GISAXS a new metrology to characterize nano-patterned samples

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Grazing Incident Small Angle X-ray Scattering (GISAXS) is introduced as a modern metrology tool that can be used complementary to optical characterization techniques to probe patterned arrays of nanometer features. Surface sensitive scattering experiments were performed close to the critical angle to reveal the in- and out-of-plane structure of sculpted Silicon/Silicon Oxide substrates (see Fig. 1).

Samples of Si were patterned by e-beam lithography and reactive ion etching. The test patterns consisted of a 40 nm period arrays of ~18 nm posts and 45 nm period gratings, each covering a 1 mm^2. An example of the scattering results from the array of pillars is shown in Figure 1b. The well defined in-plane periodicity results in Bragg-rods located at discrete points q_r in reciprocal space. The pronounced intensity modulation in q_z-direction perpendicular to the sample surface arises from the geometric form-factor of the posts. A detailed analysis of the location of the Bragg-rods in reciprocal space and their intensity profile gave information about the in-plane arrangement of the sample features and their geometric properties. Figure 2 e.g. shows the (10)-Bragg-rod for the square lattice of pillars and a simulation that calculates the form-factor for cone-shaped posts in a Distorted Wave Born Approximation. The simulation describes the data obviously very well and reveals parameter like diameter, height and sidewall inclination of the pillars.

Additionally it's shown how GISAXS can serve as a quality control in the fabrication process. For example "Stitching" errors during the writing of large area samples with the e-beam can easily be identified. They give rise to additional periodicities in the sample on length scales larger than the typical array spacing. These periodicities can be seen in the scattering experiment at relatively small q (Fig. 1b). Finally the "quality" of samples etched in Silicon and Silicon Oxide will be compared based on their GISAXS pattern.

Performing scattering experiments in grazing incident geometry has proven to be a reliable and powerful tool to reveal shape, size, sidewall profile and lateral arrangement of the probed nanometer features. The introduced technique is therefore expected to be very important to nano-scale arrays such as patterned media, photonics structures and electronics structures, such as DRAM.

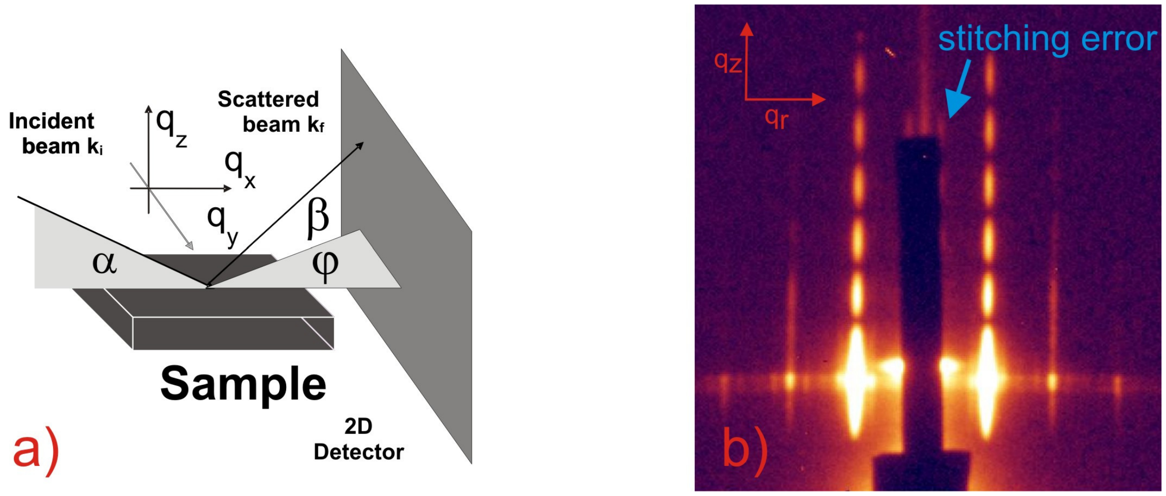

Figure 1: Scattering geometry (a) and resulting intensity distribution (b) perpendicular to the substrate for the array of cones.

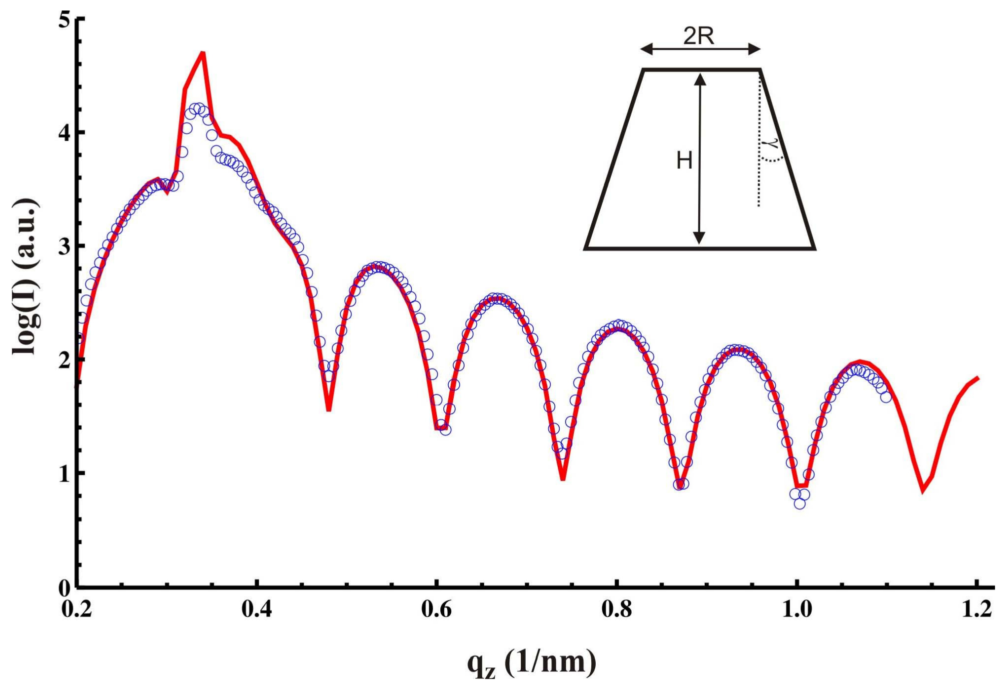

Figure 2: Scattering intensity of the (10)-rod perpendicular to the surface (circles), simulated intensity (line) assuming cone-shaped posts.