CELLULAR STRUCTURE IN Bi_2Te_3 THIN FOILS

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The structures with relief having the stepped and plateau character are revealed in p-Bi_2Te_3 thin foil. The crystal deformations appearing in growth process are accompanied by the formation of deformation relief in the form of plateau surfaces and local parallel dislocations on their surfaces. The absence of changes in X-ray diffraction (XD reflexes in bulk single crystals and $A^V{}_2B^{VI}{}_3$ thin foils shows the deformation localization process in elastic range.

Keywords: relief, plateau, step, surface, deformation, cell, dislocation.
PACS: 62.20 Fe, 61.72.Cc, 61.72.Lk

INTRODUCTION

Last years the semiconductor crystals of Bi_2Te_3 type are the object of intensive experimental and theoretical investigations because of their unique physical properties.

The stepped structures appear in growth process and in doped layer crystals of Bi_2Te_3 type. The deformations which are character for dislocations [1-3] appear near the step in crystal volume.

The obtained theoretic results present themselves the special interest at consideration of periodically rough surfaces of multilayer structures.

Using the models of formation of cellular dislocation and fragmented dislocation structures, one can reveal the surface deformation reliefs in $A^V{}_2B^{VI}{}_3$ [4-6] thin foil corresponded to them on the base of following parameters:

- change character of X-ray diffraction (XD) reflexes;
- relief character with stepped and plateau types;
- correspondence of experimentally obtained structural fragments with modeling results connected with cellular structures.

The comparison of XD of crystal structures with their $A^V{}_2B^{VI}{}_3$ thin foils and also with theoretically calculated forms of cellular dislocation structures is the aim of our work.

EXPERIMENT

The results of modeling carried out in [4] are compared with data by the investigation of surface deformation reliefs with the help of microscope of high sensitivity: *Solver NEXT и AFM-BRUKER Nano N8 Neos*. XD investigations are carried out on diffractometer of “Bruker” D2 Phaser firm.

The thin foils for atomic force microscope (*AFM*) are prepared by the way of gradual splitting of the samples with the help of scotch. This method doesn’t introduce the additional defects that are confirmed by repeat XD on which the perfect form of reflections is sometimes observed (see XD in fig.1).

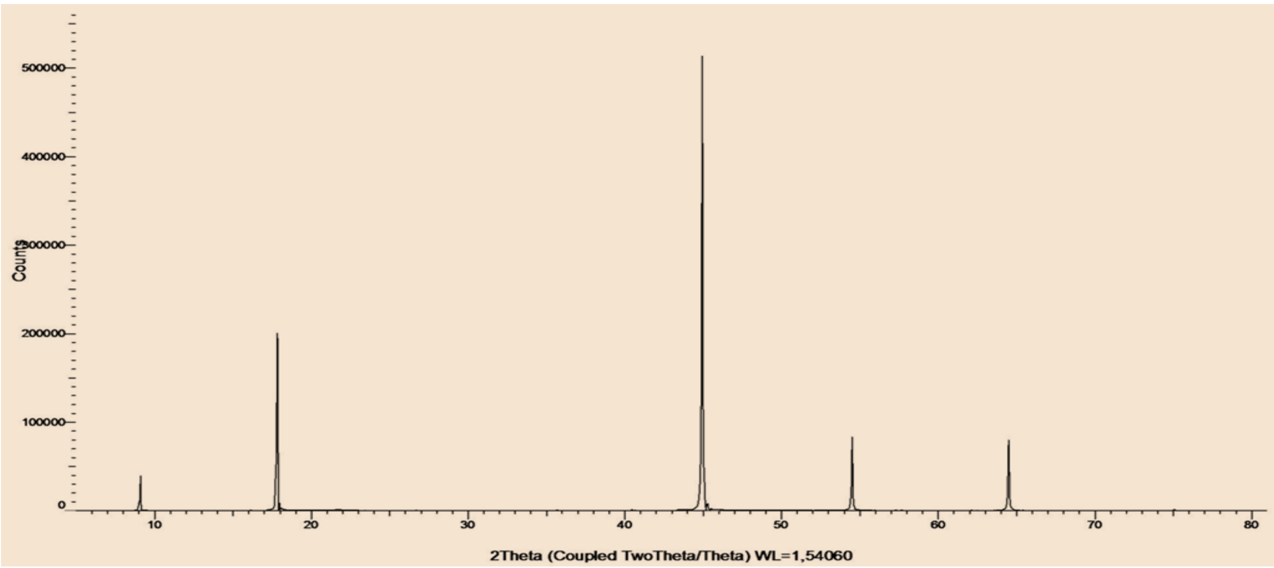

Fig.1. X-ray diffraction shot for Bi_2Te_3 thin foil. The reflexes obtained by us in bulk crystals coincide with the ones obtained in thin foil.

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The properties of such foil are studied by us first time. XD on thin foils (fig.1) are studied. The comparative analysis shows that reflexes in all samples are similar that shows the perfectness of reflection forms. The structure of all samples is perfect.

Such method is successfully applied for obtaining XD for compounds of TiX_2 (X= S, Se, Te) dichalcogenides [7].

The micro-diffractions obtained with foil plane of the investigated compounds correspond to basis plane (0001).

EXPERIMENTAL DISLOCATION STRUCTURES

The scheme of different steps and bends in planes of sliding is given in fig.2.

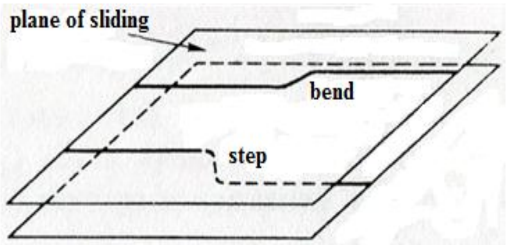


Fig. 2. Steps and bends on dislocations [8]. The cases when dislocation is in two neighbor plains of sliding, bends (blades) and another type which is step, are possible.

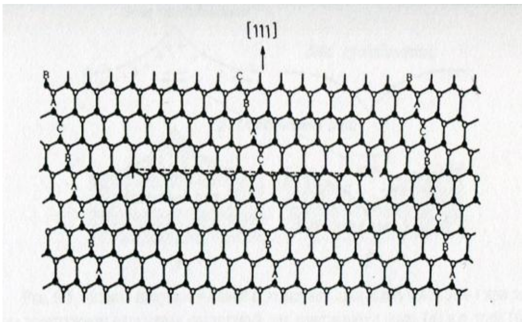


Fig.3. The cell is the type in direction of dislocation wire on atomic structure of 60% split dislocation in lattices by diamond type: the atoms of the similar elements in single crystals of *IV* group are marked by black and white circles. The detail explanation is in [8].

The positions of the steps in *(0001)* Bi_2Te_3 basal plane showing the degree of decrease from 600 up to 100 nm in Bi_2Te_3 cellular structure are given in fig.4. The relief has the stepped and plateau character.

The surface nano-objects (the places of dislocation outputs) are given in fig.5. They correspond to theoretically calculated reliefs (by G.A.Maligin data in [4-9]).

The geometric figures formed on the surfaces of semiconductor structures with nano-objects obtained by us in $A^V{}_2B^{VI}{}_3$ connect the schemes given in fig3 and fig. 4 that shows the complexity of local deformation processes presented in fig.5 and fig. 6.

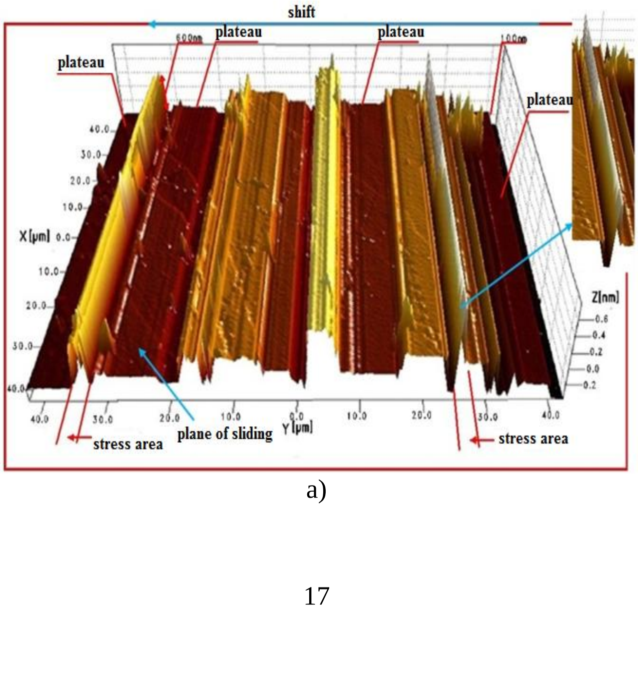
The investigation results are compared with reference data on investigation of deformed relief surfaces with the help of high-resolution microscopes. The obtained thin foils are treated by deformation in preparing process. This is accompanied by the formation of deformation relief on their surface reflecting the deformation process in crystal on meso-, micro- and nano-scale levels.

The crystal deformations appearing in growth process are accompanied by the formation of deformation relief in the form of cellular structures and local parallel dislocation formations on their surface.

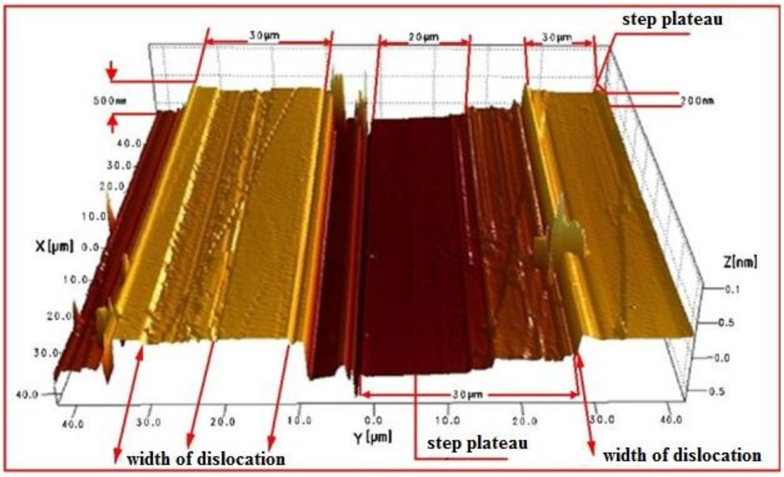
The deformation localization is the result of heterogeneous dislocation distribution in crystal; the surface deformation relief reflects the character of this distribution [12]. The dislocation distribution has the enough complex form at big degrees of deformation in conditions of multiple sliding. The example is the cellular dislocation structures in metals.

CONCLUSION

The investigated cellular dislocation structures in $A^V{}_2B^{VI}{}_3$ reflect the deformation localization process on different scale levels. This deformation localization can be the result of heterogeneous dislocation distribution moreover the deformation relief reflects the character of dislocation distribution in Bi_2Te_3. The absence of changes in XD reflexes in bulk single crystals and $A^V{}_2B^{VI}{}_3$ thin foils confirms the deformation localization processes in elastic range as there are XD reflexes at 2θ: 8°, 18°, 44°, 54° and 64°.



a)



b)

Fig.4. The plateau on corrugated nano-objects in Bi_2Te_3 samples in *3D*-scale, the stress ranges and width of dislocations and plateaus are given. a) are stress ranges, plane of sliding, the height of stress range≈ 200- 300 *nm*, the width of stress range is maximal one and it is equal to ≈ 100 *nm*; b) is width of dislocation and step plateau is ≈ 30 μm.

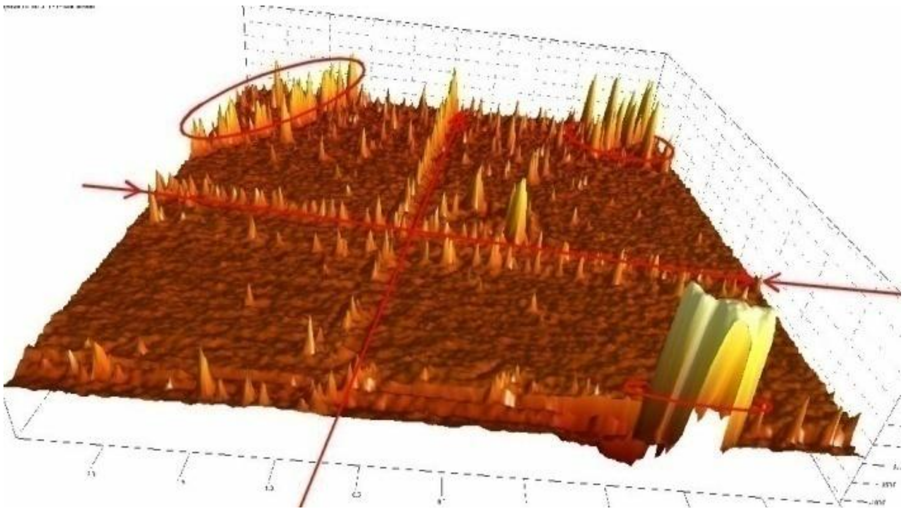


Fig.5. The dislocation structure obtained by us in Bi_2Te_3 on *(0001)* surface (the nano-objects in the form of localized nano-islands are given on top left and right in upper part of the figure) (macroscope is *AFM - BRUKERNANO)*

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Recevied: 12.10.2017