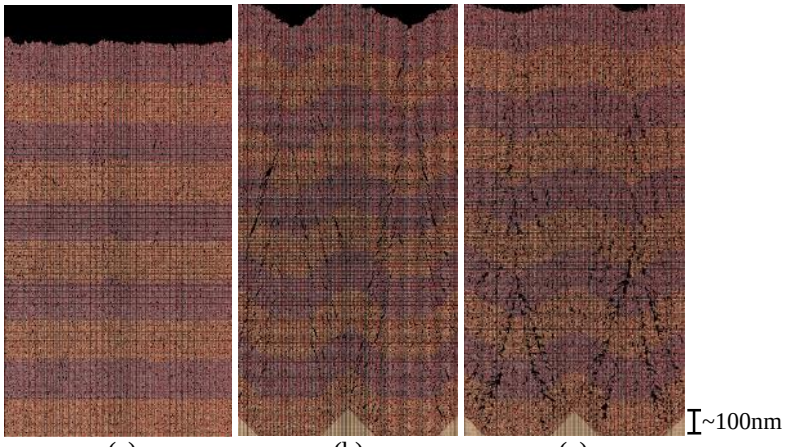
DEPOSITION OF MULTILAYER OPTICAL COATINGS ON CORRUGATED SURFACES

Julianija Nikitina[1,2*], Tomas Tolenis[1], Lina Grinevičiūtė[1]

[1] Center for physical sciences and technology, Savanorių ave. 231, LT-02300 Vilnius, Lithuania
[2] Department of Physics, Vilnius University, Saulėtekio ave. 9, LT-10222, Vilnius, Lithuania
[*]julianija.nikitina@ff.stud.vu.lt

During recent decades, thin film coating technology has experienced significant development, providing high quality laser optics with desired functionalities, like optical filters, high-reflection mirrors etc. Fabrication processes of such optical elements usually consider multilayer interference coatings deposition on initially flat substrates, thus creating refractive index modulation in one direction, as in case of 1-dimentional photonic crystal. Meanwhile, the evolving nanophotonics field requires more complex and novel optical elements with 2D or even 3D periodicity of refractive index [1]. Unfortunately, state-of-the-art fabrication technologies, even like direct laser writing, are not suitable in this case due to restricted control over the formation of the structure at nanoscale.

Present work proposes an alternative fabrication process – deposition of multilayer optical coatings on modulated surfaces employing PVD technologies together with glancing angle deposition (GLAD) method. GLAD allows to form the so called sculptured thin films by directing vapor flux towards the substrate at oblique angle. This feature potentially may help to conformally cover non-flat surfaces and maintain initial structure modulation throughout the film thickness, which is crucial considering optical elements with 2D or 3D periodicity of refractive index. In this case several variables appear: substrate relative orientation during the deposition process and the angle θ subtended between the substrate normal and the incident vapor flux. It is important to evaluate the dependence of final structure on these values. Primary numerical simulations were performed employing NASCAM (NAno SCAle Modeling) software based on kinetic Monte Carlo algorithm [2]. This software does not take into account the vibrational movement of atoms or interatomic interactions, hence allows to investigate time evolution of relatively large systems containing millions of atoms. As an example, in Fig. 1 are shown 10 alternating layers of SiO_2 and Al_2O_3 coating evolution in different cases: (a) multilayer structure on flat surface creates refractive index modulation in one direction and it can be easily deposited employing conventional PVD technologies. Although layers deposition on modulated surfaces can face several problems, like cracks formation along film thickness (Fig.1 (b) and (c)) or modulation extinction after several layers (Fig.1 (c)).



(a) (b) (c)

Fig. 1. Simulations performed by NASCAM software for 10 alternating layers of SiO_2 and Al_2O_3 deposited: (a) on flat substrate at θ=0º angle; (b) on grating at θ=30º while the plane between the vapor flux and normal of the surface is parallel and (c) perpendicular to grating lines orientation.

The aim of this research is to simulate and evaluate the growth mechanism of multilayer optical coatings on modulated surfaces and compare theoretical results with experimental measurements. Experimental part was performed with different PVD technologies, as ion beam sputtering, electron beam evaporation and with GLAD method, to evaluate their ability to conformally cover modulated surfaces.

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