Study of nano-sized clusters of phase change materials

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ABSTRACT

It has been demonstrated that size effect can have a strong impact on the crystallization mechanism of phase change materials. For thin $Ge_2Sb_2Te_5$ (GST) films the crystallization temperature increases when reducing the film thickness under 10 nm, the effect depending on the cladding material [1]. Clusters are the ideal system for studying the scalability of the phase change properties. Some results with GST nanoclusters have been reported but an unambiguous phase transition from an amorphous to a crystalline structure, at a definite temperature, has not yet been reported [2].

Nanometric GST clusters have been synthesized using a sputtering gas-phase condensation source [3]. This technique rests on the magnetron sputtering of a solid target using high pressure argon plasma, in a liquid nitrogen-cooled growth chamber. Supersaturation in the gas of sputtered atoms results in the nucleation and growth of clusters, due to collisions and thermalization by the rare gas. This apparatus produces a narrow beam of free-flying clusters, which are deposited on a Si substrate with a 6 nm Al_2O_3 underlayer and capped with Al_2O_3. The average size of the obtained GST clusters measured using time of flight mass spectrometry is 5.7 nm ±1 nm.

X-ray diffraction experiments were performed at the CRG-D2AM synchrotron beamline (ESRF Grenoble, France) on GST clusters as-deposited as well as annealed under vacuum at 200°C. The as-deposited GST clusters are amorphous while those annealed at 200°C are crystallized into the rocksalt fcc cubic structure. From in situ annealing XRD measurements we found only a small increase of the crystallization temperature of GST clusters with respect to bulk GST.

Key words: clusters, GST, size effect, crystallization temperature.

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