Spatial Profiles of Electron Density and Electron Temperature of Laser-Produced Sn Plasmas for EUV Lithography

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Abstracts: *Spatial profiles of electron density (n_e) and electron temperature (T_e) of laser-produced Sn plasmas for EUV lithography were measured using a collective Thomson scattering technique. Under a condition of high conversion efficiency (CE) (>4.0%), n_e and T_e were in the range of10^{24}-10^{25} m^{-3}, and 30-40 eV, respectively. These values are adequate to the values predicted by simulations for optimum EUV light source plasmas. Comparison with other plasma conditions, whose CE were less than 4.0 %, mentions that control of laser absorption length is important to realize the high CE.*

EUV lithography (EUVL) is a most promising candidate for next generation lithography system. As a light source for the EUVL, laser-produced Sn plasmas with moderate temperature and density has been used. As the practical use, improvement of conversion efficiency (CE) of the EUV light source corresponding to the CO_2 laser, which is used as the driving laser to produce the plasma, is one of the biggest problem to be solved. For this purpose, importance of controlling and understanding of the Sn plasma has been mentioned, because EUV emission is strongly depend on the ionic charge of the Sn plasma. In addition, opacity is not negligible when plasma density becomes too high. Optimum T_e, n_e, and Z to realize high-power EUV light source with excellent CE are predicted as 30-50 eV, 10^{24}-10^{25} m^{-3}, and 10-13, respectively. However, direct measurements of these plasma parameters of the laser-produced EUV plasma having high CE have never been performed yet.

So far, we have been developing collective Thomson scattering system to realize a simultaneous measurements of n_e, T_e, and Z of the EUV plasmas [1, 2]. The previous study shows that ion feature from laser-produced Sn plasma is detectable for the EUV light source.

The important points of this report are as follows:

(a) Thomson scattering has been performed to measure one-dimensional spatial profiles of laser-produces Sn plasmas for EUVL, whose CE range is 2.5-4.0%.

(b) It was confirmed that n_e and T_e of the Sn plasmas were in ranges of 20-50 eV, and 10^{24}-10^{25} m^{-3}, respectively.

(c) Although the condition of driving laser (CO_2 laser) was same, spatial profiles of n_e and T_e were clearly different when the initial shape of Sn droplet target was different.

References

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2) K. Tomita, et al., Appl. Phys. Express **8**, 126101 (2015).