Laser-Induced Modification and Formation of Periodic Surface Structures ("Ripples") of Amorphous GST225 Phase Change Materials

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Abstract

We studied the surface modification of Ge2Sb2Te5 (GST225) amorphous thin films under impulse laser irradiation. GST225 composition is one of the extensively investigated phase change memory (PCM) materials, which is currently used for rewritable data storage applications based on structural phase transitions.
The GST225 amorphous thin films have been prepared by both the vacuum thermal evaporation and *dc* magnetron sputtering. We used nanosecond (λ= 532 nm, 16 ns) and femtosecond (λ=515 nm, 600 fs) lasers to study surface modification. Different methods have been used to determine the composition, in-depth elemental distribution and phase state of thin films (EDX, AES, TOF SIMS surface analysis, XRD). All specimens were studied using TEM/SEM, Raman spectroscopy and AFM.

It is shown that, with specially selected parameters of laser influence, it is possible to realize different types of surface structures. We observed fully crystallized spots in amorphous GST225 matrix in the case of "weak" laser intensity. The rise of laser power caused the formation of crystalline ring-shaped roll spots with amorphous central part. Subsequent increase of laser influence permitted to form periodic surface structures (ripples) with a period of _˜ 500 nm in an outlying area of spot. In these structures it is possible realize the periodic modulation of the refractive index due to solidification after the laser action of the crests and valleys of the gratings in different phase states whose dielectric constants differ greatly from one another. We observed the destruction of an amorphous film also, and the partial evaporation of the material in the central part in the case of laser pumping intensity above the threshold. This effect is due to a sharp increase of lattice vibrations amplitude, since when a sufficiently short and powerful laser pulse is applied, the light energy is transferred from the free carriers to the lattice and it causes its rapid melting.
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