TEM Study of Lattice Bending in Sb_2Se_3 Crystals Grown in Amorphous Films

V.Y. Kolosov*,**, L.M. Veretennikov*, A.A. Kuzmin* and V.A. Mamaev**

* *Phys. Dept, Inst. of National Economy, 8th March Street 62, Ekaterinburg 620 219, Russia*
** *Phys. Dept., Ural State University, Lenin Pr. 51, Ekaterinburg 620083, Russia*

1. INTRODUCTION

Crystal growth in amorphous films can be accompanied by the unusual lattice ordering observed earlier for *Se, Te, CuSe,* Fe_2O_3 (Kolosov 1990). We studied Sb_2Se_3 crystal growth in amorphous films mainly *in situ*, under the influence of electron beams of various intensities in JEM-200CX.

Besides Sb_2Se_3 films Ge-Sb_2Se_3 bilayers of variable thicknesses of sublayers were prepared by successive vacuum evaporation from *Ge* and Sb_2Se_3 sources moved off from each other. Initially all the layers were completely amorphous and stable below·200°C. Bend contour (BC) technique (Bolotov et al 1982) was used for measuring of local and integral magnitudes of lattice bending and lattice disorientations in crystals.

2. MAIN RESULTS

2.1 Typical crystals grown in Sb_2Se_3 films

Usually more or less oval crystals are growing (Fig. 1a). For crystals exceeding the size 1-2 μms many "U-shaped" pairs of BCs appear at crystal periphery on a TEM image (Fig. 1a). Such BC patterns reveal decreasing in radius of crystal lattice bending and complicating of lattice bending geometry (rippling) at crystal periphery. Annealing at 250°C (2 minutes) results in textured crystallization (Fig 1b, [100] lies in the film plane).

2.2 Typical crystals grown in Ge-Sb_2Se_3 films

2.2.1 Ge-rich part of a film. Rhombus or its slightly distorted forms are most typical shapes of the crystals. Complex alternating BC patterns indicate strong lattice bending (radius 1-4 μms) round axis lying in the film plane.

2.2.2 Middle part of a film. Possible structures of the crystallized areas differ significantly from all structures characterized above. They vary from round-shaped to crescent-shaped and even ring-shaped areas (Figs. 1c, d). Inside such areas the circle of fine-grained *Ge* can appear. *Ge* circle can be surrounded by amorphous ring (Fig. 1c). Detailed analyses (using SADP and dark field modes) of complex BC patterns reveal the main result of the study. Strong regular internal lattice bending of the crystal growing in amorphous film is discovered for such crystallized areas. Internal bending of the lattice round [010] lying in the film plane (Fig. 1d, point B) can be deduced from sequence of BC patterns, or more traditionally - from sequence of SADPs. It makes 73° between points C_1 and F (Fig. 1d and Fig. 2). Additionally it is proved by tilting in the goniometer attachment. Angle between [104] (normal at point F, Fig. 1d) and [100] (point B) is 54°, and between [104] and [001] is 46°. Corresponding 46°-tilt about [010] (indicated by arrow on Figs. 1d, e) results in origin of [001] zone axis pattern at point A (Fig. 1e). Absence of any darkening or opacity at the crystal image (inevitable for crystal bending over 73°) approves internal lattice bending. *2.2.3 Sb_2Se_3-rich film part.* Crystallization is the same as for Sb_2Se_3 film.

2.3 General features of Sb_2Se_3 crystal growth in amorphous films
No correlation between nuclei orientations, crystal morphology (shape, facets) and crystal growth rate (in the range 10^{-1}–10^{2} μm/s) has been observed. Examination of 142 crystal orientations (at the crystal center) reveals typical orientations: [100], [101], [102], [001]. They are ordered according to the decrease in frequency of nucleation and at the same time they correspond to decrease in reticular density of the crystal planes parallel to the film surface. This evidence of the surface nucleation suits the earlier proposed model of lattice bending phenomenon (Kolosov 1992).

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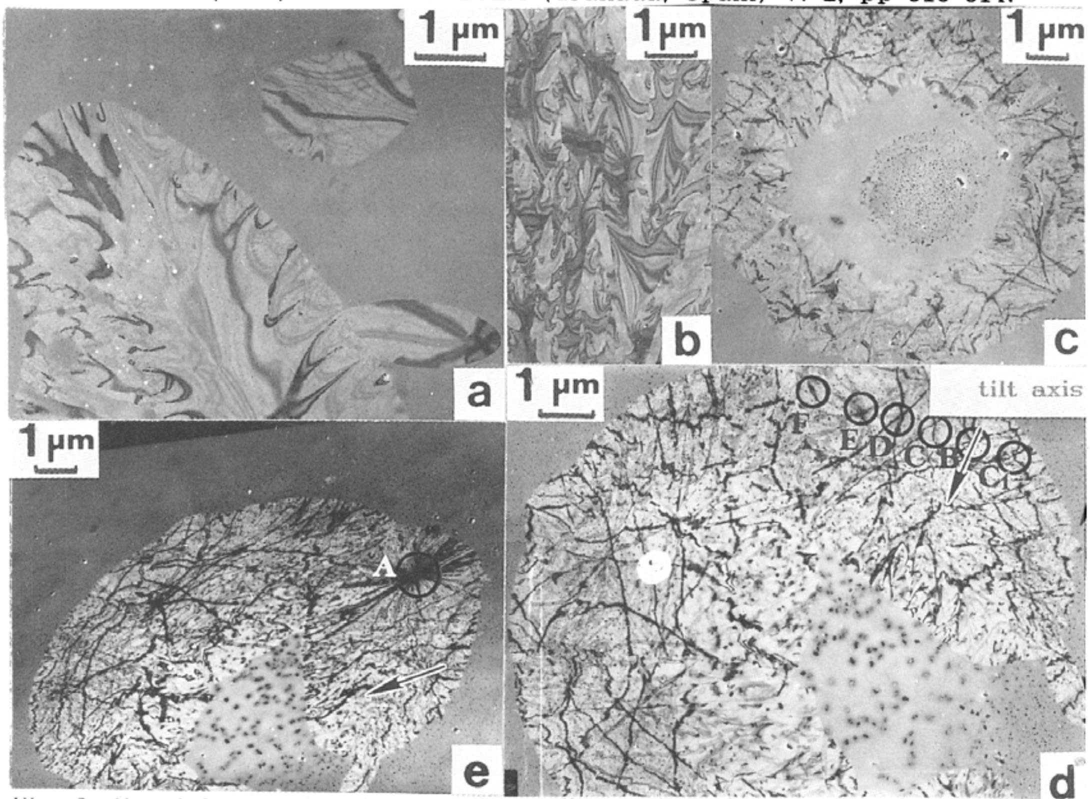

Fig. 1: Crystals growing in amorphous films: a) oval crystals, b) textured film, c) ring-shaped Sb_2Se_3 crystallized area (*Ge* circle at center), d) crescent-shape crystallized area, e) the same crystal tilted by 46° (tilt axis is shown by arrow).

010 ⟶

Fig. 2: SADPs from circled crystal regions A, B, C, C_1, D, E (Fig. 1d, white circle is the image of selected area diaphragm) with orientations: a) [001]-A, b) [100]-B, c) [101]-C or [$10\bar{1}$]-C_1, d) [102]-D, e) [103]-E.