§71. Calibration of SX-EUV Diagnostic Instruments Using LHD Plasma as a Standard Radiation Source

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The continuum radiation (bremsstrahlung emission) from high temperature plasma could be used as a standard source for calibration of spectroscopic instruments of soft x-ray and extreme ultraviolet (SX-EUV) radiation.[1, 2] In this work, the diagnostic instrument to be calibrated is a flat-field SX-EUV spectrograph with a varied spacing laminar-type holographic, aberration corrected concave grating.[2]

Main parameters of the concave grating and the spectrograph mounting are as follows; the nominal groove density is 1200 g/mm, the groove depth is 13 nm, the effective area is $44^{W}\times20^{H}$ mm^2, the radius of curvature is 5606 mm, the angle of incidence is 87° and the arm lengths of entrance-grating and grating-detector are 237 mm and 235 mm, respectively. In this spectrograph, spatial imaging has been achieved by one-dimensional pinhole imaging through a rectangular opening of an entrance slit.

The spectrograph was installed on a radial port in LHD where the line-of-sight was slightly oblique to the normal direction to the toroidal axis, where the spectrometer-plasma center distance was 9454 mm. Space-resolved images of SX-EUV spectra from 5 nm to 40 nm has been observed using an entrance slit of $0.1^{W}\times0.5^{H}$ mm^2, which gives the spectral resolution of 0.03-0.05 nm and the spatial resolution of 15 mm with 50 cm field of view. It has been confirmed that clear bremsstrahlung continuum has been observed in a high-density LHD plasma shot with hydrogen pellet injection as shown in Fig. 1.

Diffraction efficiency of gratings has been calculated by using the unified classical theory.[3] Comparison of diffraction efficiency has been made between the laminar-type grating whose groove has a rectangular profile and the mechanically ruled grating with a saw-tooth groove profile. The results of calculations are shown in Fig. 2. It has been confirmed that the higher order diffraction for the laminar-type grating is kept low throughout the wavelength range of this spectrograph. Especially it is one order lower than that for the mechanically ruled grating in the wavelength range longer than 30 nm. The first order diffraction efficiency for the laminar-type grating is higher than that for the mechanically ruled grating. Therefore the laminar-type grating is a suitable optical element for EUV spectroscopy.

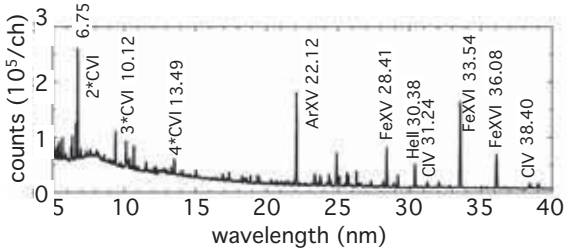

Fig. 1. SX-EUV spectrum observed in a high-density plasma shot with hydrogen pellet injection. Bremsstrahlung continuum emission is observed along with the line emissions of highly ionized Fe and C.

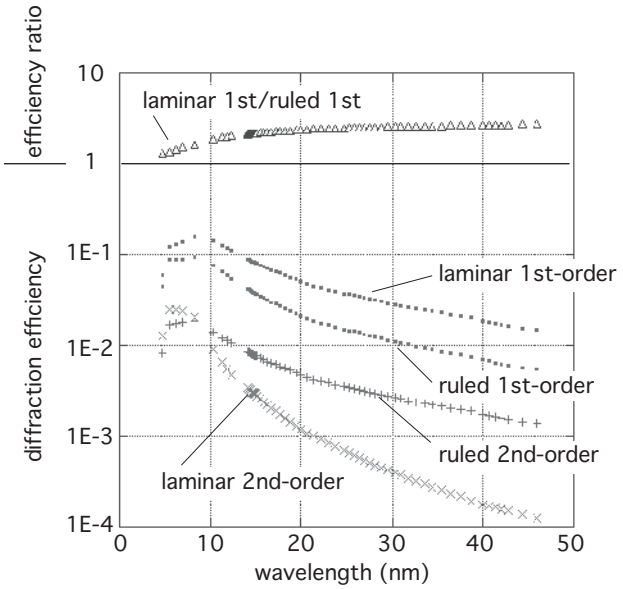

Fig. 2. Calculated diffraction efficiencies for the laminar-type grating and the conventional ruled grating.

1) Feldman, U., et al.: Astron. Astrophys. **441** (2005) 1211.
2) Chowdhuri, M. B., et al.: Rev. Sci. Instrum. **78** (2007) 023501.
3) Maezawa, H. and Miyauchi, H.: J. Opt. Soc. Am. A **26** (2009) 330.