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CFUV PhysTech

FORMATION OF SPATIALLY INHOMOGENEOUS COATINGS DURING ION SPUTTERING OF TARGETS

ABSTRACT. *In work the results of studying the features of the formation of spatially inhomogeneous films during ion-plasma and magnetron sputtering of targets are presented. It is shown that when thin functional layers are deposited for creating the composites and heterostructures using magnetron sputtering of a target with an annular erosion zone, a coating with highly inhomogeneous in thickness is formed on the substrate. The profile of the coating thickness is determined both by the parameters of the target erosion zone and by the distance from target to substrate.*

INTRODUCTION

Magnetron sputtering in vacuum is the very popular method for films manufacturing. This method allows to deposit coatings from different materials including multi-component materials. The magnetron coatings have a high adhesivity, high structural homogeneity and stoichiometry. The magnetrons with circle sputtering area are used most often. In this case the most important parameter of coating is the thickness distribution. To obtain films with homogeneous thickness the rotatable holders are used, but for some research tasks the inhomogeneous films are most have.

In our research we have been investigate the distribution of film thickness when the substrate is located in different distance from sputtered target during magnetron deposition. This inhomogeneous films we used for synthesis of gradient photonic crystal.

MODEL OF TARGET SPUTTERING

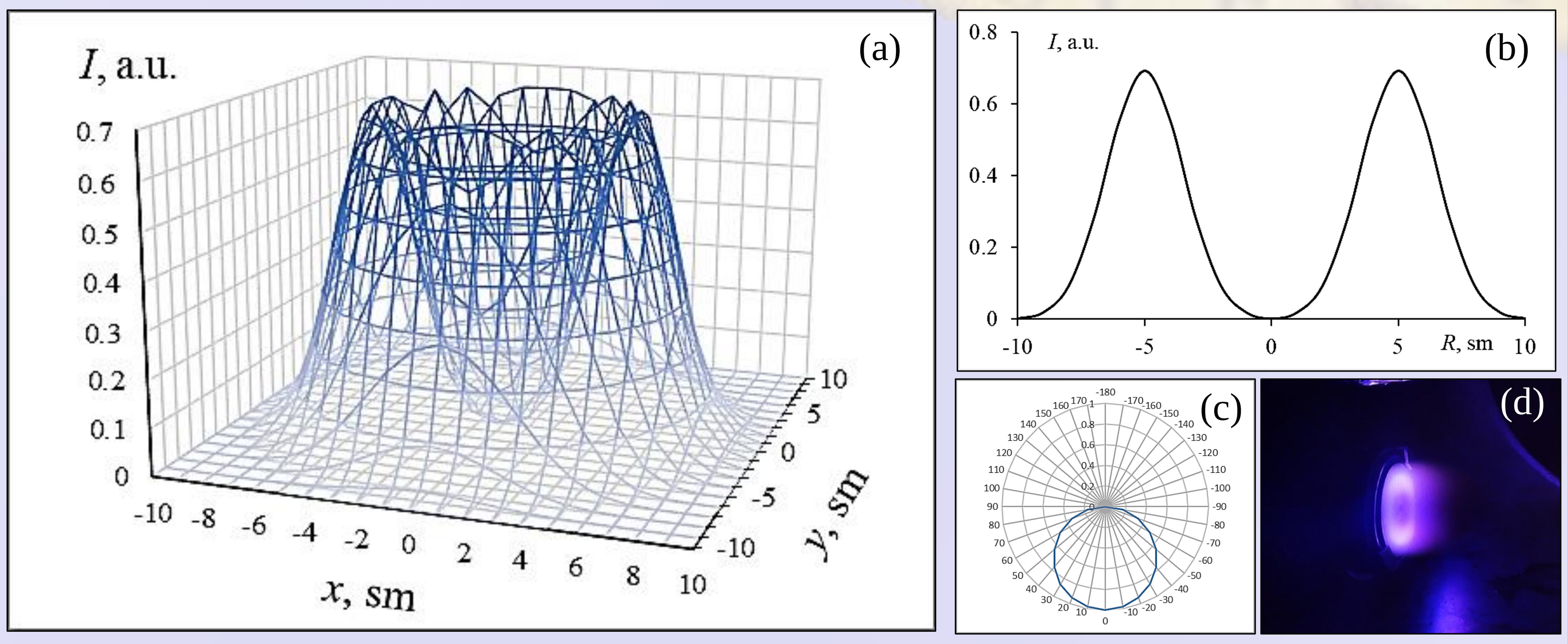


Fig. 1 – 3D-profile (a) and 2D-profile (b) of effectivity of target sputtering by magnetron with round erosion zone, (c) angular diagram of flow direction of sputtered material, (d) photo of working magnetron with round erosion zone.

FILM THICKNESS DISTRIBUTION

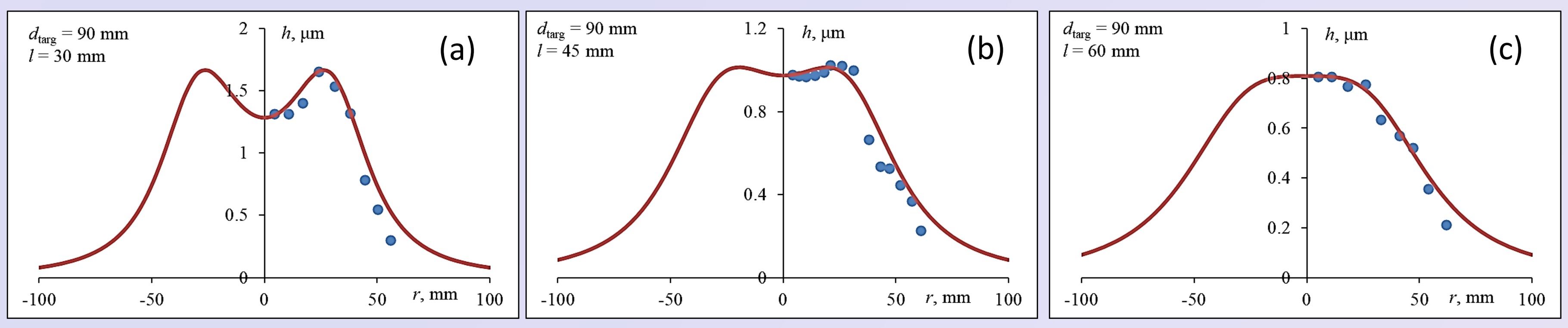


Fig. 2 – The results of experimental investigation of radial distribution of TiO_2 films thickness, which has been obtained by method of magnetron deposition with erosion zone diameter of d_{targ} = 90 mm for different distance from target to substrate: a – 30 mm, b – 45 mm, c – 60 mm.
(dots – experimental results, line – modeling simulation).

SAMPLE STRUCTURE

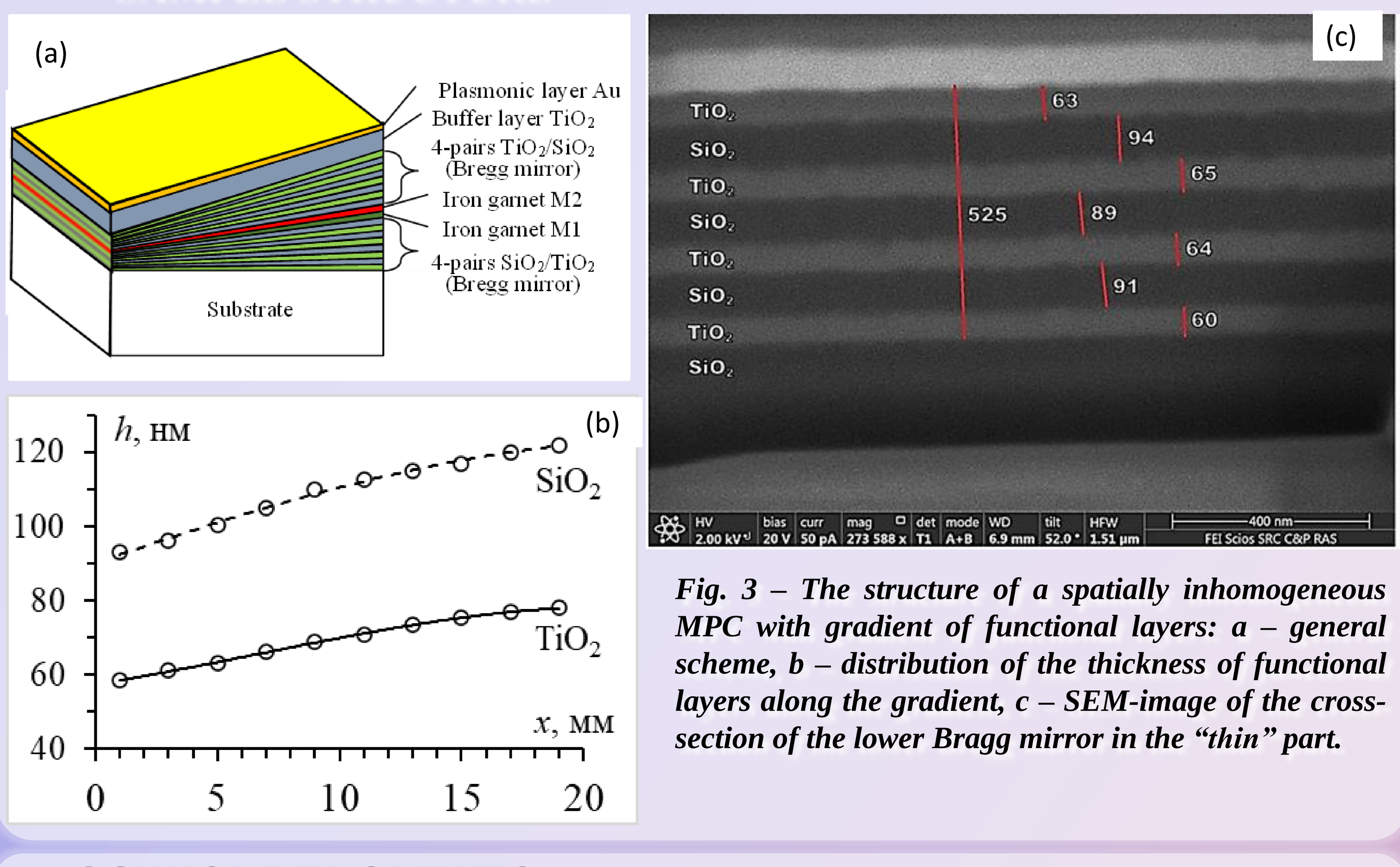


Fig. 3 – The structure of a spatially inhomogeneous MPC with gradient of functional layers: a – general scheme, b – distribution of the thickness of functional layers along the gradient, c – SEM-image of the cross-section of the lower Bragg mirror in the "thin" part.

ACKNOWLEDGMENTS

This work was financially supported by the grant of State Council of Crimean Republic (resolution № p653-2/23 from 30.01.2023)

MATHEMATICS

Target
$$j=\frac{C}{\sigma\sqrt{\pi}}\exp\left(-\frac{(r-<r>)^2}{2\sigma^2}\right)$$

Flux
$$dI=j\cdot dS=j\cdot r dr d\varphi$$

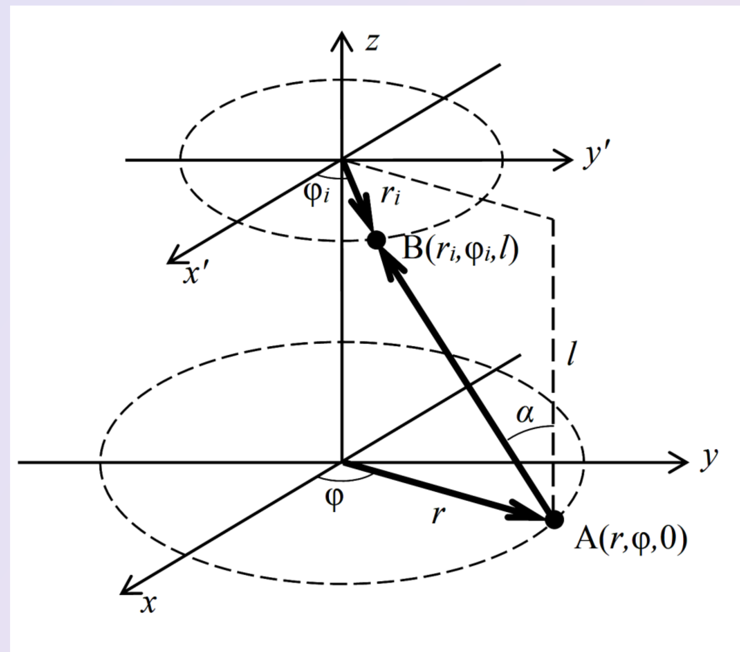
$$(AB)^2=(r\cos\varphi-r_i\cos\varphi_i)^2+(r\sin\varphi-r_i\sin\varphi_i)^2+d^2$$

$$dI_\alpha=dI\cdot\cos\alpha=dI\,\frac{d}{AB}$$

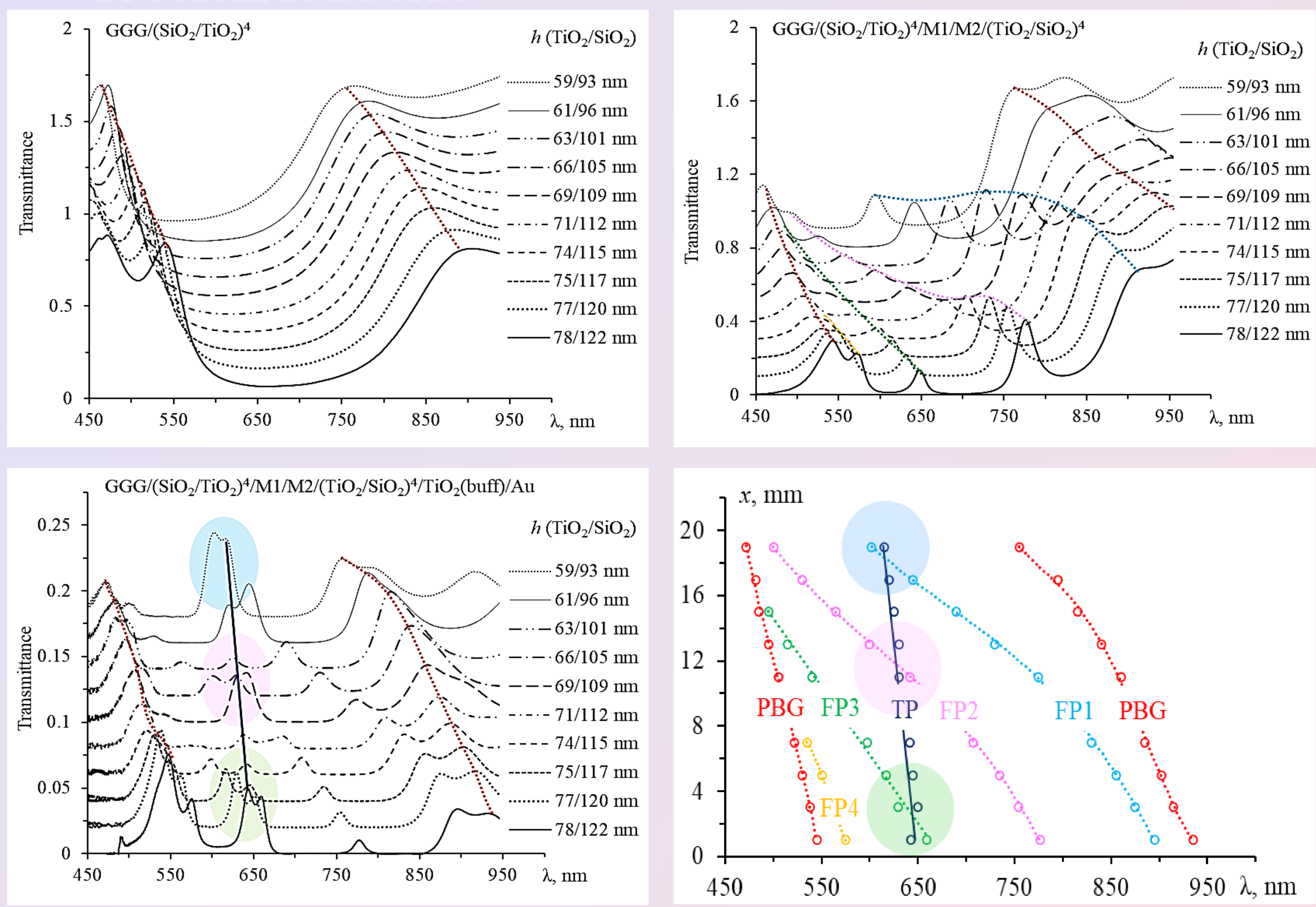
$$dh=\frac{dI_\alpha}{(AB)^2}=dI\,\frac{d}{(AB)^3}=j\,\frac{d\cdot r dr d\varphi}{(AB)^3}$$

$$dh=\frac{d\cdot C}{\sigma\sqrt{\pi}}\cdot\exp\left(-\frac{(r-<r>)^2}{2\sigma^2}\right)\cdot\frac{r dr d\varphi}{\left[(r\cos\varphi-r_i\cos\varphi_i)^2+(r\sin\varphi-r_i\sin\varphi_i)^2+d^2\right]^{3/2}}$$

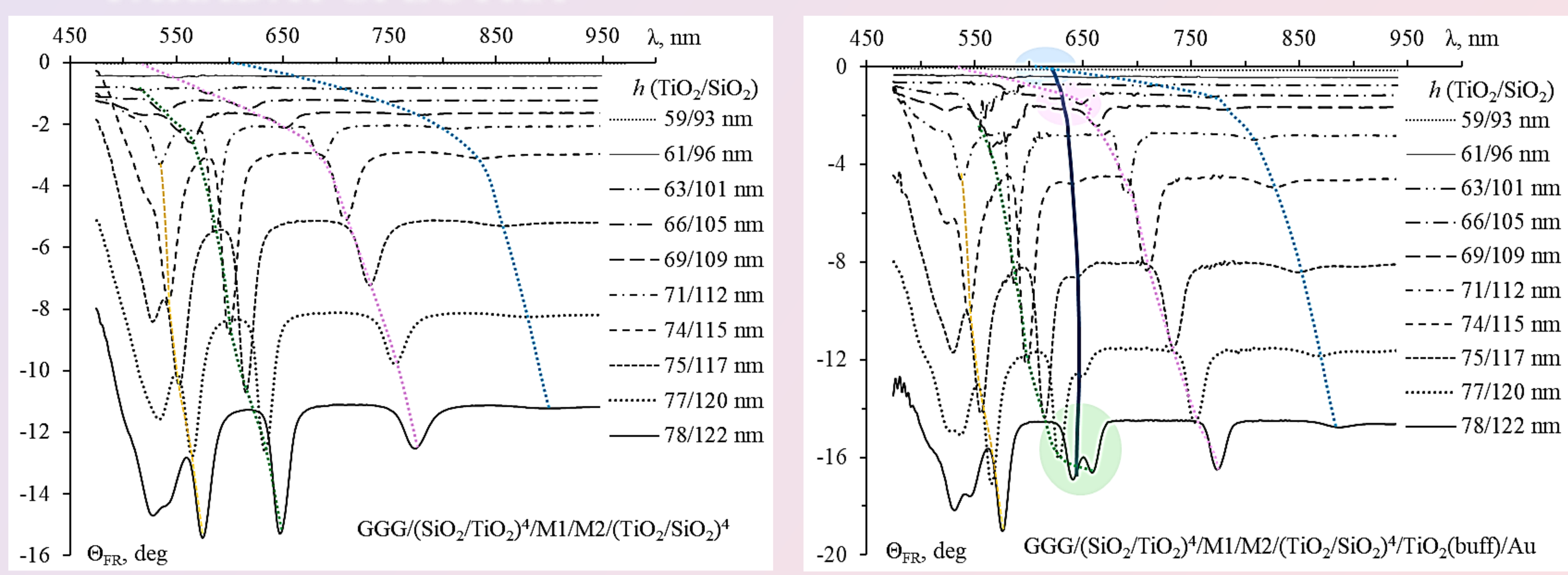
$$h(r_i,\varphi_i,d)=\frac{d\cdot C}{\sigma\sqrt{\pi}}\cdot\int_0^R\int_0^{2\pi}\exp\left(-\frac{(r-<r>)^2}{2\sigma^2}\right)\cdot\frac{r dr d\varphi}{\left[(r\cos\varphi-r_i\cos\varphi_i)^2+(r\sin\varphi-r_i\sin\varphi_i)^2+d^2\right]^{3/2}}$$



OPTICAL SPECTRA



FARADAY SPECTRA



CONCLUSIONS

Thus, the spatially inhomogeneous magneto-photonic crystal with tunable optical and magneto-optical characteristics, which basis on functional layers with a thickness gradient along the chosen direction, was synthesized using the method of deposition in a inhomogeneous flow. It is shown that in this crystal several resonant Fabry-Perrot modes and Tamm plasmon-polariton mode are generated at once, whose spectrally shift inside the photonic bandgap when the thickness of the functional layers changes along the gradient. In the areas of spectral overlap between the Fabry-Perrot modes and Tamm plasmon mode occurs their hybridization. It observed as anomalous optical transmission, which cannot be described only by the additive superposition of resonance peaks.

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