Self-organized pattern formation by ion-beam erosion for antireflection surfaces

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Nowadays in modern optics antireflection coatings are essential to suppress reflection of light from the surface of optical components and to increase the transmission of light especially in the DUV-spectral range. Commonly used antireflective coatings are limited because of their mechanical stability. Alternatively, sub-wavelength nanostructured surfaces, similar to the structured cornea of a moth-eye [1] can be used as antireflective elements. Typical for these surfaces is a nearly angle-independent reflectivity over a broad spectral range.
Recently, ion beam erosion is regarded as an alternative bottom up process for the preparation of nanostructured surfaces via self-organization [2,3]. Under certain conditions erosion with low-energy ion beams (< 2 keV) can alter the surface topography resulting in well ordered patterns. Ripple like structures are obtained by off-normal ion incidence without sample rotation, either perpendicular or parallel (by grazing ion incidence) to the incoming ion-beam. Pattern of ordered nano-dots with length scales typically smaller than 100 nm can be fabricated at off normal ion incidence with simultaneous sample rotation. Using appropriate broad beam ion-sources allow a cost efficient large-area surface processing which qualify the process as an alternative nanostructure fabrication approach in contrast to advanced and costly lithographic techniques.
In this work results concerning the direct patterning of fused silica under varying ion beam sputtering conditions (ion energy, angle of incidence, erosion time) are presented. In addition, nanostructure pattern formation on III-V semiconductors, Si and Ge will be exemplified. It will be demonstrated that height, shape and ordering can be controlled to some degree by the ion beam and process parameters. These experiments show that low-energy ion-beam irradiation can generate ordered cone structures with a high aspect ratio on different material surfaces, especially applicable for nanostructured antireflection surfaces. Therefore these materials are used as sacrificial mask-layer and reactive ion beam etching (RIBE) are applied for the pattern transfer into optical relevant materials, i.e. fused silica. The exploration and optimization of the process for the generation of broad-band antireflection surfaces for the DUV-spectral range will be discussed.

[1] P. B. Clapham, M. C. Hutley, Nature **244**, 281 (1973)
[2] F. Frost et al., Nucl. Instrum. Meth. B **216**, 9, 2004
[3] B. Ziberi et al., Phys. Rev. B **72**, 235310, 2005