Investigation of tin plasma driven by high-energy 2-µm-wavelength light

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Tin laser-produced plasmas are used as sources of extreme ultraviolet (EUV) light at 13.5 nm wavelength in nanolithography [1]. Tin plasmas driven by lasers operating at wavelengths of 1 and 10 µm are widely studied with respect to their emission characteristics in the EUV regime. We present experimental data from tin plasmas driven by a 2-µm-wavelength laser operating in the range between the 1 and 10 µm cases. Plasmas driven by a 2-µm laser provide intermediate plasma densities that help to understand the role of fundamental atomic properties in the generation of usable EUV light.

We conduct experiments where we irradiate different mass limited tin targets with a 2-µm drive laser. In these experiments, small droplets of molten Sn are dispensed from a droplet generator inside a vacuum vessel. These droplets can be deformed to a thin sheet of tin by means of an additional laser pulse, called pre-pulse. Relevant plasma characteristics such as emission spectra and the emitted in-band energy around 13.5 nm are observed for different target dimensions and laser parameters. Those parameters include pulse duration, laser intensity distribution, target -diameter and -thickness. The experiments show a significant reduction of spectral line broadening at 13.5 nm in going from 1- to 2-µm drive laser wavelength (λ) under otherwise similar conditions. The change in line broadening is attributed to a near-linear scaling of the relevant plasma mass density with λ^{-1} and thus a corresponding scaling of optical depth at 13.5 nm [2]. The 2-µm-driven plasma with reduced relevant density paired with controllable drive-laser-pulse duration and plasma dimension allows for further detailed studies of the opacity-related broadening that may limit future solid-state-laser driven sources of EUV light. Further, controlling the thickness of the target and the pulse duration allows for an investigation of laser ablation rates. The experiments provide insight into the fundamental atomic opacity limits of converting drive laser light to useful EUV photons.

References

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