Sub-ten nanosecond phase cycling of high contrast GeSbTe- and AgInSbTe-films

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GeSbTe and AgInSbTe compounds are currently receiving strong interest as suitable materials for optical data storage devices. Ge2Sb2Te5 is already known to be a fast phase change material, since both amorphization and crystallisation can be triggered with laser pulses as short as 10 ns [1]. However, little work has been done in these materials using shorter pulses or studying in real-time the dynamics of these phase transformations - which may last considerably longer than the pulse duration - despite the importance of this aspect in order to optimise data transfer rates beyond current limits. We have set out to determine the cycability of samples with maximum optical contrast between phases using shorter pulse durations. The use of real-time measurements of the reflectivity changes induced during irradiation enables us to obtain a much clearer physical picture of the transformation dynamics and the phases involved than that available from static measurements.

The chemical composition of the 50 nm thick samples sputtered on standard microscope glass slides are as follows: Ge2Sb2Te5, Ge2Sb1Te3 and Ag0.055In0.065Sb0.590Te0.290 (AIST). The as-deposited amorphous samples are initialized by exposure to ≈30 consecutive laser pulses (4 ns, 583 nm) at energies well below the melt threshold, inducing solid-state crystallization. The initialized samples are then irradiated with single laser pulses to induce amorphization, while measuring in real-time the reflectivity evolution at the sample surface, using a single-mode probe laser (514.5 nm), a fast photodiode and a sampling oscilloscope [2]. The results in Ge2Sb2Te5 show full transformation times around 5 ns for the amorphization process (Figure 1), apparently limited by the pulse duration. The speed of the transformation process is remarkably high leading to an optical contrast as large as 20%. Re-crystallization of these amorphized regions could be obtained upon irradiation with single laser pulses of an energy lower than that required for amorphization, showing transformation times also below 10 ns (Figure 1). At present, only partial crystallization could be achieved with a single pulse whereas full crystallization required exposure to three laser pulses. However, the contrast achieved after partial crystallization is considerable and amounts to 10%. Similar results were obtained for Ge2Sb1Te3 and AIST, showing slightly longer amorphization times (5 ns - 30 ns). However, partial re-crystallization could only be achieved for the GeSbTe compounds.

Overall, the results show that it is possible to amorphize and recrystallize both GeSbTe-compositions with laser pulses of a few nanoseconds and that the transformation is accomplished in the sub-ten nanosecond regime. Thus, phase cycling with high optical contrast (up to 30 % for Ge2Sb2Te5) can be achieved without compromising the transformation speed.
