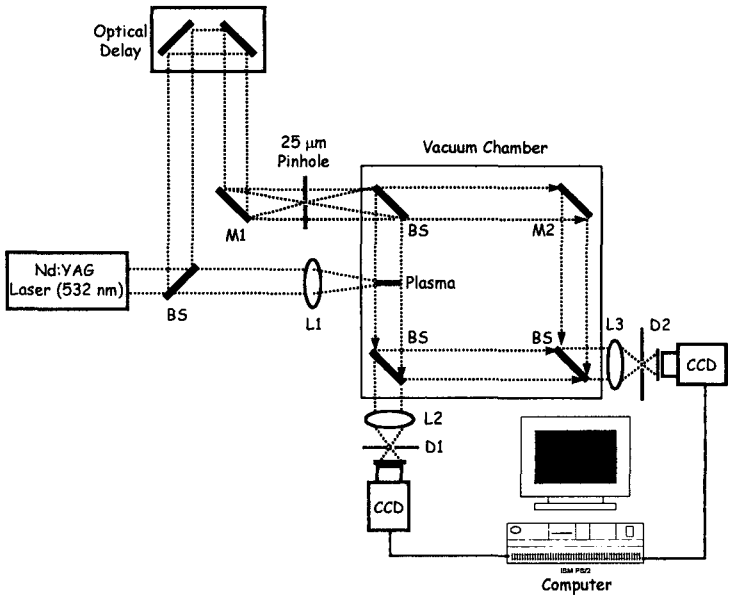

Fig. 1. Diagram of experiments for laser-produced plasma EUV light sources.

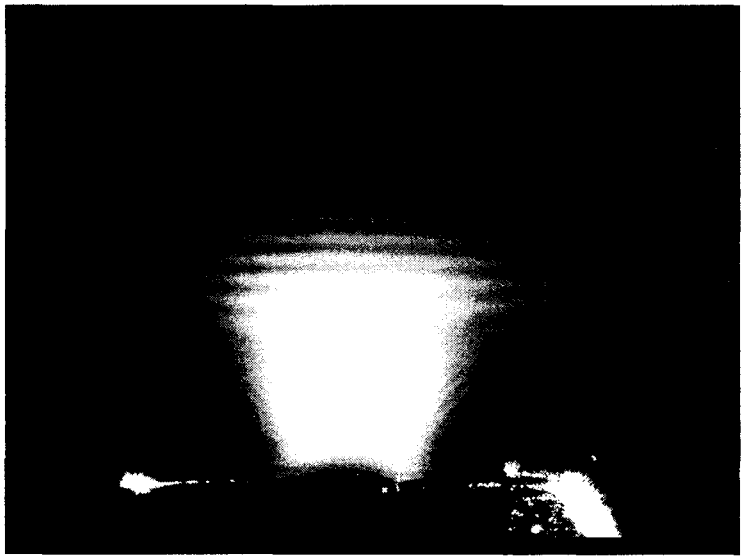

Fig. 2. The plasma in the Xe gas injected with pressure of 12 bar and irradiated by laser with energy of 900 mJ. This image was taken at 1 ns after the plasma was produced.

[References]

[1] I. C. E. Turcu and J. B. Dance, *X-Rays From Laser Plasmas*, Wiley, Chichester, 1999, Chapters 4 and 7.

[2] Abstracts of 3rd International Workshop on EUV Lithography, Oct. 2001.