Surface engineering with energetic ion beams – from pattern formation to ultra-precision smoothing –

Bernd Rauschenbach[1,2], Thomas Arnold[1], Frank Frost[1]

[1]Leibniz Institute of Surface Modification (IOM), Permoserstr. 15, D-04318 Leipzig, Germany
[2]University Leipzig, Institute for Exp. Physics II, Linnéstr. 5, D-04103 Leipzig, Germany
Email: bernd.rauschenbach@iom-leipzig.de

Ion beam sputtering, i.e. the removal of atoms from a surface due to the impact of energetic ions, is an inherent part of numerous surface processing techniques. Beside the actual removal of material induced by atomic recoils and the sputtering of atoms from the surface this surface erosion process often results in a pronounced topography evolution, generally accomplished by a kinetic roughening of the surface. Typically, during ion sputtering, the surface of the solid is far from equilibrium and a variety of atomistic surface processes and mechanisms become effective. It is the complex interplay of these processes that either tends to roughen (e. g., by curvature dependent sputtering) or smoothen (e. g., by surface diffusion or viscous flow of surface atoms) the surface, which, finally, can result in a rich variety of surface topographies.

Concerning potential applications of ion beam, it will be demonstrated how ion beam smoothing can be used for the finishing of high end optical surfaces with topography and roughness control down to the atomic scale. Using broad beam ion sources with appropriate beam dimensions an alternative cost-efficient route exists to produce large-area nanostructured surfaces in a one-step process or for polishing of high quality optical surfaces, e. g., for smoothing of surfaces or interfaces of thin films.

It is demonstrated that ion beam smoothing is suitable for the polishing of technological relevant surfaces down to 0.1 nm rms roughness level showing a great promise for large-area surface processing, which is essential for many advanced optical applications. Finally it is demonstrated modular machine systems for the ultra-precision smoothing of optics and wafers up to 700 mm in diameter by low-energy ion bombardment. Such machines are used in the optical and semiconductor industry. Typical examples for the ultra-precision smoothing under industrial conditions are discussed.

References

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