Characteristics of water window soft x-ray emission from dual laser-produced Bi plasmas

G. Arai[1], H. Hara[1], T.-H. Dinh[1], M. Nishikino[2], A. Sasaki[2], A. Sunahara[3], and T. Higashiguchi[1]

[1]*Department of Innovation System Engineering & CORE, Utsunomiya University, Utsunomiya, Tochigi, Japan*
[2] *Quantum Beam Science Center, Japan Atomic Energy Agency, Kizugawa, Kyoto, Japan*
[3]*Institute for Laser Technology, Suita, Osaka, Japan*
* *E-mail: hiroyukih1991@gmail.com*

Abstracts: *We characterized the water window soft x-ray emission from highly charged Bi ion plasmas produced by dual laser pulse irradiation for laboratory-scale single-shot x-ray microscope. The flux in water-window soft x-ray spectral region was increased at the pulse separation time of 8–10 ns and decreased at the pulse separation time around 100 ns, which was attributed to long scale length electron density gradient with the opacity effect, supporting by the hydrodynamic numerical simulation. The source size, which was measured by an x-ray pinhole camera, was almost same as the single pulse irradiation at the optimum separation time of 8 ns.*

Development of shorter wavelength sources in the extreme ultraviolet (EUV) and soft x-ray spectral regions has been motivated by their application in a number of high profile areas of science and technology. One such topic is the challenge of three-dimensional imaging and single-shot flash photography of microscopic biological structures, such as cells and macromolecules, *in vivo*. For x-ray microscopy, the x-ray source should emit a sufficient photon flux to expose the image of the biological sample on the detector. However, the total collected energy is low, when one combines the narrow line emission with the low reflectivity of the collector mirror. As a result, long exposures are needed to record an image and there is not yet published evidence of single-shot exposures using a laboratory-scale source. To overcome the low flux sources, we propose using high power water-window soft x-ray emission from laser-produced high-Z plasmas [1], analogous to the scheme used for efficient, high-volume manufacturing EUV sources. In addition, the dual laser pulse irradiation 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 [2].

In this report, we characterize the water window soft x-ray emission from highly charged Bi ion plasmas produced by dual laser pulse irradiation. The spectral structure and spectral intensity in 1.5–2.5 and 3.5–4.5 nm were changed at various pulse separation times. The flux in water-window soft x-ray spectral region was increased at the pulse separation time of 8–10 ns and decreased at the pulse separation time around 100 ns, which was attributed to long scale length electron density gradient with the opacity effect, supporting by the hydrodynamic numerical simulation. The source size, which was measured by an x-ray pinhole camera, was almost same as the single pulse irradiation at the optimum separation time of 8 ns, resulting in 1.2 times as large as that produced by a single pulse. In the water-window soft x-ray microscope, the enhancement of the image intensity was reproduced by dual laser pulse irradiation at the pulse separation time of 8–10 ns.

[1] T. Higashiguchi *et al*., Appl. Phys. Lett. **100**, 014103 (2012).
[2] T. Higashiguchi *et al*., Appl. Phys. Lett. **88**, 161502 (2006).