Achievements and upcoming Challenges on Metrology for Synchrotron optics

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Ultra-precise reflective and diffractive optical elements like blazed diffraction gratings or ultra-precise mirrors of flat, elliptic, parabolic, or other shapes have become key components in today's synchrotron optics. These optical components feature nanometre accuracy on a macroscopic length scale.
Beamlines with extreme lengths of 100 m to 1km or more (as planned for the European XFEL) will require plane mirrors characterized by a residual slope error of 0.05 µrad rms and a curvature radius of > 500 km on a length of 800 mm or even more. Diffraction limited focusing mirrors for hard X-ray application show residual slope deviations of 0.05 µrad rms on a length of 350 mm. The current slope limit for focusing mirrors in VUV-application lies at around 0.5 µrad rms, one order of magnitude inferior compared to hard X-ray focusing optics. However, technological boundaries still pose a seemingly insurmountable obstacle to exceeding this limit.
Equally important for the operation of delicate optics like this are the mechanics and mirror environment.
HZB is therefore operating a dedicated laboratory in order to meet these requirements and to ensure the high level of quality of optical components which are to be installed at synchrotron beamlines of various synchrotron sources like BESSY-II, PETRA-III, FLASH and the European XFEL.
We will report on our results in the field of metrology for synchrotron optics – like slope measuring deflectometry - and discuss achievements and upcoming requirements regarding the quality of ultra-precise synchrotron mirrors.