Evolution analysis of EUV radiation from laser-produced tin plasmas

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Synopsis We present a simplified radiation hydrodynamic model based on the fluid dynamic equations and the radiative transfer equation to rapidly investigate the radiation properties and dynamics in laser-produced tin plasmas. The self-absorption features of EUV spectra measured at an angle of 45° to the direction of plasma expansion have been successfully simulated and explained. The evolution of the plasma temperature has also been evaluated.

One of fundamental aims of extreme ultraviolet (EUV) lithography is to maximize brightness or conversion efficiency of laser energy to radiation at specific wavelengths from laser produced plasmas (LPPs) of specific elements for matching to available multilayer optical systems. For an investigation of EUV radiation of laser-produced tin plasmas, it is crucial to study the related atomic processes and their evolution so as to reliably predict the optimum plasma and experimental conditions [1].

In this work, a simplified radiation hydrodynamics model was developed to explain the complicated self-absorption profiles in EUV spectra of highly-charged tin ions. The origin of self-absorption bands and dips around 13.5 nm in Sn spectra have been successfully simulated and explained, as is indicated in Fig.1.

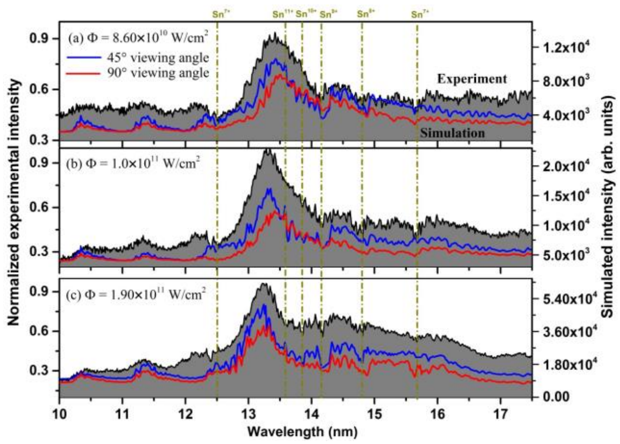

Figure 1. Comparisons of spectral profiles between the experimental and two simulated results for 90° and 45° viewing angles based on the radiation hydrodynamics model.

The plasma temperature is a very important parameter in the characterization of any plasma, since it determines the ion charge and energy distributions. To provide an intuitive description for the plasma expansion process, the contour images of plasma temperature are shown in Fig. 2. It is clearly seen that with increasing power density the distribution in space of the plasma temperature shows a gradual increase at each position considered. The results show an intuitive physical picture of the distributions of temperature within the expanding plume, which are helpful for a more detailed understanding of the spectral features and hydrodynamics evolution for highly charged ions of the mid- and high-Z elements.

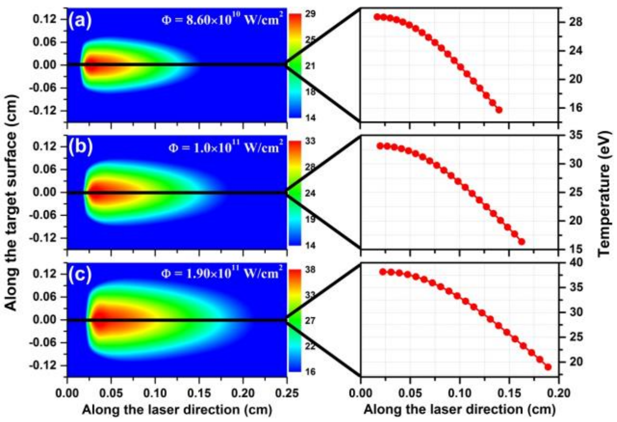

Figure 2. Contour images of plasma temperature in laser-produced tin plasmas at the different pulse power densities. The graphs on the right side show the varieties of plasma temperature along the laser direction.

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References

[1] V. Y. Banine *et al.* 2011 *J. Phys. D: Appl. Phys.* 44 253001

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