L.7.: Measurement of Absolute Diffraction Efficiency of a Variable Line Spaced Grating using Indus-1 Reflectivity Beamline

The extreme ultra-violet (XUV or EUV) radiation, from high order harmonics produced using ultra-short laser pulses (tens of fs duration), has ultra-short pulse duration and is also coherent. Hence, it is a very important pulsed, coherent XUV radiation source for a variety of applications. For any serious application, it is important to characterize the source for absolute photon flux. To record this radiation, instead of a concave grating in Rowland circle geometry (which focuses the spectrum on the Rowland circle), it is preferred to use a flat field spectrograph which can focus all the diffracted radiation in a plane (i.e. in a flat field), so that large format planar detectors like a multi-channel plate (MCP) or an XUV CCD camera can be used. The key component of a flat field spectrograph is a variable line spaced (VLS) concave grating, used for diffraction as well as focusing of the diffracted radiation in a plane. These gratings have significant diffraction in higher orders. For a continuous XUV source, it becomes necessary to correct the intensity of a particular wavelength (λ) for the contribution of the higher orders of its sub-multiple wavelengths (second order of $\lambda/2$, third order of $\lambda/3$, etc.). It therefore becomes imperative to know the absolute diffraction efficiency of the grating for the various orders, at different wavelengths.

Figure L.7.1 shows the schematic of the flat field spectrograph developed in-house at the Laser Plasma Division of RRCAT, for characterization of high order harmonics generation (HHG) in the XUV region. In this spectrograph, the XUV radiation is incident at about 3° grazing angle on the VLS grating. The grating is placed at a distance of 235 mm from the slit, and has a flat field focal plane at a distance of 237 mm from the centre of the grating, perpendicular to its plane, as shown in Fig. L.7.1.

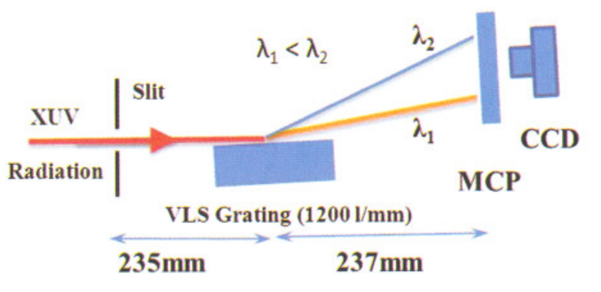

Fig. L.7.1: Schematic of the Flat field spectrograph

In order to measure the diffraction efficiency of the grating, a well characterized source such as synchrotron radiation (SR) is required. Here, we report the measurement of absolute diffraction efficiency of a blazed VLS grating in the 4.5 nm to 80 nm regime, using the Indus-1 synchrotron source at RRCAT. The grating has mean groove density of 1200 lines/mm and is blazed at 10 nm wavelength, for grazing incidence angle of 3.2 degree.

The Indus-1 beam line delivers monochromatic radiation in the wavelength range of 4-100 nm using a toroidal grating monochromator having a resolving power ($\lambda/\Delta\lambda$) of 200 - 500. The experimental station on this beamline comprises of a θ-2θ goniometer where the sample is mounted on a rotational stage and the detector on the 2θ arm. A silicon XUV photo-diode is used to monitor the reflected beam flux. The grating under test (supplied by Hitachi, Japan) had a radius of curvature of 5649 mm and a ruled area of 50 mm x 30 mm. The grating was set at grazing angle of ~3° inside the experimental station. The output wavelength from the beamline was changed from 4.5 nm to 80 nm, to measure the diffraction efficiency of the VLS grating in the first and second order. The diffracted intensity was recorded by rotating the detector arm.

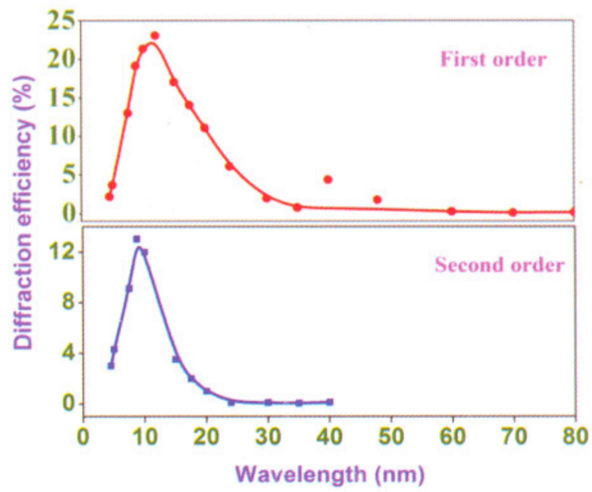

Fig. L.7.2: Absolute diffraction efficiency of the VLS grating for the first and second orders.

Figure L.7.2 shows the variation of the absolute diffraction efficiencies of the first and second orders of the XUV radiation dispersed by the VLS grating. The maximum diffraction efficiency in the first order is ~ 23% and in the second order ~ 13%. As expected, the curves have peak at 10 nm, as the grating is blazed for that wavelength. It is observed that the grating has good diffraction efficiency (> 5%) in the wavelength range of 7.5 nm to 35 nm in the first order and from 7.5 to 15 nm in the second order. The contribution of the higher orders of sub-wavelength radiation has been taken into account to calculate the absolute diffraction efficiency in various orders. In Fig. L.7.2, the appearance of a second peak at ~ 40 nm is an artifact that arises due to grating change in the monochromator of the beam line.

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