Fano tipo rezonansas moduliuotose vienasluoksnėse dangose šviesos kampiniam ir dažniniam selektyvumui

Fano-like resonances in modulated single-layers for angular and frequency selectivity of light

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Modern tendency to miniaturize laser systems and enhance its laser power, evoke the need to create novel optical elements with periodically modulated inner nanostructure, as photonic crystals. Artificially created refractive index modulation in such structures forms the allowed and forbidden energy bands, that are useful to manipulate light propagation in various ways. And yet, when the required refractive index periodicity decreases to nano-scale (<100 nm), the possibilities of state-of-the-art lithography to fabricate such photonic crystals are restricted. Therefore, multidimensional photonic crystals are quite rare in practice.

One of alternative fabrication method is conformal deposition of thin films on structured surface, where every layer repeats initial surface modulation. Among physical vapour deposition technologies, ion beam sputtering shows most promise in conformal deposition, since its energetic particles tend to form highly dense and smooth layers. The practical value of such complex multilayer nanostructures has been demonstrated in Ref. [1], however its optical characteristics deviate from "ideal" one, i.e., theoretical predictions. Here, the discrepancies arise due to various reasons, such as modulation extinction after the thickness of deposited layers reaches several microns, distortion of modulation form etc.

Keeping the above discussions in mind, this work was of a more fundamental nature and was aimed to investigate the growth process of ion beam sputtered single layers on periodically modulated surfaces using different optically transparent materials, as hafnium, niobium, tantalum and silicon oxides. As the results show, replicability of surface modulation depends on material of choice. Among investigated materials, silica layer showed the most rapid smoothening of modulation, which can be associated with its "light" atoms (relatively small molecular weight), that are easier scattered by residual gasses and form low-density layers. Speaking of optical properties, when the periodically modulated single-layer structure with high refractive index is surrounded by a low refractive index media (see Fig. 1a), it features Fano-like resonance phenomena due to coupling of thin film waveguided modes with Fabry-Perot modes [2]. This phenomenon results in the appearance of extremely low transmittance lines in the transmittance (Θ, λ) maps (Fig. 1b). Also, these resonance lines show sensitivity with respect to the angle and the wavelength of the incident light, which can serve as a demonstration of spatial and spectral filtering in such compact photonic single-layer structures.

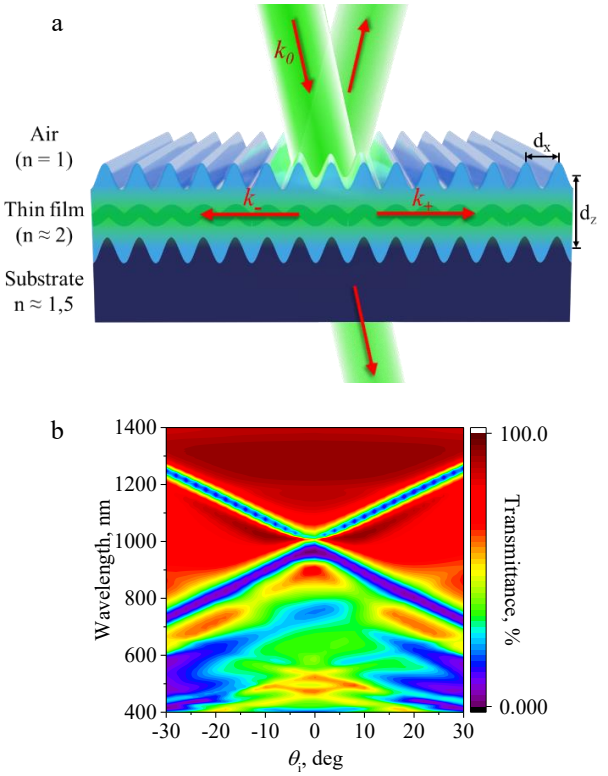

Fig 1.a. The schematic representation of Fano-like resonance in periodically modulated single-layer photonic structure; b. Transmission map in a plane (Θ, λ) for 0.2 μm thick tantalum oxide structured layer [2].

Key words: optical coatings, ion beam sputtering, nanostructured surface, angular and frequency selectivity.

Literature

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