Feature of soft x-ray emission from laser-produced multi-charged Pt ions

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Abstracts: *We characterized strong unresolved transition array emission in carbon window soft x-ray spectral region. Arrays resulting from n = 4–n = 4 (Δn = 0) transitions were overlaid with n = 4–n = 5 (Δn = 1) emission. The emissivity and opacity were evaluated by use of the atomic code of HULLAC, and the plasma parameters and the spectral structure were reproduced by the hydrodynamic code. We also observed the enhancement and decrease of the emissions in dual laser pulse irradiation.*

In the past decade, the development of plasma light sources has progressed rapidly, especially for lithography in the extreme ultraviolet (EUV) region predicated on the development of multilayer mirrors (MLMs) with good reflectivity at specific wavelengths. The 13.5-nm and 6.*x*-nm light sources exploit the advantage that $4p^6 4d^N – 4p^6 4d^{N-1} 4f + 4p^5 4d^{N+1}$ (n = 4–n = 4, Δn = 0) unresolved transition arrays (UTAs) in several charge states appear at almost same wavelength in spectra from laser-produced plasmas (LPPs) of these elements, while transitions of type $4d^{10} 4f^M – 4d^9 4f^{M+1}$ also make contributions to the 6.*x* nm region. In this regard, it follows that n = 4–n = 4 UTAs from LPPs of other elements could provide light sources at other wavelengths for other applications such as x-ray microscopy in the water window of 2.3–4.4 nm and the carbon window of 4.4–5 nm. We have shown that the strong resonance UTAs of Nd:YAG LPPs for elements with Z = 50–83 obey a quasi-Moseley's law [1]. A laser-produced Bi plasma is one of the candidates for a water window source, whose spectrum was analyzed using Cowan code calculations in a previous work [2]. Laser-produced Pt plasma emission spectra are considered here as a candidate for a carbon window source.

In this report, we characterized strong unresolved transition array emission in carbon window soft x-ray spectral region. Arrays resulting from n = 4–n = 4 transitions were overlaid with n = 4–n = 5 emission. The emissivity and opacity were evaluated by use of the atomic code of HULLAC, and the plasma parameters and the spectral structure were reproduced by the hydrodynamic code. The maximum electron temperature was evaluated to be 600 eV at the peak of the laser intensity of 1×10^{14} W/cm^2 at a laser wavelength of 1064 nm, which was corresponded to the ionic charged state around $q \approx 30$. The scheme would allow the effective utilization of the main laser pulse energy to heat a preplasma, which would otherwise be wasted to ionize the target material. The emission flux was enhanced 1.2 times at the pulse separation time of 8–10 ns as large as that under single laser irradiation. In addition, the flux was decreased at the pulse separation time of 40 ns, related to long electron density gradient and opacity effect. We will open various experimental results and numerical simulation.

[1] H. Ohashi *et al.*, Appl. Phys. Lett. **104**, 234107 (2014).
[2] T. Higashiguchi *et al.*, Appl. Phys. Lett. **100**, 014103 (2012).