Ion beam modification of Mo/Si multilayer EUVL optics

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Since the first demonstration of ion beam polishing to smoothen interfaces in X-ray multilayer coatings, this technique has been used to extensively improve the optical properties of various multilayer systems.
The reason for this is twofold: it produces very smooth layers and, equally important, the ion polishing can be optimized independently of the deposition process, thus providing an extra degree of freedom in the multilayer production process.
For one of the most challenging applications of multilayer coatings, EUVL, we optimized the ion polishing process of the Si-layers of coatings produced with e-beam evaporation. Polishing with 2000 eV Kr^+-ions at an angle of incidence of 50° results in an interface roughness of 0.2 nm rms, which is substantially less than the initial 0.3 - 0.35 nm roughness of the substrate.[1] This smoothening of the Si layers by ion polishing has been analyzed in detail and is best described as viscous flow.
Furthermore, the spatial frequency dependence of the roughness has been investigated by measuring the diffused scatter using Cu-K_α radiation. The correlation length determined from the PSD was found to be 50 nm or more, as 50 nm is the upper limit determined by this measuring technique.
The performance of the EUV multilayer coatings is directly connected to the roughness of the substrates. Up to now, substrate manufacturers are making significant progress to meet the demands on surface figure of aspherical substrates for EUVL. However, simultaneous control of surface figure and substrate roughness in the high and mid spatial frequencies remains to be the main challenge.
Therefore we carried out experiments to determine the extend of the ion beam modifications and the possibility to smoothen the substrate roughness in the high and upper part of the mid spatial frequencies.

[1] H.-J. Voorma, E. Louis, F. Bijkerk and S. Abdali, J. Appl. Phys. **82**, 1878 (1997)