Nano-gratings study using 2D X-ray standing waves excited by an in-lab X-ray source

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Nanofabrication technology is rapidly progressing in two directions. First, more complex 3D architecture, and second, structure sizes reduced down to sub-nm scale. The state of the nanofabrication technology is already beyond the capabilities of the state-of-the-art nano-metrology. The International Roadmap for Devices and Systems from 2020 assumes that implementing of a hybrid metrology will address this challenge. The extended scatterometry is considered a part of this hybrid metrology.

We focus our study on two scattering techniques: X-ray diffraction (XRD) and angular resolved grazing-incidence X-ray fluorescence (GIXRF). XRD is based on the analysis of the far-field of X-rays scattered on the periodic structure. The GIXRF is based on the secondary scattering modulated by the near-field in a form of the 2D/3D X-ray standing wave (XSW). The XRD signal depends on the geometrical configuration of the structure such as grating period, high and shapes. By using a grazing incidence geometry one can tune the probe depth and its lateral position to study the buried structures at sub-nm resolution. The buried structures are then detected by fluorescence analysis, making the scheme element-specific and showing the material and its in-depth position inside the structure. Very recently, a similar measurement scheme was demonstrated to be useful for the characterization of buried periodic 2D and 3D nanostructures.

We plan to extend this analysis by combining it with XRD: measuring both XRF and XRD at each incidence and azimuthal position. Both XRD and GIXRF signals can be simulated using the many-beam dynamical diffraction theory. To evaluate the perspectives of an in-lab implementation of this technique we have measured the GIXRF maps and XRD patterns from periodic nano-scale 2D gratings with various periods and marker-coatings using our laboratory XRD setup. The results of the first measurements will be discussed in the presentation as well as the initial step of GIXRF map analysis using the recently published semi-analytical approach, capable of relatively fast simulation of these complex XRF maps.