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Report:

The aim of the experiment was the installation of a coherent reflection set-up to determine surface fluctuation on thin polymer films. Whereas the requested coherence of the incident beam in visible light can be easily achieved with laser sources, the use of incoherent sources like an x-ray undulator requires a suitable collimation and monochromation. The coherent intensity obtained in that way depends directly on the brilliance of the source. To observe speckle the transverse coherence width of the incident beam should be equal or greater than the beam size and greater than the length scales of the inhomogeneities of the system to be examined. This is necessary to prevent incoherent averaging of many overlapping speckle patterns. In addition the optical path difference of scattered rays must be smaller than the longitudinal coherence length of the beam. We performed our experiment at the beamline 9 (TROIKA IDlOA) at the ESRF with a configuration which provides a maximum coherent flux by restricting the longitudinal coherence length to about 100 A.

As model system we used a blend of polystyrene PS with a molecular weight M_W = 30600 g/mol and polybromstyrene P(Br,S) with a degree of bromination of x=0.72 with a molecular weight Mw = 42000 g/mol .

Installing the above described requirements for coherent x-ray scattering we measured the static speckle pattern by performing common 'detector-scans' (the sample is held fixed at one angle of incidence α_i and the detector position is varied around the specular one). According to $\Delta q_x \approx \pm 2\pi/\lambda\,(\alpha\Delta\alpha)$ and $\Delta q_z \approx \pm 2\pi/\lambda\,(\Delta\alpha)$ the changes in the exit angle $\Delta\alpha$ will mainly result in a change of q_z and only very small changes in q,. In a q_xq_z-map a detector scan is a parabolic path through the reciprocal space. Typical speckle patterns are presented in the figure. The exit angle equals the critical angle which corresponds to α_i=0.54°. Therefore the measurements are performed through the Yoneda peak. In the figure the left graph result from measurements with a front pinhole aperture of p=5µm and the right graphs from measurements with an enlarged pinhole aperture of p=12µm. From the bottom to the top the detector sided pinhole aperture is varied from 200µm to 20µm. The comparison of different detector size pinholes displays a variation in the detector resolution and is no proof for speckle pattern. It yields that a 20µm is needed to resolve the speckle pattern whereas broader apertures are not sufficient. The width of the speckle pattern is caused by the front pinhole aperture. The angular extend of each spot is comparable to that of the central peak of the Frauenhofer diffraction pattern (λ/p) of the pinhole. An enlarged pinhole aperture causes a narrower diffraction pattern and therefore narrower speckles. The solid lines in the top curves (20µm detector sided pinhole) show the width of the measured central peaks of the primary beam with the corresponding front pinhole. The good agreement proofs that the observed intensity distribution is due to a static speckle pattern from the sample surface.