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MULTILAYER STRUCTURES BASED ON PCM WITH TUNABLE REFLECTION AND TRANSMISSION CHARACTERISTICS FOR FULLY OPTICAL ROUTING DEVICES

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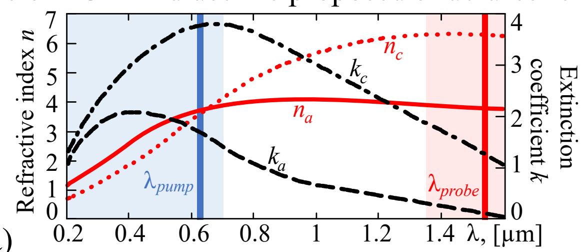
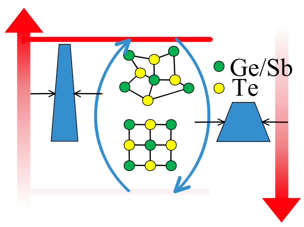
Abstract. Today phase-change material (PCM) based on chalcogenide glassy semiconductors are widely used. These materials are the basis for such devices as memory cells, rewritable optical discs (DVD-RW, Blu-ray). The use of GST is interesting, but at the same time poorly studied for optical routing in integrable fiber-optic systems, miniature network-on-chip, programmable photonic circuits [1]. So, investigations in this area are attractive and actual. We have the following problems with optical switching of PCM phase state: reproducibility of optical parameters; reversibility switching of phase state; optical power losses. These problems are related to the fact that the optical (absorption, reflection, transmittance), geometrical (film thickness) and structural parameters (complex refractive index, switching energy exposure) of PCM film (layer of multilayer structure) in the amorphous state differ from those parameters for the crystalline state. Therefore, it is required to solve a multi-parameter task to find optimal parameters. We have solved this task with a combination of methods of finite difference time domain, nonlinear optimization of Maxwell's and Fresnel-Airy equations for optical multilayer structures. We performed modeling of multilayer structures with different PCM layer materials of $Ge_2Sb_2Te_5$ (GST) and $Ge_2Sb_2Se_4Te$ (GSST) and layer thicknesses for 638 nm pump and 1550 nm probe laser radiation (see Figure 1) [2]. Pump laser changed the phase state of the PCM layer. Probe laser was reflected from the multilayer structure or passed through it depending on the phase state of the PCM layer. The structure of "Air – 24 nm GST – SiO_2 substrate" had high optical losses for 1550 nm radiation (23 % reflection and 74 % transmittance with the amorphous GST layer, 57 % reflection and 18 % transmittance with the crystalline GST layer). Change GST to GSST and addition of SiO_2 and Si layers in the structure of "SiO_2 – 111 nm Si – 277 nm SiO_2 – 111 nm Si – 251 nm SiO_2 – 10 nm GSST – 241 nm SiO_2 – 110 nm Si – 276 nm SiO_2 – 112 nm Si – SiO_2 substrate" allowed to reduce losses (0 % reflection and 100 % transmittance with the amorphous GST layer, 92 % reflection and 0 % transmittance with the crystalline GST layer). So, the optimization of parameters of the multilayer thin-film structure made it possible to reduce optical losses. This makes it possible to expand the scope of PCM and use the proposed structures for fully optical routing devices.



(a)



(b)

Figure 1. Spectral (a) and optical (b) properties of GST in amorphous and crystalline states [2].

References

1. Programmable photonic circuits / W. Bogaerts, D. Perez, J. Capmany [et al.] // Nature. – 2020. – Vol. 586, Iss. 7828. – P. 207 – 216.

2. Optical switching in multilayer structures based on $Ge_2Sb_2Te_5$ / N. M. Tolkach, N. V. Vishnyakov, P. I. Lazarenko [et al.] // J. Phys. Conf. Ser. – 2020. – Vol. 1695. – P. 12075 – 12079.

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