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ЭЛЕКТРОПЛАСТИЧЕСКИЙ ЭФФЕКТ ПРИ ДВОЙНИКОВАНИИ МЕТАЛЛОВ

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ELECTROPLASTIC EFFECT AT TWINNING METALS

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Использование импульсов тока высокой плотности, электрических и магнитных полей, ионной имплантации позволили интенсифицировать пластическую деформацию металлов, предоставив принципиальную возможность управления двойникованием, с помощью немеханических сил, влияющих на условия и характер упрочнения материала.

Ключевые слова: *двойникование, двойникующие дислокации, металл, электропластический эффект, деформация, дислокация, индентор.*

Use of pulses of a current of high density, electric and magnetic fields, ionic implantation allowed intensifying plastic deformation of metals, thus, giving basic opportunity for management of plastic deformation twinning with the help of forces of the nonmechanical nature, influencing on conditions and character of hardening of a material by means of controllable twinning.

Keywords: *twinning, twinning dispositions, metals, electroplastic effect, deformation, disclosing, indentor.*

Introduction

Fundamental and applied problems of modern materiology on increase of production efficiency, and increase of its technological level are defined by necessity of creation of complex of high physic mechanical properties of materials for extreme physical conditions with high service characteristics. The basic kinds of plastic deformation of crystal bodies are sliding and twinning. In spite of the fact that twinning concerns the basic kinds of deformation of crystals, as against sliding, the given kind of plastic deformation is investigated insufficiently full. At the same time experimental results of the twinning study prove to be true discovery of all new phenomena taking place at the given kind of deformation. Deformation of metals at low temperatures and great speeds load results in the fragile destruction. These processes of plastic deformation have no time to be realized. Therefore studying the processes of plastic deformation twinning is an actual task, both in scientific, and in the applied plan.

Twinning realization is carried out in the case of orientation and interdiction for usual disposition sliding, and also at great speeds load and at low temperatures. Sources of generating twinning dispositions are concentrators of tension, and the development of doubles is carried out with great speeds and the subsequent deformation processes on borders of doubles frequently result in the destruction of a material. In this connection management kinetics controllable twinning for creation uniform disposition structures on borders of doubles with the purpose of reduction in concentration of load, gives a real opportunity to use twinning as a reserve of increase of plasticity of a material. On the other hand systems of thin doubles at the subsequent deformation will create natural obstacles for full dispositions. The creation of twinning structures in the material will probably promote effective hardening of the material which is an independent way and the channel of the twinning metals hardening.

Results and discussion

Influence of pulses of a current on twinning metal crystals, on analogy to sliding and for brevity electroplastic effect (EPE) at twinning was revealed by the author in 1978. It served as the certain impulse for studying the electroplastic effect at twinning, as well as sliding, and is crucial for realization of plastic deformation of metal. The study of the influence of ionic implantation, alloy, and electronic irradiation on physicomechanical properties of materials are of great scientific and practical value as they in many respects define their operational characteristics. From the practical point of view actual researches of joint influence of ionic irradiation and electric field on deformation processes in metals are represented. It is known, that the specified kinds of power influences are effective ways of influence on the condensed system of the metal which in the certain conditions improve and modify its physical characteristics.

By this time there are practically no ways of hardening twinning materials that constrain practical use of some perspective metals and alloys on their basis. According to this statement, it is clear that the research of the ways of increase of plasticity and durability of twinning materials represents the important practical task.

The decision of this task can be carried out in three directions:

1. Increase in plasticity of twinning materials due to the initiation and development of additional twinning under the influence of external power influences.

2. Decrease in the role of twinning borders as concentrators of internal tension in metal by their reduction, or updating.

3. Creation of the structures at electroplastic deformation twinning, capable of strengthening the material without decrease in its plasticity.

Thus, in the true work in a counter balance to the existing practice the structural and mechanics thermal influences on a crystal lattice of metal, the new way of management is offered due to non-mechanical forces – pulses of a current of high density, electric and magnetic and fields and ionic implantation.

The purpose of this work is finding-out physical mechanisms of plastic deformation of metals twinning in conditions of external power influences electric and magnetic fields, ionic implantation, electronic irradiation, creation of physical bases of hardening of twinning materials and technological receptions on the basis of electroplastic processing of metals by pressure, in difficult field conditions and in the crossed fields, in particular.

Twinning, as well as sliding, develops only on certain crystallography to planes, and these processes are mutually causing.

Twinning and sliding are not in a thermodynamic equilibrium condition, and at any temperatures their structural sensitivity depends on updating defects.

At deformation of a crystal by the concentrated loading on the plane cleavage concentrators of tension a system of the wedge doubles appears on certain crystallographic directions. The double wedge represents a set of planes in which the process of reorganization of a lattice in twinning position starts, but up to the end it is not realized if each plane (figure 1) comes to the end of the twinning disposition.

Passing through metal monocrystals the impulses of an electric current with density from 50 – 1000A/mm^2 and duration 10^{-4}s , deformation redistribution twinning in vicinities of concentrators of mechanical pressure is observed.

Comparison of pictures of deformation with an impulse of a current and without it shows that at joint action of electric and mechanical pressure there is a stimulation of plastic deformation twinning.

Under the influence of the concentrated loading on a crystal the occurrence of doubles is provided with excitation of dot sources twinning dispositions. Twinning germs have double wedge. Their development follows the bill of simultaneous moving of regional making dispositions in a plane of shift and screw in a plane unity. Such doubles can arise in the volume of a deformable material near concentrators of pressure at any kind of loading.

One of the features of development of the doubles arising «in a point» is the sequence of elementary certificates of development: at a short-term action of loading there is a thin double of final length. At increase in time of influence on a crystal generating twinning dispositions and their translation on borders of section without increase in the length a twin wedge is observed. It is natural, that moving from a mouth to top twinning dispositions one can meet an obstacle and form congestion. This will sharply increase incoherent twin borders in planes (III), and internal pressure can lead to disclosing of cracks in a secondary plane unity.

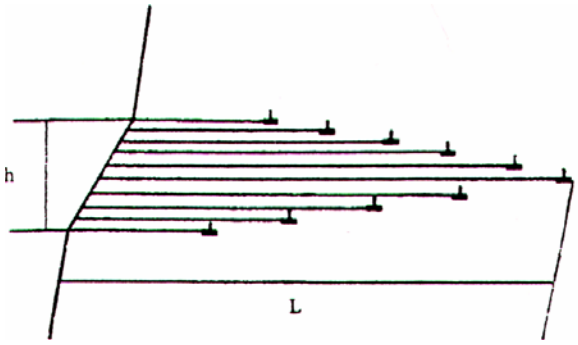

Figure 1 – Disposition model wedge the double

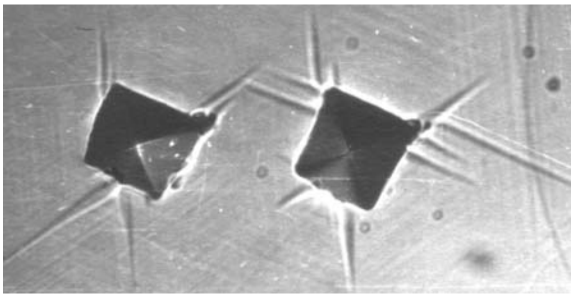

Figure 2 – A microphoto of doubles on a plane (III) monocrystals of bismuth, x 530. The print at the left is received at loading 10g. The print on the right is at the same loading, but when the deformation through a crystal was passed, the density of a current pulse was 600 A/mm^2

A new kind of interaction screw twinning dispositions with an obstacle is observed when the current impulse passes through a crystal at deformation. Excitation of an electronic subsystem of the sample leads to the intensive reproduction of twinning dispositions on borders of the section and to collective interaction screw making twinning dispositions with an obstacle. As a result there is a phenomenon of branching of doubles not observed earlier.

Branching of doubles always arises on curve borders of the section where the degree of the incoherent twinning borders is the greatest.

Doubles usually arise on dispositions congestions and relaxations of internal pressure at a print lead. Till now it was known, that the relaxation of internal pressure can be carried out at the expense of sliding development, for example, in the areas of the crystal adjoining twinning borders. In the given work it is revealed for the first time that under the influence of electric impulses the relaxation of the internal pressure is carried out as a result of the development of new doubles, and new doubles arise not only on congestions of full dispositions but also on borders twinning layers, i. e. on congestions of twinning dispositions. Doubles arising in places of concentration of pressure discharge dislocation congestions thereby reduce the probability of fragile destruction in reintense places of a crystal lattice.

In the absence of external power influences «branchy» doubles arise on twins' borders with small degree coherent (figure 3) more often.

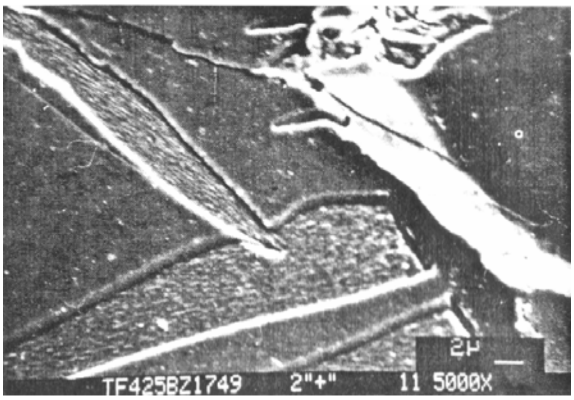

Figure 3 – Origin of the double on the twin border with small degree of coherency

The curvature twinning borders appear owing to superfluous concentration of twinning dispositions on them. The raised density of dispositions on the twin border conducts localization of the internal pressure on it whose sources are twinning dispositions. Thus, in places of the congestion of dispositions there can be pressure comparable in the volume with the occurrence of the threshold aspect of the double wedge. The relaxation of the given pressure occurs in the origin of the twin border and in the new double which develops in a new energetically favourable direction (figure 4).

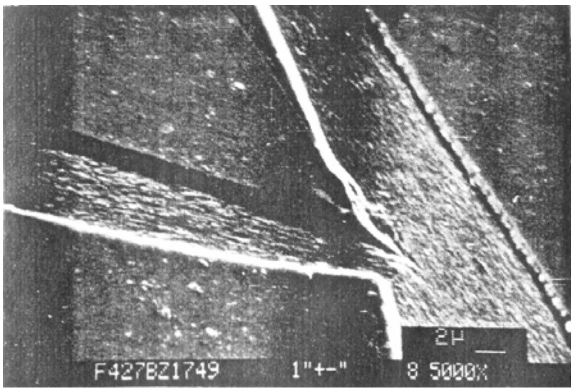

Figure 4 – Branching of the double at a stopper

The picture of fields of pressure at the aspect of the double wedge (figure 5) which is received as the assumption that the twin's border consists of from full [1]–[3], instead of partial dispositions. Fields of pressure around of the congestion of such dispositions of looking like wedge can be calculated under the formula:

$$\sigma_{xy}=\frac{Gb}{2\pi(1-\nu)}\left\{\sum_{n=0}^{N_1}\frac{(x+nd)\left[(x+nd)^2-(y+nh)^2\right]}{\left[(x+nd)^2+(y+nh)^2\right]^2}+\right.$$
$$\left.+\sum_{n=0}^{N_2}\frac{(x+nd)\left[(x+nd)^2-(y-nh)^2\right]}{\left[(x+nd)^2+(y-nh)^2\right]^2}\right\}.$$

Where σ_{xy} – chopping off pressure, b – module of vector Burgersa, G – shift module, ν – factor Puassona, n – summation index, N_1 and N_2 – number of dispositions on twin borders. In our case at the computer plotting, presented on figure 5, it was accepted $N_1 = N_2 = 10$.

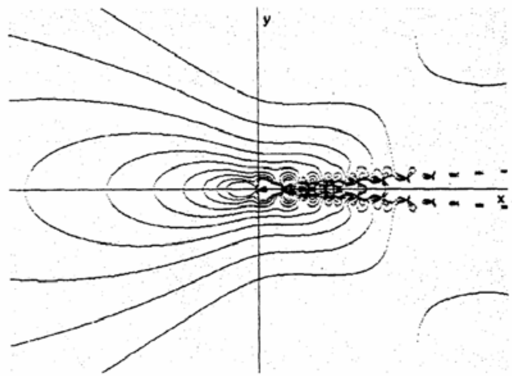

Figure 5 – Fields of pressure at aspect wedge the double

Figure 3 shows that the pressure increased when approaching to twin border. Moreover, at the top of the double they have the same order, as at direct affinity twin borders, but on the dist the aspect wedge is two-three times more. As a result, in the presence of stoppers on the propagation of the aspect double wedge, there is a redistribution of pressure at its top in such a manner that the size of their projections to a new direction twin becomes comparable with the threshold value of the occurrence of the double.

It is possible to stimulate dislocation processes at twinning crystals by passing impulses of an electric current through them [4]–[7]. With the growth of density of the current in the impulse, generating processes of twins' dispositions amplify. Thus, the collective moving on twinning to borders twinning dispositions can co-operate with an obstacle not only with formation of the new double, but also overcome resistance of the stopped dispositions with formation of the second top.

It is possible to explain stimulation by impulses of the electric current. Branching of the doubles increases the internal pressure in a crystal at the expense of pinch-effect realization. As a result of the occurrence of additional pressure in a crystal the probability of occurrence of the second top of the double raises.

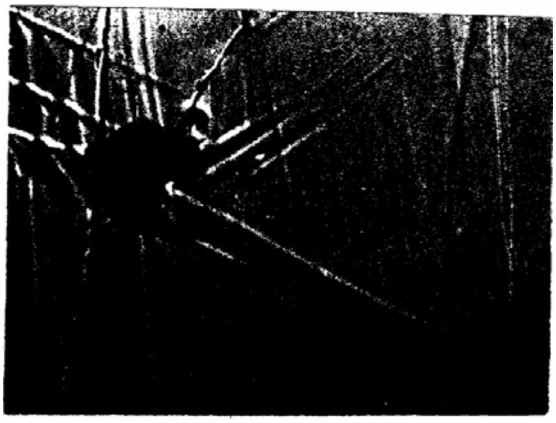

Figure 6 – Formation of the second top of the double in a crystal Be. Density of a current 700 А/мм^2; x 600

Thus, with the help of the elektroplastic method of research and method of computer simulation of the fields of pressure around the aspect double wedge, it is established that the relaxation of internal pressure in bismuth monocrystals can occur due to realization of twinning at the expense of branching of doubles. And, the new top of the double arises not on full dispositions, but on partial twins.

With the increase in time of influence, the indentor before passing a current impulse leads to the density growth of twinning dispositions on borders and branch strengthening. Thus, the density twinning on borders of section of each new generation of doubles is less than dispositions in the previous cases (figure 6).

The growth of density of the current in the impulse amplifies generating processes in twinning dispositions. Thus, the collective moving of the twin to borders twinning dispositions can co-operate with an obstacle not only with formation of the new double, but also overcome resistance of the stopped dispositions with formation of the second top. In figure 4 formation of the second top of the double in a crystal Be is shown.

Conclusion

The described phenomena testify the additional possibility of plasticization of mechanically twinning materials at creation, in the course of deformation, the conditions favorable for reproduction twinning of dispositions. Such conditions can be created in the process of deformation when impulses of a current of high density pass through a material. Thus, the relaxation of the internal pressure arising at dislocations of congestions on borders of section can occur not only at the expense of formation of new doubles. Therefore the reserve of plasticity increases, and the probability of fragile destruction and the result of the partial destruction in twinning decreases.

REFERENCES

1. *Kosevich, A.M.* Effect of electromagnetic fields on the ductility and strength of materials. Abstracts conference / A.M. Kosevich // Successes of physical sciences. –1971. – Vol. 104. – № 2. – P. 201–254.
2. *Bashmakov, B.I.* Studying of electromechanical effect at bismuth crystals in interval temperatures / B.I Bashmakov, V.S. Savenko // News of High schools. Physics of Metalls. – 1980. – № 7. – P. 29–33.
3. *Savenko, V.S.* Action of electromagnetic fields on plasticity and durability of materials / V.S. Savenko, O.M. Ostrikov // IV International conference. Effect of electromagnetic fields on the ductility and strength of materials. Abstracts conference. – Voronezh, 1996. – P. 20.
4. *Savenko, V.S.* Influence of an irradiation on electromechanical effect at twinning bismuth crystals. / V.S. Savenko, M.S. Tsedrik // News AN BSSR, Fiz-Mat Sciences. – 1980. – № I. – P. 105–108.
5. *Bashmakov, B.I.* Studying of electromechanical effect at twinning crystals of bismuth in the range of temperatures 77-530 К / B.I. Bashmakov, V.S. Savenko // Izv. High schools. Physics. – 1980. – № 7. – P. 29–33.
6. *Elektroplastic effect at simultaneous imposing electric and a magnetic field in bismuth monocrystals* / V.S. Savenko [et al.] / Bulletin BSU. – 1995. – Sulfurs 1. – № 2. – P. 27–30.
7. *Savenko, V.S.* Elektron-plastical effect at twinning bismuth monocrystals / V.S. Savenko, V.I. Spitsyn, O.A. Troitsk // Reports of academy of sciences of the USSR. – 1985. – Vol. 283. – № 5. – P. 1181–1183.

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