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Thomson scattering diagnostics of a streamer discharge in atmospheric-pressure air and laser-produced plasmas for light sources

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Laser Thomson scattering (LTS) is well-known as a powerful technique to measure electron density (n_e), electron temperature (T_e), averaged ionic charge (Z), and so on. LTS yields local values with high temporal resolutions. In this paper, collective and non-collective Thomson scattering measurements for two types of industrial plasmas are described. One is a streamer discharge in atmospheric-pressure air. The other one is laser-produced plasmas for extreme ultra-violet (EUV) lithography. Streamer discharge in atmosphere-pressure air has been studied for a long time and is used for various applications. To analyze the production mechanism of reactive species, information on electrons, especially for the electron velocity distribution function (EVDF) is crucial. The EVDF are provided by solving the electron Boltzmann equation. However, there has been no direct measurement of the EVDF in the air streamer. Then, LTS was performed to measure the EVDF of the air streamer. It was found that the measured EVDF clearly deviated from the Maxwellian distribution, as predicted by the Boltzmann equation. Extreme-ultraviolet (EUV) lithography is a promising technology for high-volume manufacturing of next-generation semiconductor devices. Laser-produced Sn plasma is known to show sharp and strong spectrum in the EUV regime (at λ =13.5 nm). However, the optimization of Sn plasma requires to measure and control Z and T_e in the region of larger ion density (n_i) within the etendue limit. However, these parameters (Z, T_e and $n_i = n_e/Z$) have never been measured owing to the extremely small size (˜500 μm) and short lifetime (˜20 ns). We performed LTS measurement. Then, time-resolved and two-dimensional profiles of n_e, T_e, and Z of the EUV light sources were revealed. As the result, 1) a characteristic hollow-like density profile was observed, 2) significant amount of useless Sn ions should exist within the limited etendue, whose temperature was too low to contribute EUV emission.