Innovative ion beam processing and coating techniques for X-ray optics

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Processing of X-ray optical surfaces, i.e. figuring, smoothing, cleaning and coating, has to meet highest quality requirements. Contour accuracy and surface roughness are important parameters which have to be controlled carefully. Additionally, X-ray mirrors typically have 2-dimensionally curved, aspheric contours, which are mostly created by sophisticated figuring techniques starting from a flat or spherical substrate (silicon or quartz glass). The resulting micro-roughness of the surfaces but also the subsequent interface roughness of the multilayer coatings must be in the order of 0.1 nm to ensure sufficient X-ray reflectance of the mirror.

Ion beams are very suitable for processing of optical surfaces because of their defined and reproducible interaction with solids, combined with a low penetration depth. Furthermore, ion beam (assisted) deposition of thin films and multilayers is a well known technique for the production of X-ray optical coatings.

We present experimental results of ion beam processed X-ray optics of various shapes and coatings (fig. 1). The dual ion beam sputtering machine we used can perform all mentioned processing steps to produce X-ray optics. Combining all steps in one machine has the advantage of keeping the surface under vacuum conditions and thus avoiding unfavorable changes during exposure to air. A primary ion beam is used for sputtering of the coating material(s). In addition a secondary ion beam, directed onto the substrate surface, can be used for figuring, smoothing or deposition assistance. Each processing step needs specific ion energies and ion yields of the two linear ECR sources, which can be adjusted in the range between 50 ... 2000 eV.

Typical slope errors of the meridional contour we currently obtained during figuring and polishing of aspheric curved X-ray optics of up to 150 mm length are about 100 µrad (0.006 °). The processing of 2-dimensional figured X-ray optics remains difficult because the sagittal radius often is only some millimeters. Examples of figuring and subsequent multilayer coating of such single bounce mirrors will be shown.

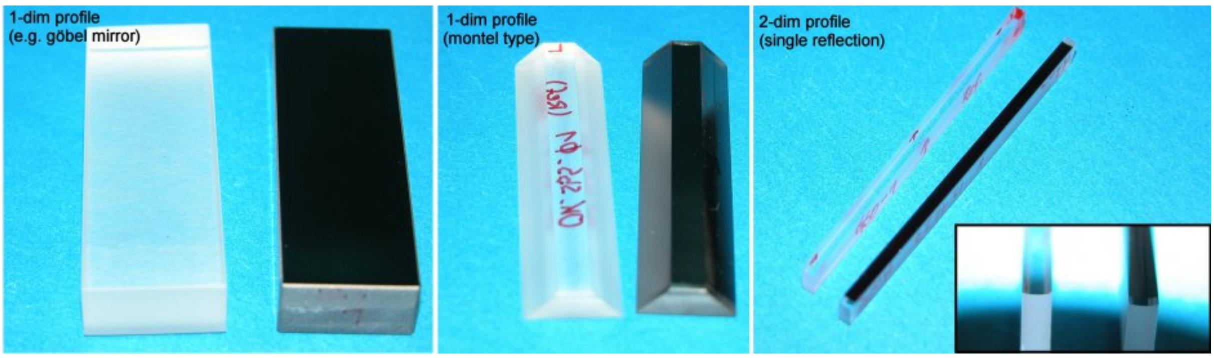

Fig. 1: Examples of X-ray optics figured and coated by the ion beam technology