Radiation properties and hydrodynamics evolution of highly charged ions in laser-produced silicon plasma

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Synopsis We present a simplified radiation hydrodynamic model based on the fluid dynamic equations and the radiative transfer equation, which can be used to investigate the radiation properties and dynamics evolution of highly-charged ions in a laser-produced plasma in vacuum.

Impressive progress has been made in recent years in understanding the fundamental mechanisms governing laser produced plasmas (LPP), both in terms of laser–material interaction and the plasma evolution. There is no surprise that LPP attracts much attention from both theorists and experimenters as this technique is applied in many aspects, such as inertial confinement fusion, magnetic confinement fusion, light and ion source and so on[1].

In order to explore the internal state of plasma, the evolution and radiation characteristics of LPP is studied from theory and experiments. Firstly, the EUV emission spectra of Si plasma have been measured by using the spatio-temporally resolved laser-produced plasma technique. On the other hand, we present a simplified radiation dynamic model based on the fluid dynamic equations and the radiative transfer equation. Meanwhile, calculation of the ionization balance and the charge states is respectively performed within the time-dependent collisional radiative model (CRM).

To provide an intuitive description for the plasma expansion process, the contour images of plasma temperature for Si plasma expansion in vacuum as a function of time were obtained from the present model output, and are shown in figure 1. It is clearly seen that the electron temperature at the plasma core is about 24.8eV at a time of 20 ns after the end of the laser pulse and rapidly decays to 15.9eV after 50 ns. Figure 2 shows the spatial distribution of total ion number density and ions density of Si VII-Si I in the plasma with the delay time of 70ns. From this figure, we can clearly see that the center of plasma is dominated by the highly charged ions. As the plasma expands, ions move outwards and recombine, resulting in cooler edge of plasma where lowly charged ions are the dominant species.

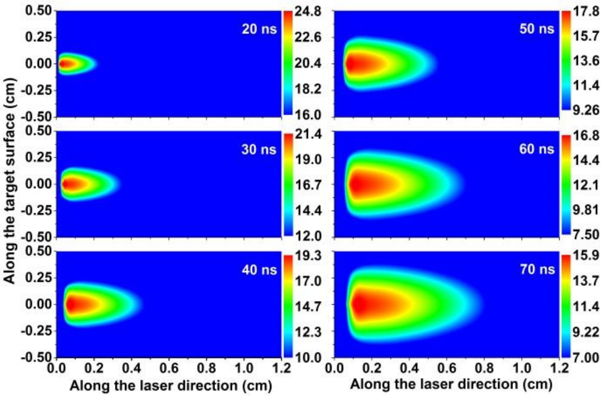

Figure 1 The temporal and spatial evolution of temperature in the silicon plasma

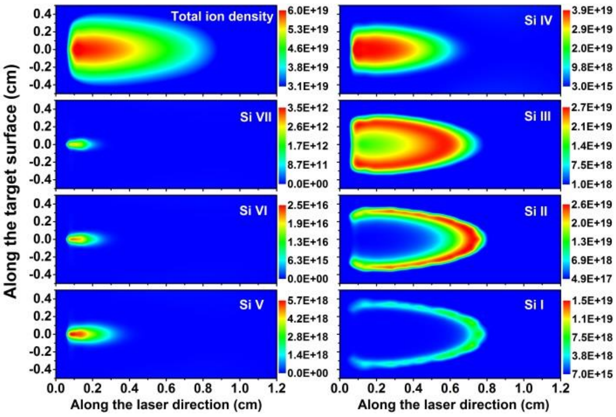

Figure 2 The charge state distribution in laser produced Si plasma

Reference

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