THE FORMATION OF SLIP BANDS IN LAYERED CRYSTALS

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The formation of slip bands in A^VB^{VI} foils is considered as dislocation process self-organization being in dislocation ensemble at level 10-20nm. The band distortion region in Bi_2Te_3 and Sb_2Te_3basal planes are revealed.

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INTRODUCTION

At plastic deformation of layered single crystals (non-homogeneously doped [1 -4]) it is revealed that the formation of slip lines and bands in them is sensitive to layer hardness. The band "splitting" on separate more narrow slip bands evidences about process of advanced deformation localization in hard layers in comparison with smooth ones.

In [3-5] it is also revealed that penetration of spiral bands in hard layers not always leads to band splitting (branching) on separate more narrow ones and can be accompanied by only effect of bandwidth reduction. The general uniform decrease of band width at its penetration in strong layer and also small gradual decrease of band width as far as this penetration [1] is accepted as effect of bandwidth reduction. This circumstance shows on the fact that localization and delocalization effects of deformation are connected with mobility of spiral dislocations in transversal direction to dislocation slip plane and ability of spiral dislocation to multiplication by double transversal slip the parameters of which are strongly depends on doping level [6,7].

As the formation of slip bands is the result of dislocation process self-organization developing in dislocation ensemble at meso-level [8], it is obvious that observable peculiarities of slip band formation in layered crystals should be explained within the framework of kinetic approach to these phenomena. The solution of this task is the aim of work [1]. The equations of dislocation density evolution are used.

DISLOCATION DENSITY. THE NARROWING EFFECTS OF SLIP AND BRANCHING BANDS.

The equations of density evolution of $p_m(x, y, t)$ mobile and $p, (x, y, t)$ immobile dislocations describing the formation of slip band lengthening in direction of **x-** axis and widening in direction of y-axis, have the form [1]:

$$t_m \frac{\partial \rho_m}{\partial t} = \left(R_x^{(m)}\right)^2 \frac{\partial^2 \rho_m}{\partial x^2} + \left(R_y^{(m)}\right)^2 \frac{\partial^2 \rho_m}{\partial y^2} + n\lambda_m + \rho_m - \beta\rho_i \tag{1}$$

$$\rho_i(x,y,t) = \left(R_x^i R_y^i\right)^{-1} \int_x^{\infty} e^{-\frac{|x-x'|}{R_x^{(i)}}} dx' \times \int_y^{\infty} e^{-\frac{|y-y'|}{R_y^{(i)}}} \rho_m(x',y',t) d \tag{2}$$

Here t is time, t_m —λ_m/u and λ_m are time and distance between dislocation multiplication acts and mechanism of double transversal slip of spiral dislocations correspondingly, u is dislocation velocity, n is density of dislocation sources by Frank-Reed type, β is relative coefficient of dislocation immobilization in dipoles. $R_{x,y}^{(m)}$ and $R_{x,y}^{(i)}$ parameters define the character self-organization scales of mobile and immobile dislocations at lengthening and widening of the band. They depend on kinetic coefficients defining the multiplication processes intensity, immobilization and dislocation diffusion [8]. The crystal doping strongly influences on kinetic coefficients [6,7] and consequently, on $R_{x,y}^{(m)}$ and $R_{x,y}^{(i)}$ parameters and their ratio that influences on slip band formation process.

The formation of slip bands and peculiarities of their formation in non-homogeneously strong (layered) crystals are connected with dislocation self-organization process.

The thin crystal foils $A^V{}_2B^{VI}{}_3$ are obtained by gradual (0001) surface peeling. The films by thickness from 10^3 nm up to 20nm are obtained by this way. The above mentioned is proved by process of growth and surface morphology of layered crystals on example of thin foils Sb_2Te_3 and Bi_2Te_3. The linear and planar defects of crystal structure and their electron-microscopic images are schematically shown in fig.1 on the base of results of series of experimental and theoretical works [9].

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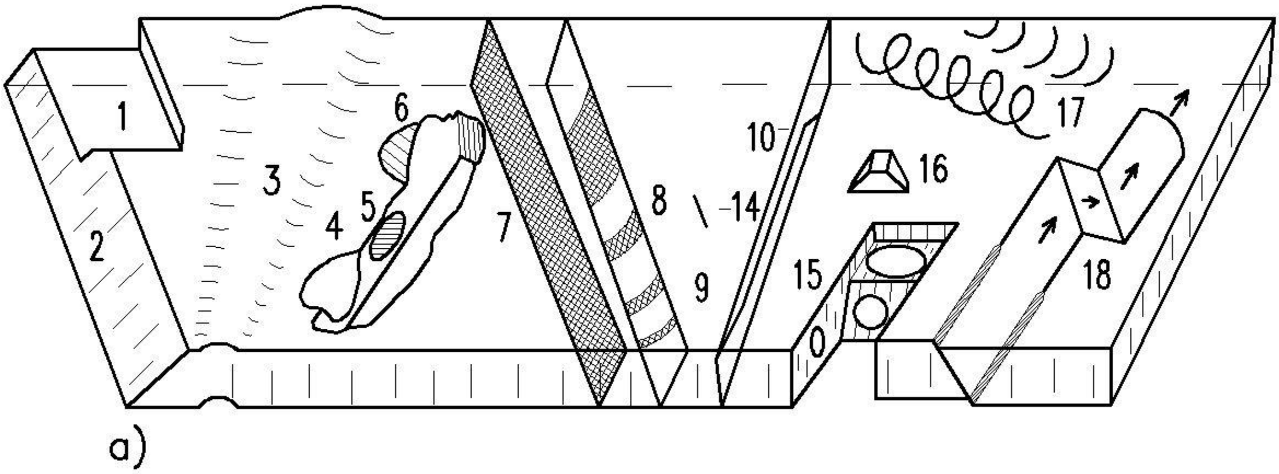
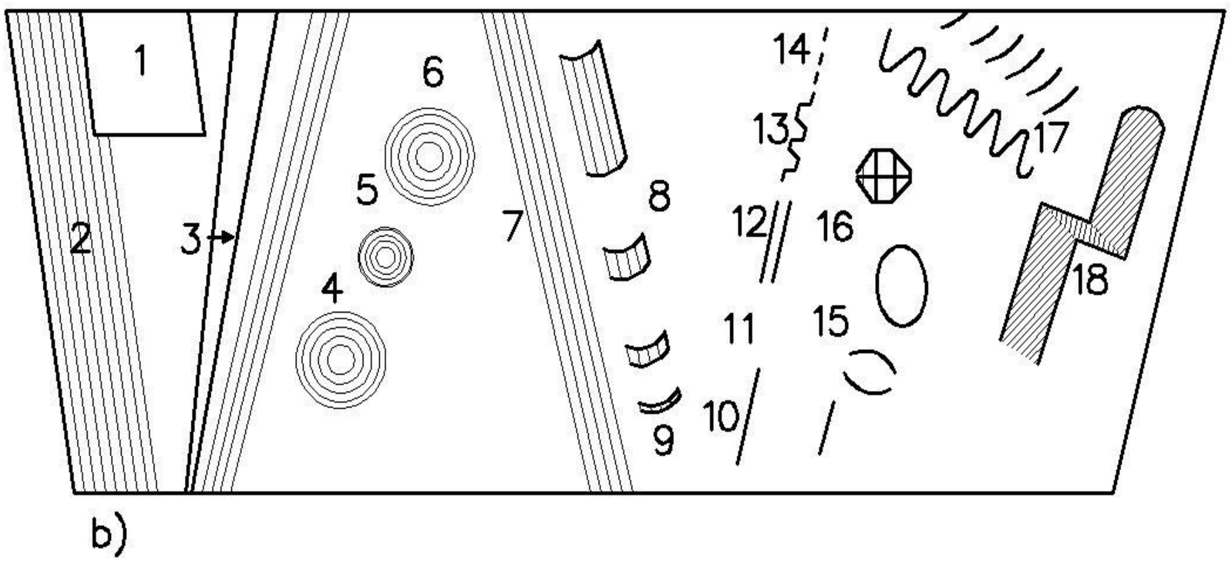


Fig.1.a. The foil with main defects.

1 - 6 - are heterogeneities of thickness or foil inclination; *7-18* are defects of crystal structure; *1* is decreased thickness region, *2* – foil taped edge, *3* is foil bend,4 *-5* are pores; *6* are nano-islands on the foil; *7* is package defect; *8* are splitted dislocations with package defect different thickness between partial dislocations; *9* is total (undissociated) dislocation, *10* is dislocation general type



Electron image of defects

Fig.1.b. The scheme of metal foil image in transmission electron microscope, designations: *10 - 14* is long dislocation; *11* is invisible dislocation; *12* is double image on which the different contrast effects are shown, *13* is zigzag, *14* is dotted line; *15* are dislocation loops differently situated in foil; *16* is packing defect tetrahedron; *17* are helicoidal dislocations; *18* is the track of previous dislocation with double transversal shift (arms show on the dislocation movement direction).

The forms of slip bands and regions with plates in basic plane of Sb_2Te_3 and Bi_2Te_3 crystals are experimentally revealed by us and scales of their decrease are observed (see fig.2 - 4).

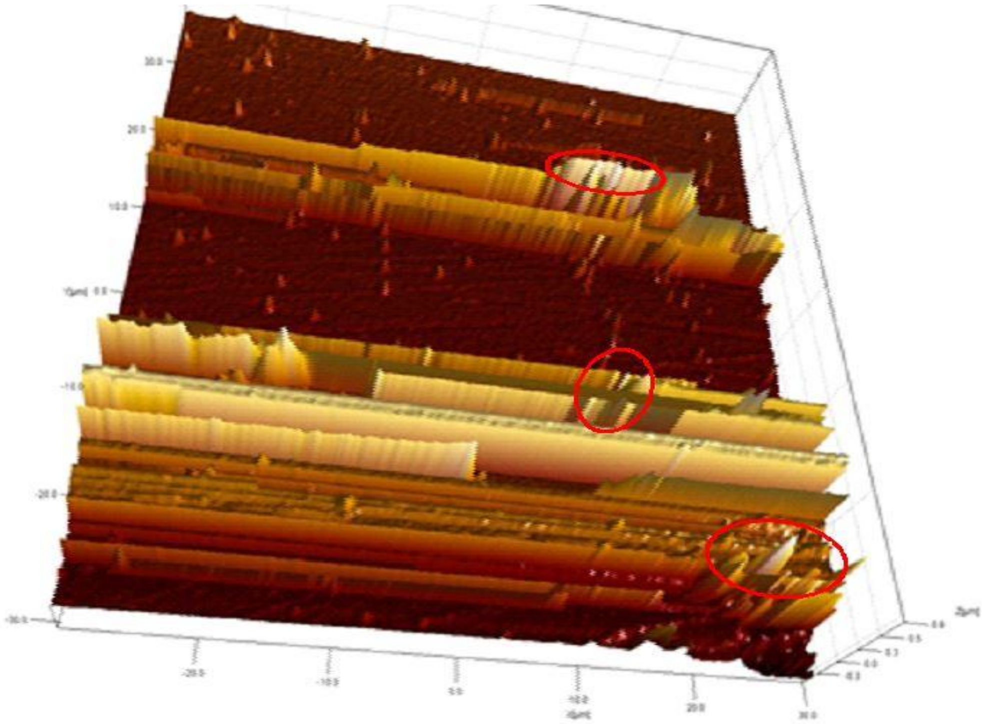


Fig.2. The experimental form of slip band on surface (0001) Bi_2Te_3 doped by (In-Cu) forming the n-type region. The defect places of slip bands are shown by circles.

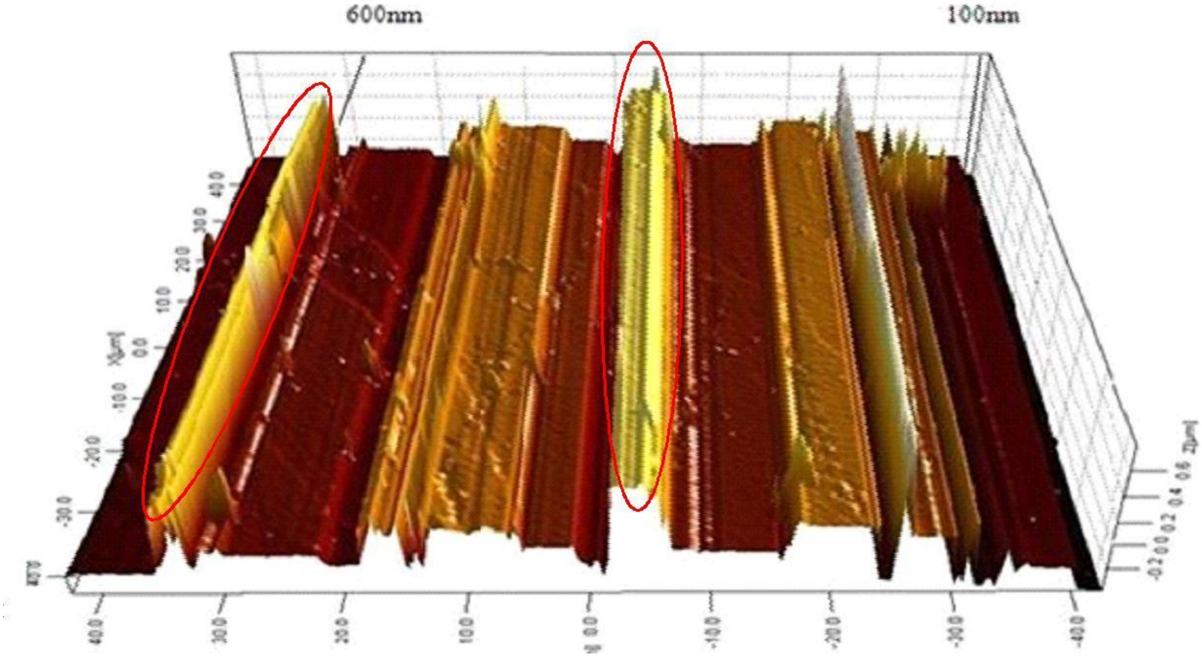


Fig.3. The stressed regions with plates in Sb_2Te_3 in basic plane (0001) in 3D-scale with decrease level.

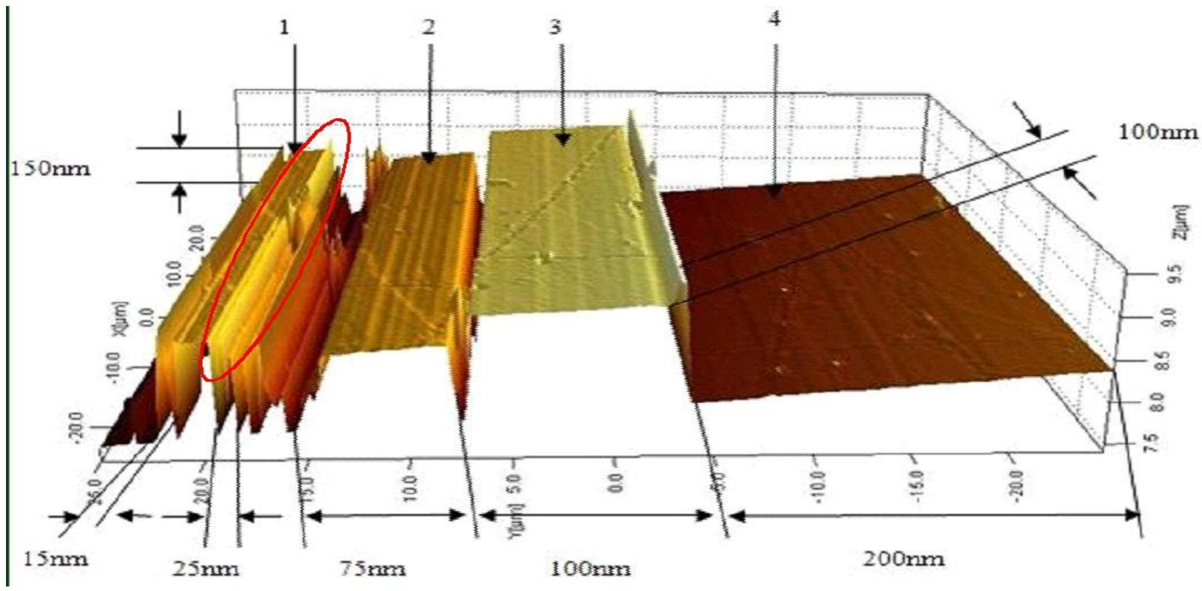


Fig.4. Sb_2Te_3 relief with decrease scale from 150 up to 100nm and dislocation width. Designations are: 1 is dislocation width 10-15nm; 2 is step plateau by size 75nm; 3 is step plateau 100nm, 4 is step plateau 200 nm.

The relief has the stepped character proving the process of branching self-organization in layered crystals. The regions of plateau and stresses between plateaux shown by ellipses are emphasized in fig.2 - 4.

The following conclusions are made on the base of equation analysis of density dislocation evolution with sample surface morphology.

CONCLUSIONS

A^VB^{VI} foil surface including several structural levels by height from 150 up to 1,5nm is the one of peculiarities of slip bands. (0001) A^VB^{VI} surfaces have the stepped plateau-like character proving the branching self-organization process in layered crystals by $A^V{}_2B^{VI}{}_3$ type.

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