A new optical design for compact soft x-ray microscope

Kyong-Woo Kim[1], Young-Man Kwon[1], Kyu-Gyeom Kim[1], Jae-Hee Kim[1], Jong-Hwan Min[1], Jong-Hyeok Lim[1], Ki-Yong Nam[1], Jin-Young Min[2], and Kwon-Ha Yoon[1], [3]

[1]*Institute for Radiological Imaging Science, Wonkwang University*
[2]*LISTEM Corporation, 414-4 Chongchon-dong, Pupyong-gu, Inchon, Korea*
[3]*Department of Radiology, Wonkwang University*
344-2 Shinyong-dong, Iksan, Jeonbuk, Korea, e-mail:
khy1646@wonkwang.ac.kr

The lab-scale x-ray microscope reported so far mostly uses the laser plasma source which contains limited brightness and bandwidth of wavelength comparing with the synchrotron radiation source. The lab-scale system has been not enough to examine the live cells because exposure time is too long to get reasonable resolving power. In this reason, we introduce that high spatial resolution (50 nm) the compact soft x-ray microscope can be performed with reasonable exposure times and contrast. In the present paper, we describe the new optical system design and development of a compact soft x-ray microscope that have high reflective condenser optics and objective micro zone plate (OZP). This x-ray microscope operates in wavelength region of the water window (2.3~4.4nm), where natural contrast between carbon (protein) and oxygen (water) allows imaging of unstained cells under the natural, hydrated environment.

Our compact soft x-ray microscope consists of the laser plasma as an x-ray source, doubled ellipsoidal reflective condenser optics, diffractive zone plate optics and MCP-coupled CCD to record x-ray image. A liquid-jet laser plasma target system was used for the x-ray generation due to its debris free and high average power operation. The doubled ellipsoidal condensing mirror will increase the photon density in the object plane more than one order of magnitude compared to the zone plate condenser adjusting the numerical aperture of the optical system between condenser mirror and objective zone plate. The spatial resolution of the system is determined by a ~12% efficient gold zone plate with an outmost zone width of 35nm which generates an enlarged image of the object in the image plane of detector. The enlarged x-ray image of the object is recorded with CCD coupled with a Chevron-typed MCP.