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POSSIBILITIES OF THE BEND-CONTOUR METHOD IN THE ANALYSIS OF THE LATTICE DISORIENTATIONS IN CRYSTALS ON THIN-FILM TRANSFORMATIONS

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The paper summarized some of the authors data on the transmission electron microscope (TEM) investigations using bend-contours (BC) the transformations of crystal lattice orientations on crystallization of amorphous films and recrystallization. Most investigations were made *in situ* in JEOL and TESLA microscopes under the influence of the electron beam, Fig. 3-5, 8, 9. In some cases the video record was produced, some clippings supposed to be demonstrated.

1. The possibilities of BC method were outlined earlier (e.g. [1]). In particular they are similar to Kikuchi lines[2] method and sometimes are more powerful.[3] However these and some other options are rarely used in practice though BC patterns often present on the TEM images and carry the unique diffraction information written in the image plane. The merits of BC method in the evaluation of the lattice orientation, if compared with traditional selected area diffraction (SAD) - high locality, the possibilities of simultaneous analysis of large areas (fields of orientations) and visual ability, the demerits - fitness only to crystals with large orientation gradients (more than 10^{-2} rad/μm).

2. As was reported earlier[4] for the case of cylindrical lattice bending and parallel BC (this case can be easily generalized to arbitrary case) the BC location on TEM image and spot location on SAD pattern can be defined analytically. The cases of reflecting planes zone axis deflection from electron beam through angle Band bending axis deflection through angle α were considered. The derived formulas can be used for depicting the theoretical BC patterns, useful for the comparing with the experiment. More promising is picturing the atlases of BC patterns for different bending parameters on the computer. The atlases enable express determination of the lattice orientation, disorientations at the grain boundaries Fig.l, peculiarities of complex texture, Fig.2. From analytical equations some qualitative regularities are also revealed, e.g. the displacement of BC at the twist and tilt low angle boundaries.

3. Most interesting experimental results. In amorphous films the growth of unusual crystals (some of them dislocation-free) which lattice is formed with regular continuous strong bending (up to 2 rad/μm) round the axis (axes) lying in the film plane is revealed. Investigated crystals are the crystals of Se, Fig. 3. *Te,* Fig.6, their compounds with *Cu,* Fig.7, α-Fe_2O_3, Fig.9, *Co-Pd.* The different realized geometries are described, e.g. for *Te* it differs for [001] and [001] growth directions in the same crystal, Fig.6. The bending of the lattice depends upon the conditions of growth, the orientation of the nucleus. Effect do not occur for the small growth velocities *Vg* for Se, Fig. 4, for Fe_2O_3, Fig.8 and also for Se for the nuclei with [100] normal to the film plane, Fig.5. For Fe_2O_3 crystals Vg varies synchronous with the change of the crystal lattice orientation and the density of the grain boundaries at the growth front. Fig.9. The examination of the neighbour frames on the video records for large *Vg* (10-500 μm/s) reveals the intensification of TEM contr a st on the image of growing crystal, BC arrangement being the same. This fact and the presence of the preferential orientations revealed by the analysis of SAD from numerous nuclei allow to propose the model for the formation of the crystal with curved lattice nucleated at the film surface.

4. Some other applications of BC method are demonstrated for the following studies: the formation of subgrains in thin perfect Se crystals, the "explosive" recrystallization in Dy_2O_3 films, the buckling of *TISe* crystals during the growth,5

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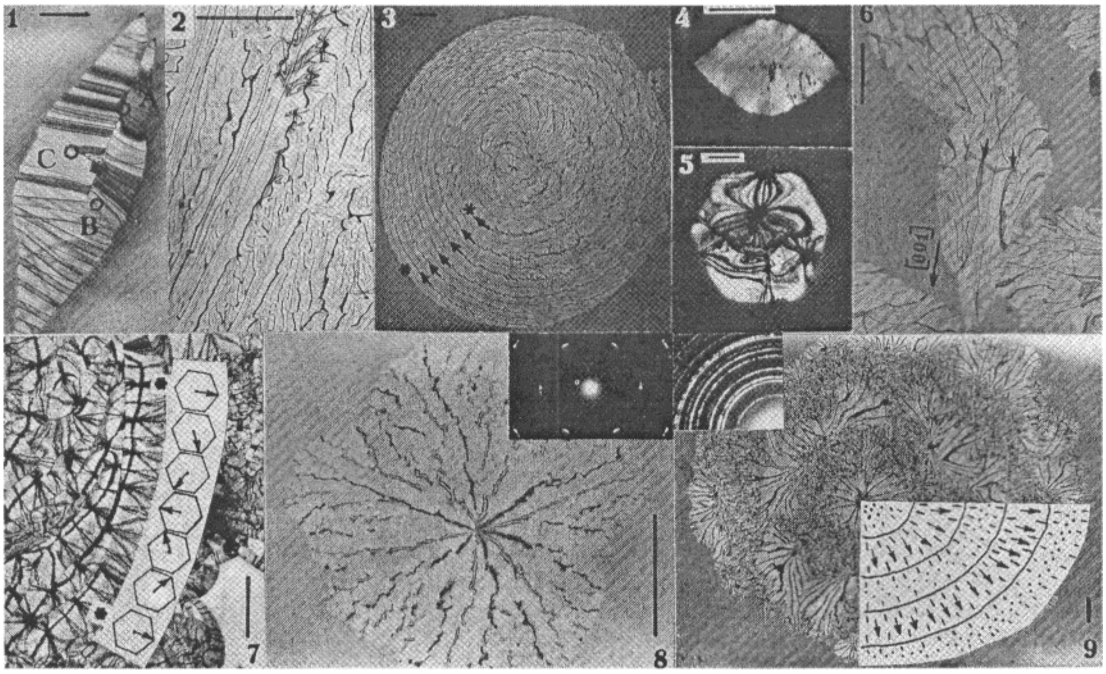

Bar=lμm

FIG. 1.—*Se* crystal. Disorientations on boundaries determined by BC in points : A - twisting 21°, tilting 8°, B -, tilting 20°, C - tilting 2-5°.

FIG. 2.—Textured *Te* film on Ge film. Alternation of large elongated single crystal areas (B *100*~0-2°) and regions with less grains, sized 0.1-1/μm (B_{110}~2-5°). Main lattice bending round [001].

FIG. 3. — Se spherulite, Vg-10 μm*/s*. Different geometry of lattice bending at crystal centre and at periphery, where disorientation between any neighbour contrast lines, marked by arrows ([110] zone axis patterns) is 60°. Lattice bending in radially elongated subgrains is identical to *CuSe* whiskers in Fig.7. FIG. 4.—Se single crystal, Vg-0.01 μm/s.

FIG. *5.* — Se crystal without effect of lattice bending, [001] normal to the film plane (in centre of crystal on Fig.3 - parallel). Corrugated buckling of the crystal. FIG. 6.—*Te* crystals. Rotation of [110] between spots, marked by arrows - 60°. Central crystal illustrate different bending geometry and *Vg* along [001] and [001]. FIG. 7.—Knitted thin *CuSe* whiskers. Rotation of [110] between spots, marked by asterisks - 360° (sketched in the cross-section of hexagonal CuSe on inset). FIG. 8.—Fe_2O_3 crystal, Vg - 0.1 μm*/s* and SAD from centre.

FIG. 9.—Fe_2O_3 crystal and diffraction pattern (SAD from centre is similar to privious, Fig.8). Average Vg - 60μm/s, less for polycrystal concentric zones (dark on photo), more for single crystal zones (light on photo). The orientation of [001] in alternate zones is sketched by arrows and dashes on inset.

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