Broadband high-resolution imaging spectrometers for the soft X-ray range

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Abstract: *We develop high-resolution (imaging) spectrometers with the use of VLS gratings and focusing multilayer mirrors, including broadband (aperiodic) multilayers.*

We develop an approach to high-resolution spectral imaging in the XUV (2 – 40 nm) [1]. A broadband stigmatic spectrometer makes combined use of a normal-incidence multilayer mirror (MM) (in particular, a broadband aperiodic MM) and a grazing-incidence varied line-space (VLS) reflection grating. The concave MM produces a slightly astigmatic image of the radiation source (for instance, the entrance slit), and the VLS grating produces a set of its dispersed stigmatic spectral images. The spectral width of the operating range is defined by the multilayer structure of the MM and may range up to more than an octave in wavelength (e.g. 12.5–30 nm for an aperiodic Mo/Si MM [2]). The stigmatism condition for the rays lying in the horizontal (dispersion) plane may be satisfied simultaneously for two wavelengths, e.g.14 and 27 nm. This is achieved at the expense of reducing by one the number of degrees of freedom of the optical configuration. In this case, the condition of non-rigorous stigmatism is fulfilled for the whole wavelength range selected. The residual astigmatism signifies that the spectrograph forms two-dimensional spectral images of an object with a good spatial resolution along and across the dispersion direction throughout the operating range. Numerical ray tracing for a 1-m long spectrometer shows that the spectral images of a point source are all confined in a detector cell size (13 mcm). Similarly, a stigmatic scanning spectrometer/monochromator with a constant deviation angle was designed. To this end, plane VLS-gratings with a central line density of 600 mm^{-1} were made by e-beam lithography (MIPT, Dolgoprudnyi) and interference (State Institute of Applied Optics, Kazan) lithography. Work is underway to make plane VLS-gratings by mechanical ruling on a programmable ruling engine.

This approach may be extended down to 6.9 nm using La/B_4C MMs with barrier layers [3].

Another practical way to obtain ~10-μm spatial resolution in combination with high spectral resolution throughout a broad operating spectral range involves the use of a spherical VLS-grating jointly with a crossed grazing-incidence concave mirror. Use should be made of a VLS-grating with a stronger line density variation across the aperture than for a Harada-type spectrograph. In this case, the grating–detector distance can be made constant – to within a fraction of a millimeter – which favors attainment of high spatial resolution [4].

This work was supported by the Russian Science Foundation (Grant No. 14-12-00506).

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