Grazing incidence EUV surface metrology: Benchmarking of DPP source table-top scatterometry versus PTB synchrotron based EUV-Radiometry

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Optical scatterometry is a powerful technique for surface roughness metrology and profile characterization of nano-structured layered surfaces. Besides being a fast, non-contact and non-destructive method, it provides spectrally resolved data on the roughness power spectral density (PSD). Several mirror samples with a multilayer coating (ML) with different periods were produced on substrates of different roughness. The samples are characterized in terms of surface roughness by both atomic force microscopy and EUV scatterometry. The EUV scattering patterns where recorded first using a table-top scatterometry setup [1] based on a discharge-produced plasma (DPP) source [2] with a CCD camera and second using the PTB EUV-reflectometer at the EUV-Radiometry beamline at the Metrology Light Source (MLS) [3]. The latter data were recorded by scanning the angular range of the scattered radiation with a photodiode detector of known solid angle of detection. Figure 1 shows typical grazing incidence scattering patterns as recorded using the CCD at the laboratory set-up (a) and using the photodiode detector at the PTB EUV beamline (b).

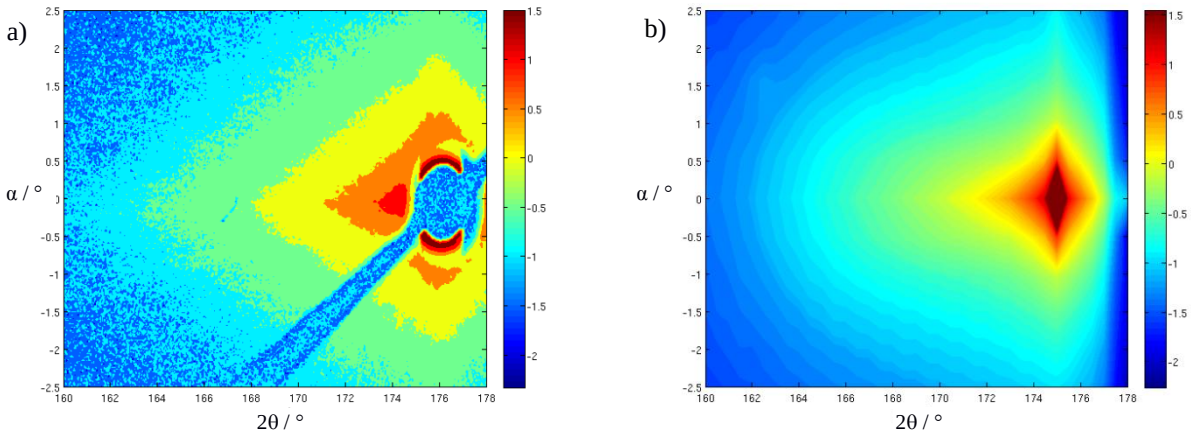

Figure 1. Example of scattering patterns from a test sample with CeO_2/B_4C multilayer coating (N = 10, d = 20 nm), measured with the DPP source with CCD detector (a) and measured at the synchrotron with diode detector (b), both under AOI = 87.5° @ 13.5 nm wavelength.

The laboratory DPP source provides enough photons for recording scattering patterns in reasonably short times from 5 to 10 min. The CCD scattering patterns provide principally higher angular resolution, but due to the lower photon flux from the DPP source the data are effectively limited by signal to noise ratio. The CCD also requires a beamstop (Figure 1a) for blocking the specular beam. At grazing incidence angles the EUV light does not penetrate into the ML-stack and hence does not reflect internal ML interface roughness. We only observe scatter related to the surface roughness which can therefore be directly compared to AFM data. The quality of the PSD as obtained using a laboratory source will be discussed and compared to results derived from synchrotron radiation based measurements.

References:

[1] O. Maryasov et al. “Table-top EUV scatterometer MARYS with high-brightness discharge plasma source”, JARA-FIT Annual Report (2015)
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[3] C. Laubis, et al. “Update on EUV-Radiometry at PTB”, Proc. SPIE, 977627 (2016)