

Molecular Beam Epitaxy of GST

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Phase change materials from the GeTe - Sb₂Te₃ (GST) system, specifically compositions close to Ge₂Sb₂Te₅, are very promising candidates for future solid state memory devices. Their switching mechanism, however, is still not well understood on the atomic scale. While the local order can be reliably probed by EXAFS, a detailed study of the structural changes on longer length scales during switching has so far been hindered by the fact that the metastable cubic phase cannot be grown in bulk form. We have succeeded to grow cubic GST on closely lattice matched GaSb(001) by molecular beam epitaxy from elemental sources, demonstrating that a lattice-matched cubic substrate can indeed stabilize the cubic phase. The GaSb(001) surfaces were prepared in the usual way by oxide desorption and buffer growth, after which the surface was cooled down to temperatures between room temperature and 300 °C. All three shutters for Ge, Sb and Te were then opened simultaneously to grow the layers. The growth process was analyzed in situ by RHEED and synchrotron x-ray diffraction.

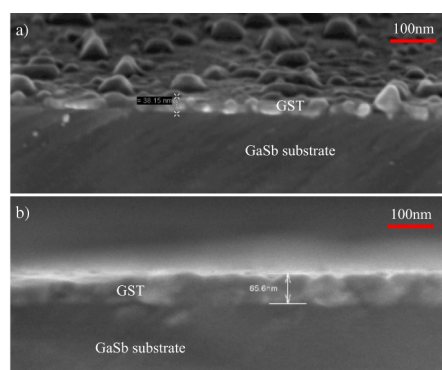


Figure 1: SEM images of films grown at (a) 190 °C and (b) 180 °C. Crystalline GST films exhibit a nonuniform morphology and structure.

Whereas amorphous films grown at substrate temperatures below 130 °C have a homogeneous structure and smooth surfaces, crystalline layers grown at higher substrate temperatures from stoichiometric fluxes show rough morphologies (Fig. 1). At around 200 °C, the cubic struc-

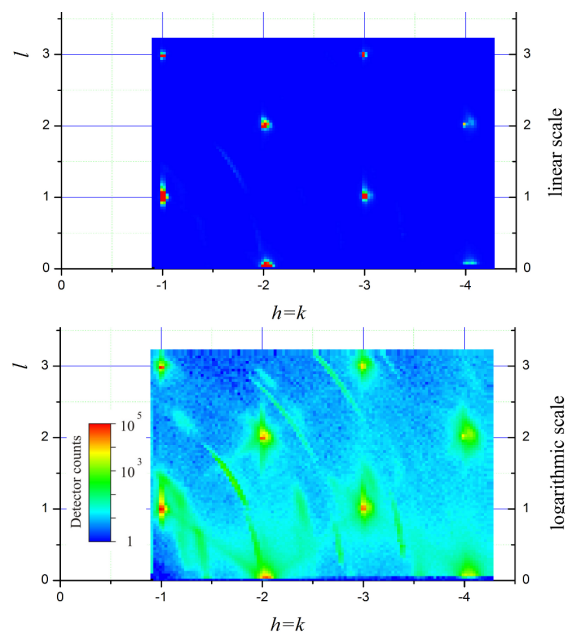


Figure 2: X-ray intensity in the plane normal to the surface along the in-plane face diagonal of the cubic unit cell. Top: linear, bottom: logarithmic intensity scale. The body-centered reflections of the distorted rocksalt structure are clearly seen.

ture nucleates out of an initial amorphous layer and stabilizes in an epitaxial cube-on-cube orientation. At higher temperatures, the deposition rate quickly goes down to zero, although a stable, atomically flat surface is maintained, demonstrating the thermodynamical stability of GaSb(001) in contact with GST.

The deposition rate does not depend on film thickness. The films relax to a lattice constant that is even below the value expected for Ge₂Sb₂Te₅. This indicates a possible Sb deficiency of the layers. In situ x-ray reflectivity (not shown) finds that the density of crystalline layers is less than expected for the single crystal, indicating the formation of voids. X-ray intensity maps such as the one shown in Fig. 2 demonstrate the strongly dominant epitaxial cubic orientation of the films in the expected distorted rocksalt structure.