

High-Resolution, High-Efficiency Spectrometers in the EUV and Soft X-ray Range

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Reflection zone plates (RZPs), an innovative class of 2-D varied line space gratings that combine dispersion, one- or two-dimensional focusing and reflection in one element [1], are good candidates to provide optimized efficiency at high energy resolution. Conventional RZPs on planar substrates suffer from a narrow energy range in parallel spectra registration, limiting the applications of this type of optics to monochromatization. Recent developments in theory, technology, and metrology of RZPs make it possible to fabricate off-axis, parallel-line-projecting RZPs [1] on spherical substrates with a small radius of curvature down to 2 m, extending the range wherein high-resolution flat field spectra can be measured in parallel on a single, two-dimensional pixel detector within an interval of about $\pm 25\%$ around the design energy [2]. With customized RZPs, additional aberration correction of the substrate or other optics in the system becomes feasible [3].

In our contribution, we present different usage examples of RZPs, combining their simplicity and efficiency in spectrometers and monochromators. We present results obtained with novel parallel wavelength dispersive X-ray spectrometers, developed at NOB Nano Optics Berlin GmbH in cooperation with the Institute of Applied Photonics e. V., designed for the analysis of fine structures in the energy states of the bonding electrons in compounds of ultra-light elements like Li or B. The lab-based spectrometer "WDSX-300" has an energy resolution of 0.3 eV at the Al $L_{2,3}$ -edge with an overall efficiency of the optics up to 30 % in the energy range of (35 - 130) eV [4]. Thanks to its versatile construction and compact setup with an overall optical path length of 0.3 m, it can be mounted on any commercially available scanning electron microscope or electron probe micro-analyzer. As an option, the spectrometer can be equipped with RZP optics for the energy range up to 1200 eV.

A challenge with all wavelength dispersive X-ray spectrometers is the presence of higher diffraction orders in the spectra. For example, the fifth order of C K_{α} appears at 55.4 eV, very close to the first order of Li K_{α} at 54.3 eV. We have improved our optical setup to reduce the higher order contributions in our spectra, including the most abundant carbon and oxygen contributions. We are aiming for a reduction by a factor of 10^4 , as predicted by simulations, and hope to confirm this expectation in upcoming experiments.

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