§45. Comparison on Spectral Characteristics between 1200 Grooves/mm Ruled and Holographic Gratings for EUV Spectroscopy

Chowdhuri, M.B., Morita, S., Goto, M.

Spectral emissions in the extreme ultraviolet (EUV) wavelength range from magnetically confined high temperature plasmas can be used to estimate the radiation losses from impurities, to study the impurity transport phenomena, and also to understand the plasma-wall interaction. For this purpose a flat-field EUV spectrometer with a varied line spacing grooves ruled grating (1200g/mm) has been developed to study the emission spectra from highly ionized medium-Z impurities in Large Helical Device (LHD) in addition to the impurity behaviors. Later the ruled grating was replaced by a laminar type holographic grating to compare the spectral characteristics between the two gratings. The relative sensitivities have been determined using EUV continuum radiation.

EUV spectrometer was installed on LHD to measure emission spectra from plasmas. The 1200grooves/mm VLS concave grating covers a wavelength range of 50 to 500Å at an angle of incidence of α=87°. A radius of curvature is 5649mm, then the distance between the grating center and the entrance slit is 237mm and the distance between the focal plane and the grating center is 235mm. A back-illuminated CCD is used as a detector. The size of the CCD is 26.6x6.6mm^2 with a pixel size of 26x26μm^2 and the number of channels of 1024x255. Data are transferred with a time interval of 5ms in full vertical binning mode. The theoretical reciprocal linear dispersion varies from 4.26Å/mm to 11.48Å/mm over the corresponding wavelength range of 50 to 500Å.

Spectral resolution $\Delta\lambda_0$ (full width at foot position of a spectral line) was determined from the emission spectra of LHD plasmas and is shown in Fig.1. It shows nearly constant $\Delta\lambda_0$ values of 4 channels independent of the wavelength for both gratings. The full width at half maximum (FWHM) of the spectral line, $\Delta\lambda$, estimated from a Gaussian fitting is 0.25Å at 192Å, which corresponds to 1.3 channels of the CCD detector. The capability of the two gratings was also examined to check the contribution of the higher order light. The peak intensities of higher order light from CVI (33.73Å), CV (40.27Å) and FeXX (132.67Å) are plotted in Fig.2 for ruled and holographic gratings. All the intensities are normalized by their 1st order light. It is confirmed that the holographic grating can sufficiently suppress the higher order spectra in comparison with the ruled grating.

Theoretically calculated and experimentally measured bremsstrahlung continuum is compared to get relative sensitivity of two gratings, as shown in Fig.3. It has been found that the sensitivity of the ruled grating deteriorates at a wavelength lower than 150Å, but the holographic grating indicates a constant sensitivity against the wavelength.

Through this study it is concluded that the holographic grating has better spectral characteristics than ruled grating.

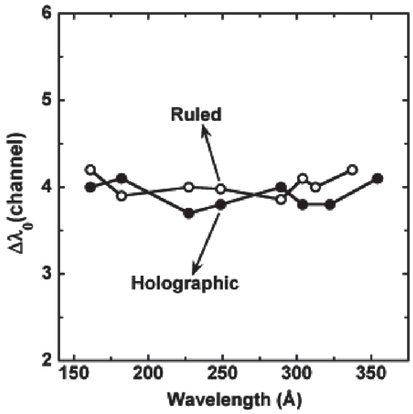

Fig. 1 Experimentally obtained spectral resolution $\Delta\lambda_0$ at spectral foot position for ruled and holographic gratings.

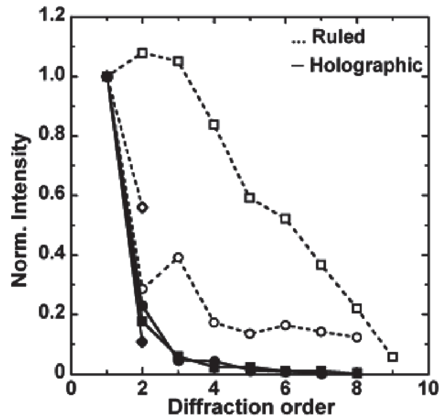

Fig.2 Peak intensities of higher order light normalized to the 1st order light for ruled and holographic gratings (circles: CVI (33.73Å), squares: CV (40.27Å), diamonds: FeXX (132.67Å)).

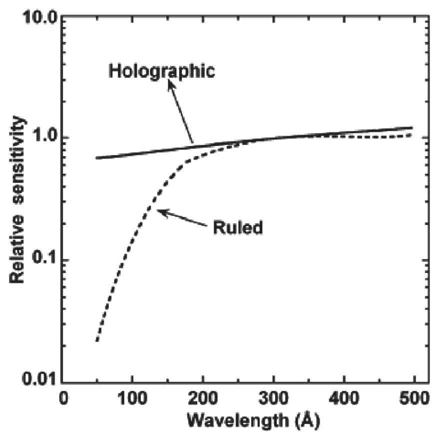

Fig.3 Relative sensitivities as a function of wavelength for ruled and holographic gratings.