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Optically controlled fine-tuning phase shift cell based on thin-film $Ge_2Sb_2Te_5$ for light beam phase modulation

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Presented the experimental study of free-space optical control of the optical beam phase shift caused by the formation of a layered structure in an elementary controllable cell made of phase-change material $Ge_2Sb_2Te_5$ subjected to the controlling effect of pulsed laser radiation. The phase change of the signal optical beam passing through the controlled cell from phase-change material relative to the control beam in the Jamin interferometer is demonstrated.

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$Ge_2Sb_2Te_5$ has strong contrast optical and electrical properties between amorphous and crystalline states [1–3]. Because of the high stability of both phase states, this material has been successfully used in rewritable optical storage media and electronic non-volatile memory devices for many years [4, 5]. The unique capabilities of phase-change material (PCM) have already been demonstrated in meta-optical devices, where an easy-to-fabricate PCM layer as a functional material [6]. Efficient prototypes of PCM-based devices providing light control have been demonstrated [7–9]. A comprehensive study of the control of the phase of reflected and transmitted light during switching of a phase changeable material cell is necessary.

Experimental studies (Fig. 1) have shown that using 100 nm films it is possible to achieve a dynamic range of $\pm 2/5\pi$ for tuning the phase of the light wave when controlling the state of the cell by nanosecond laser pulses [10]. Structural properties were analyzed by Raman spectra [11, 12]. This roughly coincides with the theoretical estimate obtained from the refractive indices for different phases of the material measured by ellipsometry methods [13]. At the same time, 50 nm films allow to achieve approximately half the phase tuning range. The PCM-based technology is mature and perfectly scalable [14]. Based on the experimentally investigated unit cell, it is possible to construct a phase shifter for the conversion of an optical beam of arbitrary aperture. If a small and fast adjustment of the phase optical transparencies is required, the proposed method of controlling the optical beam front can be very promising.

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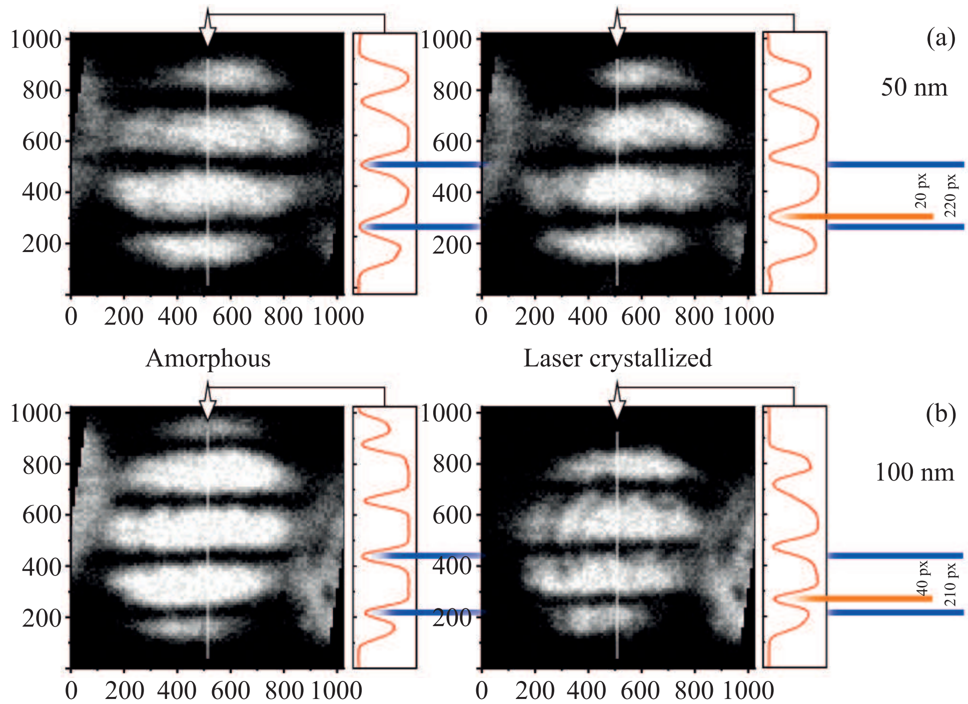

Fig. 1. (Color online) Phase shift fine tuning in thin-film PCM optically controlled cell: (a) – 50 nm $Ge_2Sb_2Te_5$ cell with maximum shift $\Delta \approx \pi/5$ $(2\pi \cdot 20/220)$ and (b) – 100 nm $Ge_2Sb_2Te_5$ cell with maximum shift $\Delta \approx \pi/2,5$ $(2\pi \cdot 40/210)$

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