Smoothing of surface roughness by ion beam deposition and etching

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The performance of multilayer X-ray optics strongly depends on the roughness of the substrates to be coated. Even small roughness increases, e. g. from 0.2 nm to 0.5 nm rms, have huge impacts on the reflectance of the multilayers. However, typical roughness values of optically polished glasses are in the order of 0.5 – 1 nm rms. The polishing to smaller values is possible but very expensive.
The aim of the current work is to smooth surface roughness by applying ion beam deposition and etching. The experiments are carried out using the dual ion beam machine "IonSys 1600". The machine is equipped with two linear ECR ion sources with a grid length of 400 mm. The primary ion source is directed onto the target in order to perform the sputtering of the materials. A secondary ion source can be used to bombard the substrate surface with monoenergetic ions. For the investigations shown in this presentation, two different operation modes of "IonSys 1600" have been used: Surface coating and surface polishing (fig. 1).

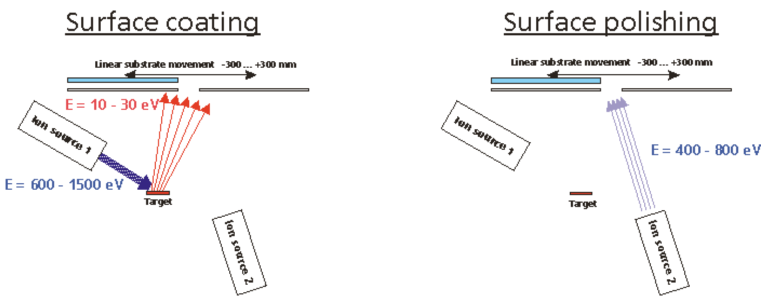

Fig. 1: Left hand side: Surface coating using ion beam deposition with ion energies between 600 and 1500 eV. Right hand side: Surface direct smoothing with ions of 400 – 800 eV.

The coating of the surfaces has been carried out with carbon and silicon as coating materials. Both materials are known to form amorphous films. That is necessary in order to grow atomically smooth layers. Depending on the initial roughness of the substrates, the energies of the primary ions and the layer thickness, the surface roughness of the coatings has been characterized by atomic force microscopy. It has been shown that, under optimized conditions, the surface of a silicon wafer with an initial roughness of 0.51 nm rms can be smoothed to 0.34 nm rms after deposition of a silicon layer with a thickness of 200 nm.
In addition to the coating experiments, several surfaces have been treated with monoenergetic ions having energies in the range of 400 – 800 eV. For the ion beam smoothing two different gases (Ar, Kr) have been used and the results have been compared. We explored that the surface topography of commonly used fused silica substrates with an initial roughness of 0.55 nm can be polished to 0.14 nm rms by using ion beam direct smoothing.