# A New X-ray Reflecto-interferometer Based on Refractive Optics

S. Lyatun[1], D. Zverev[1], P. Ershov[1], I. Lyatun[1], O. Konovalov[2], I. Snigireva[2], A. Snigirev[1]

[1] Immanuel Kant Baltic Federal University, 14 Nevskogo, 236041 Kaliningrad, Russia
[2] European Synchrotron Radiation Facility, 71, avenue des Martyrs, 38043 Grenoble, France
**anatoly.snigirev@gmaol.com**

Compound refractive lenses (CRLs) have been widely used for more than 20 years on leading synchrotrons for X-ray beam transport, collimation and focusing [1-2]. The area of CRLs applications was extended to the field of coherent diffraction and imaging techniques, Fourier optics and interferometry.

A new amplitude division X-ray interferometer operating in reflection mode was proposed and realized for the study of thin-film structures [3]. The reflecto-interferometer employs a CRL to produce a converging fan of radiation, incident onto a sample surface, and a high resolution CCD detector to simultaneously collect the reflecto-interferogram over an angular range matching that of the incident fan. The interference pattern, which is in fact specular X-ray reflectivity, is recorded in a single shot using very simplified experimental setup without the need to rotate the specimen or detector. Another feature of the proposed reflecto-interferometer is the spatial resolution, which achieved due to focusing by CRLs, allowing to probe different regions on the film.

The capabilities of the new reflecto-interferometer were demonstrated at the ESRF ID06 beamline using X-rays from 10 to 20 keV. The $Si_3N_4$ membranes of thicknesses in the range from 100 to 1000 nm were studded. Experimentally obtained reflecto-interferograms are in good agreement with calculated ones, and the distance between fringes correspond to the thickness of the tested membranes. While the interference pattern in rather wide angular range is recorded in one shot, the proposed approach has a very good temporal resolution, which is limited to a few milliseconds, depending on the X-ray flux and the sensitivity of the detector. The temporal characteristics of the interferometer were demonstrated by studying the radiation damage of the resist layer. The high spatial resolution of the interferometer was revealed on interferograms recorded from the gold strip deposited on the $Si_3N_4$ membrane. It was shown that the interference pattern is very sensitive to deviations in the thickness of the layer, resulting in ability to determine very accurately not only the average thickness of the gold layer, but also to reconstruct the cross-section profile of the gold layer.

The recording of the interference pattern in a single shot allows an express analysis of films, which is especially important for radiation sensitive materials, including organic and biological films. The spatial resolution property is very significant possibility to study samples with small lateral size, and is also necessary for the local analysis of the film. It should be emphasized that the put forward reflecto-interferometer can be employed for characterization of films with thickness from 20 nm up to few microns. In addition, this reflecto-interferometer can be easily adapted for use with laboratory X-ray sources.

**References**

[1] - A. Snigirev, V. Kohn, I. Snigireva and B. Lengeler, *Nature* **384** (1996) 49.
[2] - A. Snigirev, I. Snigireva, *Comptes Rendus Phys*. **9** (2008) 507.
[3] - S. Lyatun, D. Zverev, P. Ershov, I. Lyatun, O. Konovalov, I. Snigireva, A. Snigirev, *J. Synchrotron Rad.*, accepted.