TEM Studies of the Microstructure Resulted from Amorphous-Crystalline Transition under Electron Beam Irradiation in Chalcogenide-Based Films

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Chalcogenide-based films are widely used as the active media for rewritable information storage and are prospective for further developments. Anyway the detailed microstructure characterisation of the spots (pits) used seems lacking.

Using some initially amorphous vacuum condensates (Sb_2Se_3 and bilayers Ge-Sb_2Se_3, Se-Te, Ge-Te) we study the crystals growing under the influence of electron beam (e-beam) annealing in TEM. Mainly we explore the most specific feature inherent to amorphous-crystalline transformation in thin films - "transrotational" structure [1], most prominent between micro- and nanoscale [2]. Extinction bend contours that indicate these regular imperfections on the TEM images of crystallised areas of chalcogenide thin films (e.g. used as phase changed materials for optical recording) are rather common and can be found on the micrographs published by a number of authors (e.g., see [3-4]). The surprising thing is that the strong lattice bending (transrotational crystal structure) is identified and analysed rarely. We used bend contour techniques primarily to measure local and integral magnitudes of lattice bending as well as to estimate geometry and general character of lattice disorientations in the crystallized areas.

To study the effect of thickness (10-100 nm) and composition the films with strong gradient either of thickness (Sb_2Se_3) or relative layer thickness (bilayers Ge-Sb_2Se_3) or composition (Se-Te, Ge-Te) were prepared and placed on the TEM grids. Samples were irradiated by the e-beam inside TEM with a broad choice of various intensities (and therefore effective temperatures) at different illuminated areas (starting from a minimal spot of about 1 μm) that also makes possible *in situ* studies.

Strong internal lattice bending around axes lying in the film plane are observed for all the materials studied. In Sb_2Se_3 films the internal lattice bending strongly increases (the width of bend contour pairs decreases, FIG. 1) as the film gets thinner, while the growth rate decreases. In Ge-Sb_2Se_3 bilayers with variable thicknesses of the layers the influence of Ge layer on the crystal growth and microstructure can be more or less pronounced though depends upon the layer position (i.e. sublayer or overlayer). In particular, the intensity of the electron beam radically influences the crystallization and the structure of the crystallized spot in the case of Ge sublayer, FIG. 2. In Se-Te, Ge-Te films the relative concentration strongly influences the internal lattice bending.

It is obvious that some microstructure parameters (accessible for TEM) typically ignored (i.e. internal lattice bending) can strongly influence the time and energy needed for writing/rewriting in chalcogenide films for optical storage.

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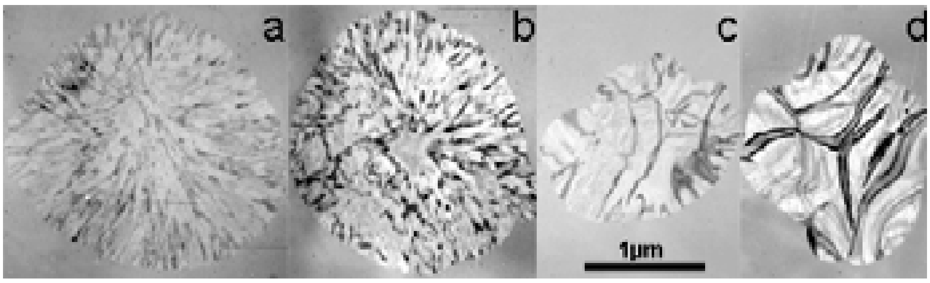

FIG. 1. The variation of the microstructure of crystallized spots in Sb_2Se_3 film across film thickness (increases from a to d).

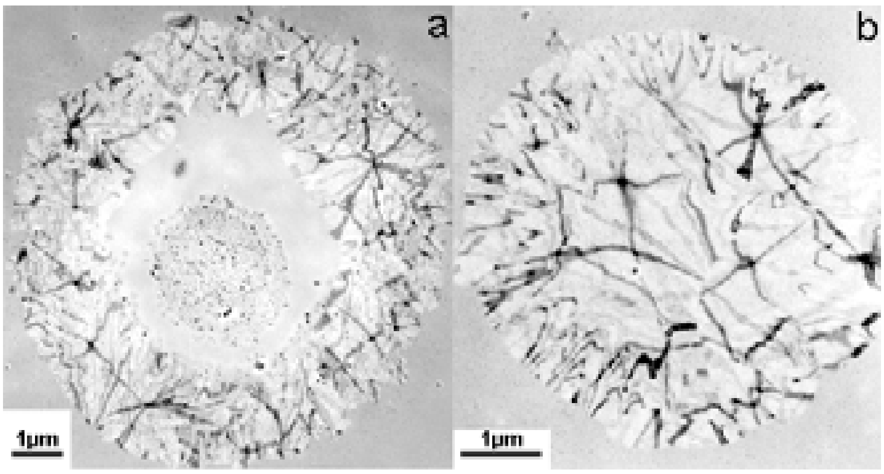

FIG. 2. Different structure of the crystallised spot in Ge-Sb_2Se_3 bilayer resulted from different e-beam intensity (a – stronger)