Surface engineering with ion beams: from self-organized nanostructures to ultra-smooth surfaces

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Low-energy ion beam sputtering, i. e., the removal of atoms from a surface due to the impact of energetic ions or atoms, is an inherent part of numerous surface processing techniques. Besides the actual removal of material, this surface erosion process often results in a pronounced alteration of the surface topography. Due to different roughening and smoothing mechanisms a multitude of topographies can result from surface erosion. Under certain conditions, sputtering results in the formation of well ordered patterns. This self-organized pattern formation is related to a surface instability between curvature dependent sputtering that roughens the surface and smoothing by different surface relaxation mechanisms. If the evolution of surface topography is dominated by relaxation mechanisms surface smoothing can occur.

In the first part of the talk the current status of self-organized pattern formation and surface smoothing by low-energy ion beam erosion is summarized. In detail it will be shown that a multitude of patterns as well as ultra smooth surfaces can develop, particularly on Si surfaces. Additionally the most important experimental parameters that control these processes are discussed.

In the second part of the talk examples are given for the application of low-energy ion beams as an approach for passive optical device engineering. Especially, it will be demonstrated that ion beam assisted smoothing is suitable also 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. Examples related to R&D activities at IOM are given for technological developments in the field of ion beam smoothing of high-end optical surfaces, in particular for finishing of x-ray optical components and components for the EUV lithography.