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ABSTRACTS OF PUBLISHED ARTICLES

UDC 539.2:539.374

Study of plastic strain heterogeneity in a polycrystal at meso-scale. Van Houtte P., Kanjarla A. K., Seefeldt M. and Delannay L. – Problems of Materials Science, 2007, N 4(52), pp. 7–12.

Three statistical multilevel models for the plastic deformation of polycrystalline materials are discussed: the Taylor model, the LAMEL and the ALAMEL models. The specific assumptions made by the two latter with regard to strain heterogeneity within the grains of a polycrystal are confronted with the results of a detailed CPFEM study of this distribution in a multicrystal.

Keywords: Taylor model; ALAMEL model; meso-scale strain heterogeneity.

UDC 539.2:539.374

Deformation structure versus grain structure after severe plastic deformation. Pantleon W. – Problems of Materials Science, 2007, N 4(52), pp. 13–23.

Dislocation boundaries form continuously during plastic deformation and subdivide grains of initially homogeneous orientation into smaller regions of deviating orientations. The orientation differences increase with plastic strain and new high-angle grain boundaries form during severe plastic deformation, but a significant fraction of boundaries has lower disorientation angles reflecting their origin from an initial homogeneous grain; the orientations on both sides of deformation-induced boundaries are still related. Orientation correlations can be resolved from spatial orientation data obtained e. g. by electron backscatter diffraction. Deformation structures with inherent orientation correlations are distinguished from grain structures without orientation correlations between neighboring grains by the dependence of the disorientation angles on the distance between measuring points. Quantitative analysis shows that the microstructure of severely deformed metals cannot be interpreted consistently as grain structure and must be characterized as deformation structure of fragmented grains with deformation-induced boundaries.

Keywords: severe plastic deformation, deformation structure, grain structure, dislocation boundaries, disorientations, orientation correlations, chord length, EBSD, ECAE, MODF.

UDC 669.3:539.2:539.374

Microstructural evolution at grain boundary in a copper bicrystal during multi-directional forging. Miura H., Yoshida Y., Sakai T. – Problems of Materials Science, 2007, N 4(52), pp. 24–29.

Preferential evolution of fine grains at grain boundary during severe plastic deformation (SPD) was investigated by using an orientation controlled Cu bicrystal having [0 0 1] twist boundary. The bicrystal was multi-directionally forged (MDFed) at 523 K to cumulative strain of $\Sigma\varepsilon$= 3.6 at maximum. Microsubstructure began to evolve preferentially at and around the grain boundary even at lower strain region, while it was not obvious in the grain interiors far from the grain boundary. With increasing strain, the evolved substructure at around grain boundary changed gradually to form fine grains. Contrary to that, the evolved substructure in the initial grain interior far from the grain boundary was still unchanged to fine grains even after MDF to $\Sigma\varepsilon$= 3.6. Therefore, the important role of grain boundary on fine grain evolution during SPD is evident. Because the misorientation distribution among the newly evolved subgrains and grains changed gradually from low to high with increasing cumulative strain, the mechanism of the new grain evolution during MDF could be confirmed as low temperature continuous dynamic recrystallization. The mechanisms of the fine grain evolution at grain boundary during MDF are discussed.

Keywords: severe plastic deformation, multi-directional forging, hot deformation, bicrystal, grain boundary, copper.

UDC 548.4:539.2:539.27

Investigating the dependence of grain subdivision on the solid solute content in Al and Cu alloys. Seefeldt M., Kusters S., Van Boxel S., Verlinden B. and Van Houtte P. – Problems of Materials Science, 2007, N 4(52), pp. 30–36.

An approach to investigate the dependence of orientation fragmentation on material and process parameters is presented. The working hypotheses are that two essentially different types of grain subdivision

can be distinguished – fragmentation due to grain-grain interaction and fragmentation due to the launch of new mechanisms in dislocation kinetics – and that the latter type is realized in a nucleation and growth process. An EBSD study of grain subdivision in the solid solution couple AlMg and AlCu is sketched to illustrate how dependencies on different material parameters like stacking fault energy and friction stress can be separated from each other. A model for fragment boundary nucleation based on double cross-slip is briefly summarized. The model predictions for the alloy couple CuAl and CuMn are in reasonable agreement with experiments, while the ones for the couple AlMg and AlCu illustrate the importance of accurate input parameters like stacking fault energy and cross-slip activation energy as well as of a proper physical picture of the elementary processes.

Keywords: grain subdivision, EBSD, double cross-slip, disclinations.

UDC 669.141.247:539.2:548.4

Detection and micromechanical reconstruction of junction disclinations in low deformed IF steel based on EBSD data. Zisman A. A., Rybin V. V., Seefeldt M., Van Boxel S., Van Houtte P. – Problems of Materials Science, 2007, N 4(52), pp. 37–50.

Based on the lattice rotation field, as determined by EBSD orientation mapping around a triple grain junction in a low deformed IF steel, disclinations have been detected and quantified on the junction line and on a line of neighboring boundary ledge. Incompatible plastic strains, responsible for these linear defects, are reconstructed from inter-granular disorientations by a simple micromechanical model that allows for interaction of the three grains. Then corresponding fields of *elastic* rotation and stress are calculated. The rotation field, accommodating the strain induced part of disorientations, proves to fit satisfactorily EBSD data and evidences that along with junction disclinations there are induced planar stress sources (Somigliana dislocations) on the considered grain boundaries. The calculated stress field locates probable areas of *plastic* accommodation, which are also in good correspondence with appropriate features of the orientation map.

Keywords: polycrystal, grain junction, strain induced defects, disclination, crystal rotation, EBSD.

UDC 539.22:539.374:539.27

Experimental methodology for the study of metals at large plastic strains by electron back scatter diffraction. Adams B. L., Landon C., Kacher J., Wagoner R. H. – Problems of Materials Science, 2007, N 4(52), pp. 51–56.

Experimental methods for sampling the lattice curvature fields that develop in crystalline materials with plastic deformation are reviewed. The focus is on electron back scatter diffraction (EBSD) patterns that form in the scanning electron microscope (SEM) operated in spot mode. Standard orientation gradient methods depend upon recovery of the lattice orientation by indexing each local EBSD pattern. The limitations of this method are discussed, and recent results are described. New methodology, based on the cross correlation between adjacent EBSD images, is described. Preliminary results obtained for a well-annealed Ni sample suggest at least one order-of-magnitude improvement in orientation resolution can be obtained, relative to the standard orientation gradient method.

Keywords: electron back-scatter diffraction, lattice curvature, plastic deformation.

UDC 669.141.247:548.4:539.27

Gradient matrix method to image crystal curvature by processing of EBSD data and trial recignition of low-angle bounaries in IF steel. Zisman A., Seefeldt M., Van Boxel S., Van Houtte P. – Problems of Materials Science, 2007, N 4(52), pp. 57–67.

A gradient matrix has been introduced to derive the lattice orientation gradient, indicative of crystal substructures, from EBSD orientation data. A trial mapping of this term around a grain junction in a low deformed IF steel proves to reveal a distinct low-angle boundary extending from the junction line. The background dislocation substructure, however, is imaged rather poorly because of the mapping noise.

Keywords: IF steel, triple grain junction, low-angle boundary, lattice curvature, EBSD.

UDC 539.374:548.73

Study of the large plastic deformation of crystalline materials by local X-ray diffractometry. Part 1: Single and large grained polycrystals. Kalabushkin A. E., Titovets Yu. F. – Problems of Materials Science, 2007, N 4(52), pp. 68–74.

Local Xray diffractometry technique is described briefly. A simple model for orientation determination is presented. Error level of measurements and calculation of orientation and misorientation is observed. Typical X-ray pictures from single crystalline areas of Al samples with different plastic deformation levels and registered recovery process are shown and discussed.

Keywords: local X-ray diffractometry, lattice orientation, large plastic deformation.

UDC 539.374:548.73

Study of the large plastic deformation of crystalline materials by local X-ray diffractometry. Part 2: Polycrystalline materials. Kalabushkin A. E., Titovets Yu. F. – Problems of Materials Science, 2007, N 4(52), pp. 75–81.

The simple model for the single crystal orientation determination, described in the first part of the work, was applied to "multicrystal" X-ray pictures taken by the local X-ray diffractometry technique. A solution for the multicrystal problem and typical example are shown and discussed. Linear scale of the studied by the method objects is reduced from the 300 down to the 50–70 μ. An application of the solution for the study of the "ideal" and large deformed crystalline materials is demonstrated on examples of X-ray pictures taken from the deformed and recrystallized Al sample.

Keywords: Local X-ray diffractometry, lattice orientation, large plastic deformation.

UDC 669.15–194.53:621.778:620.187

Comparative study of microstructure and texture evolution in low carbon steel and pearlitic steel under cold drawing. Nesterova E. V., Rybin V. V., Zolotorevsky N. Y., Titovets Y. F. – Problems of Materials Science, 2007, N 4(52), pp. 82–90.

The microstructure and texture evolution during cold drawing of two materials – low carbon ferritic steel and pearlitic steel – has been studied using TEM and X-ray technique for true strains from about 0.3 to 2. The examined steels are shown to differ both in fragmentation and texture development. In ferrite, the microstructure evaluates at first due to the formation and multiplication of low angle dislocation boundaries and this stage extends up to $\varepsilon \sim 1$. In pearlitic steel, the fragmented microstructure inherits the lamellar morphology of non-deformed pearlite and develops from the outset by the way of misorientation accumulation. The deformation induced misorientations increase therefore much more intensely in the pearlite than in the ferrite. The <110> texture develops more intensely in the ferrite at early stages of the drawing ($\varepsilon < 0.5$). With increasing strain the textures of the two materials draw together. The hardening anisotropy associated with the lamellar structure is suggested to influence both the fragmentation and the texture development in the pearlitic steel. The conservation of considerable random texture component is found to be characteristic for the drawing of BCC metals rather than relate to the specific character of the materials studied.

Keywords: low carbon ferritic steel, pearlitic steel, microstructure and texture evolution, TEM and X-ray technique.

UDC 539.2:620.187:621.77.016.2

Substructure inhomogeneity of ECAP rods by X-ray data. Isaenkova M., Perlovich Yu., Fesenko V., Grekhov M. – Problems of Materials Science, 2007, N 4(52), pp. 91–96.

By taking into account an interconnection between substructure non-uniformity and substructure anisotropy, a new approach to study the substructure non-uniformity is developed as applied to metal rods, subjected to Equal-Channel Angular Pressing (ECAP). The X-ray method of Generalized Pole Figures (GPF) was used for construction of distributions of substructure parameters. Some experimental data are presented, illustrating possibilities and efficiency of the used approach.

Keywords: substructure, ECAP, X-ray data.

UDC 539.2:548.4

Prediction of crystallographic texture evolution and anisotropic stress-strain response during large plastic deformation in high purity α-titanium. Wu X., Kalidindi S.R. – Problems of Materials Science, 2007, N 4(52), pp. 97–103.

A new Taylor-type polycrystalline model has been developed to simulate the evolution of crystallographic texture and the anisotropic stress-strain response during large plastic deformation of high purity

α-titanium at room temperature. Crystallographic slip, deformation twinning, and slip inside twinned regions were all considered as contributing mechanisms for the plastic strain in the model. This was accomplished by treating the dominant twin systems in a given crystal as independent grains once the total twin volume fraction in that crystal reached a predetermined saturation value. The newly formed grains were allowed to independently undergo further slip and the concomitant lattice rotation, but further twinning was prohibited. New descriptions have been established for slip and twin hardening and the complex coupling between them. Good predictions were obtained for the overall anisotropic stress-strain response and texture evolution in three different monotonic deformation paths on annealed, initially textured samples of high purity α-titanium.

Keywords: twinning, plastic deformation, hardening, anisotropic.

UDC 621.78:621.77.016.2:539.2:620.187

Thermal stability of select ECAP processed FCC metals. Gottstein G., Molodova X. – Problems of Materials Science, 2007, N 4(52), pp. 104–110.

Pure Cu, CuZr and an Al-alloy were processed by Equal Channel Angular Pressing (ECAP) at room temperature applying route B_c. The effect of heat treatment on microstructure evolution was investigated. The deformed and annealed states were characterized by EBSD, TEM and microhardness tests. The study revealed a very low thermal stability of ECAP deformed pure Cu samples compared to cold rolled material with the same total strain. However, the thermal stability was significantly improved by alloying with low amount of Zr. By contrast, ECAP deformed Al-alloy showed a conspicuous retardation of discontinuous recrystallization at higher number of ECAP passes.

Keywords: ECAP, EBSD, TEM, recrystallization, annealing.

UDC 669.71:539.374:539.431

Slip system based model for work hardening of aluminium, including transient effects during strain path changes. Van Boxel, S., Seefeldt M., Verlinden B., Van Houtte P. – Problems of Materials Science, 2007, N 4(52), pp. 111–117.

Experimental observations for two different types of strain path change tests on aluminium are discussed. A transient behaviour is explained in both cases by microstructural processes that change the anisotropy of the sample. A multiscale texture-work hardening model is presented which is capable of capturing the main effects.

Keywords: strain path changes, work hardening, reversal test, cross test, aluminium.

UDC 669.3: 539.22:621.777

Effect of post-processing on the microstructure, texture and mechanical properties of ECAP copper. Pereloma E. V., Cao W. Q., Gu C. F., Lapovok R. V., Davies C. H. J. – Problems of Materials Science, 2007, N 4(52), pp. 118–124.

Ultrafine grained oxygen free high conductivity copper (99.95% purity) was processed by 8 passes equal channel angular pressing (ECAP) and then subjected to several rolling passes at room temperature (RT) and liquid nitrogen temperature (LNT) to 96.5% reduction in thickness. The microstructure, texture, and mechanical properties of the post-ECAP rolled materials were examined using a scanning electron microscope equipped with electron back scattered diffraction (EBSD), by X-ray diffraction, and by tensile testing. It was found that rolling can further refine the ECAPed microstructure. After rolling a stronger-than-expected Brass texture component was present, and it is suggested that this arises as a result of the change in strain path from ECAP to rolling, with the resultant activation of previously latent slip systems. Liquid nitrogen temperature rolling led to a higher brass component fraction than room temperature rolling. The post-ECAP rolling resulted in improved uniform elongation.

Keywords: ultrafine grain size copper, equal channel angular extrusion/pressing, rolling, texture.

UDC 669.14.018.8`786:621.78–977:539.4.014

Effect of temperature-strain parameters at HTMP on the stress-strain behavior of nitrogen-bearing stainless steels. Kodjaspirov G. E., Rudskoy A. I., Karjalainen L. P. – Problems of Materials Science, 2007, N 4(52), pp. 125–128.

The effect of temperature-strain parameters in the high temperature thermomechanical processing (HTMP) conditions on the hardening-softening behavior of nitrogen-bearing stainless steels has been studied. Axisymmetric compression tests were carried out on a Gleeble 1500 thermomechanical simulator.

As an indication of strengthening, the hardness of HTMP treated specimens increased with the lowering of deformation temperature and increasing strain at temperatures 800–1000°C.

Keywords: stainless steels, high temperature thermomechanical processing.

UDC 539.531:539.431

Ultimate strengthening and «theoretical» hardness. Firstov S. A., Rogul T. G., Danylenko M. I., Gorban V. F., Pechkovsky E. P. – Problems of Materials Science, 2007, N 4(52), pp. 129–137.

The essence of ultimate strengthening of materials is discussed. The new concept of “theoretical” hardness is proposed for rapid and effective estimations of the maximum possible strengthening of materials. The definition of “theoretical” hardness is proposed and the formula for its calculation is derived. The estimated theoretical hardness of some materials is analyzed.

Keywords: hardness, indentation, strengthening, films, nanostructure

UDC 669.018:539.374

Recent developments of severe plastic deformation techniques for processing bulk nanostructured materials. Valiev R. Z. – Problems of Materials Science, 2007, N 4(52), pp. 138–149.

Despite great prospects, the use of nanostructured (NS) metals and alloys as structural and functional materials of new generation has remained an open question until recently. Only in recent years has a breakthrough been outlined in this area, associated both with development of new routes for the fabrication of bulk NS materials and with investigation of the fundamental mechanisms that lead to new properties of these materials. Although a deep understanding of these mechanisms is still a topic of basic research, pilot commercial products for medicine and microdevices can enter the market in the nearest future. This paper presents new concepts and principles of using severe plastic deformation (SPD) techniques to fabricate bulk NS metals with advanced properties. Special emphasis is laid on the analysis of the effect of microstructural features of NS materials processed by SPD on deformation mechanisms and mechanical properties, as well as the first examples of their innovative application.

Keywords: bulk nanostructured materials; severe plastic deformation; strength and ductility; superplasticity.

UDC 539.2:621.73

Bulk nanostructured materials: deformation methods of fabrication, properties and application potentials. Mulyukov R.R., Nazarov A. A., Imayev R. M. – Problems of Materials Science, 2007, N 4(52), pp. 150–155.

Key results of research on bulk nanostructured materials carried out at the Institute for Metals Superplasticity Problems (IMSP) of the Russian Academy of Sciences are reviewed. Application of the deformation methods for top-down nanostructuring of metals has been pioneered at IMSP. The basic concepts of one of the most efficient deformation methods for the production of bulk nanostructured materials, isothermal multiple forging, are formulated. Unusual physical and mechanical properties of bulk nanostructured materials are reviewed. Promising structural and functional applications of bulk nanostructured materials are outlined.

Keywords: nanostructured materials, isothermal multiple forging, mechanical properties, physical properties.

UDC 539.22:539.389:620.186.8

Physics of grain boundary hardening for a wide range of grain sizes. Kozlov E. V., Zhdanov A. N., Koneva N. A. – Problems of Materials Science, 2007, N 4(52), pp. 156–168.

A view of modern representations about structure and mechanical properties of nanopolycrystalline metals and alloys, methods of grain refining, peculiarities of deformation mechanisms in the nanosize region with special consideration of a role of grain boundary gliding and problems of Hall–Petch relation are introduced.

Keywords: nanopolycrystalline metals, hardness, grain sizes.

UDC 669.14: 539.25:621.778

Regularities of dislocation substructure evolution upon wire drawing of steels with high degrees of deformation. Gromova A. V., Ivanov Yu. F., Kozlov E. V., Konovalov S. V. – Problems of Materials Science, 2007, N 4(52), pp. 169–173.

The analysis of electron – microscope qualitative and quantitative investigations of dislocation substructure of steels of different structural classes upon wire drawing and upsetting with the degrees of reduction up to 75% was made.

Keywords: wire drawing, steel, dislocation substructure.

UDC 669.295: 539.2:621.73–973

Effect of cryogenic forging straining on the evolution of titanium texture. Neklyudov I. M., Azhazha V. M., Sokolenko V. I., Chirkina L. A., Kovtun G. P., Borisova I. F., Kalinovsky V. V., Malykhin D. G, Metolidi E. N., Okovit V. S. – Problems of Materials Science, 2007, N 4(52), pp. 174–179.

To define the mechanisms of nanostructure formation and their dependence on the temperature regimes the processes of texture creation were studied in the polycrystalline VT1-0 titanium being in the as-received condition and strained by various-directional forging at 300 K and 77 K. The sample strained at 77 K is specified by the particular texture state. It can be evaluated as the most isotropic state which aroused due to texture failure owing to macro- and microscale twinning. The data of X-ray structure investigations are in accord with the results of measurements on the internal friction and reflectance in the infrared region.

Keywords: titanium, cryogenic temperature, forging, twinning, nanostructure, texture.

UDC [669.295+669.295]:539.2:621.777

Texture aspects of structure development in metal materials under Equi-Channel Angular Pressing. Perlovich Yu., Isaenkova M., Fesenko V., Grekhov M. – Problems of Materials Science, 2007, N 4(52), pp. 180–185.

Formation of the crystallographic texture under Equi-Channel Angular Pressing (ECAP) and its interconnection with substructure development are considered by the example of rods from Ti and Zr. On the basis of texture data the positions of loading axes and operating deformation mechanisms were determined by analogy with the case of rolling. ECAP by routes C and B_C differs from other deformation modes by repeated rotation of grain lattice to the stable orientations under successive passes. Texture scattering in Ti rod testifies about activization of dynamical recrystallization.

Keywords: ECAP, Ti, Zr, crystallographic texture, plastic deformation mechanisms, texture scattering.

UDC 669.245:539.214:539.374

Mechanical properties of nickel-based alloys after severe plastic deformation. Mukhtarov Sh. Kh., Valitov V. A., Dudova N. R.. – Problems of Materials Science, 2007, N 4(52), pp. 186–191.

The influence of structure formed from severe plastic deformation (SPD) on properties of nickel-based alloys is investigated. SPD has been studied via schemes of multi-axis forging and high-pressure torsion.

It is shown that the submicro- and nanocrystalline alloys can display features of low temperature superplasticity (SP). With decreasing the mean grain size of the alloy the temperature boundary of SP becomes lower, the flow stress reduces and the ductility increases.

The microstructure examinations of the gage length of deformed specimens show that SP deformation results in transformation of non-equilibrium grain boundaries into more equilibrium ones, that is accompanied by decreasing dislocation density and increasing grain size. Some grain boundaries demonstrate banded contrast typical of equilibrium high-angle boundaries.

The comparative analysis of the structure and the mechanical properties of bulk and sheet Inconel 718 after SP deformation and heat treatment has been carried out. It is shown that standard heat treatment provides the attainment of mechanical properties corresponding to standard requirements.

Keywords: nickel-based alloy, severe plastic deformation, structure, superplasticity, mechanical properties.

UDC 539.43

The structure and elastoplastic properties of ultra-fine grained commercial purity titanium and Ti–6Al–4V alloy. Psakhie S. G., Dudarev E. F., Kashin O. A., Naydenkin E. V., Ratochka I. V. – Problems of Materials Science, 2007, N 4(52), pp. 192–197.

Complex examination of a microstructure, deformation behavior during micro- and macroplastic strain, elastoplastic and inelastic properties of commercial purity (CP) titanium and Ti–6Al–4V alloy with the ultra-fine grained (submicrocrystalline) structure processed by severe plastic deformation is given. It is shown that the regularities of deformation hardening in the range of microplastic strain are maintained and in the range of macroplastic strain are essentially changed by formation of ultra-fine grained (submicrocrystalline) structure. Regularities of elastoplastic and inelastic properties variations of CP titanium and Ti–6Al–4V alloy by transition from coarse-grained to ultra-fine grained structure are discussed. The interrelation between true grain-boundary sliding and superplasticity of Ti–6Al–4V alloy in an ultra-fine grained state is demonstrated.

Keywords: severe plastic deformation, ultra-fine grained titanium alloys, deformation behavior, mechanical properties.

UDC 539.2:539.374

Mechanisms and model of refining grains in metals severe cold deformation. Utayshev F. Z., Raab G. I. – Problems of Materials Science, 2007, N 4(52), pp. 198–204.

Methods of severe cold plastic deformation (SPD) have been recently started to be used for imparting unusual physical and mechanical properties to metallic materials owing to deep refinement of grains. It is supposed that in such SPD methods as equal-channel angular pressing (ECAP) of rods and torsion of thin discs under pressure (TD), the refinement occurs due to the realization of pure shear route [1].

This paper considers the grain refinement in metals as the effect of the process of forming fragments and bands as the result of crystallographic and non-crystallographic shears at bending and / or torsion of a sample. The said mechanisms of deformation and refinement are realized at any methods of large cold deformation. It is these mechanisms that are responsible for structure refinement which is reached during rolling, drawing and other methods of metal forming since those imply, in one way or another, subjecting a sample to bending-torsion. The peculiar feature of ECAP and TD methods is that sample's bending-torsion in a localized deformation center are evidently and strongly growing that leads to a non-monotonic deformation and increase in the angular misorientations of boundaries of the formed bands and fragments. It is shown that the depth of structure refinement depends on the contributions of the said mechanisms in total strain, depending, in ones turn, on scale factor – the dimensions of deformation center and sample..

Key words: deformation, mechanisms, nanocrystalline metals, fragments, banded structures, tensor density, curvature, torsion.

UDC 539.385:621.318.1

The structure and mechanical properties of FeCoCr hard magnetic alloy, subjected to high pressure torsion at room temperature. Korznikova G. F., Lomayeva S. F., Korznikov A. V. – Problems of Materials Science, 2007, N 4(52), pp. 205–210.

The evolution of the structure magnetic and mechanical properties of a Fe–8%Co–30%Cr hard magnetic alloy during shear deformation at various angles of rotation in the Bridgman anvils was studied. Two initial structural states were considered, i. e. as-quenched α solid solution and high-coercive (α_1 + α_2) state. Severe deformation was found to cause formation of nanocrystalline structure with a grain size about 100 nm irrespective of initial phase composition; whereas mechanism and kinetics of structure transformation depends on initial phase composition. The deformation was demonstrated to initiate the decrease of coercivity and enhance of plasticity of high coercive state and increase of coercivity of α-phase solid solution.

Keywords: hard magnetic alloy, severe plastic deformation, nanocrysatalline structure**.**

UDC 669.295: 539.2:621.771.016

Formation of submicrocrystalline structure in titanium sheets by cold rolling and their mechanical properties. Malysheva S. P., Salishchev G. A., Yakushina E. B. – Problems of Materials Science, 2007, N 4(52), pp. 211–216.

The paper considers changes occurring in microstructure, texture and mechanical properties of commercial pure titanium with initial coarse-grained (CG) and submicrocrystalline (SMC) structure during cold sheet rolling. SMC structure was processed by multiple forging. Strains admissible for rolling of titanium with different grain size have been determined. It has been shown that samples with SMC and CG structures can be deformed by 96% without intermediate annealing. The investigations of microstructure and mechanical properties of sheets processed by rolling at room temperature have shown that in the process of rolling the microstructure of sheets refine and become more uniform. Moreover, after rolling by 50% grains of a submicron size are formed in the sheets with initial CG structure and their volume fraction increases with strain. A typical texture of rolling is formed in semi-products of both types. The sheets of CG titanium have high mechanical properties compatible with properties of SMC titanium. The comparative analysis of mechanical properties of titanium samples with SMC structure processed by different methods has been made.

Keywords: severe plastic deformation, submicrocrystalline structure, cold rolling, titanium, strength, elongation, texture.

UDC 669.71:539.219.2:539.374

On fracture and crack resistance of severely deformed aluminium alloys with micro- and submicrocrystalline structures. Markushev M. V. – Problems of Materials Science, 2007, N 4(52), pp. 217–223.

The features of room temperature failure of commercial aluminium alloys 1560 (Al–6,5Mg–0,6Mn) and 5083 (Al–4,4Mg–0,7Mn–0,15Cr) with fragment and grain submicrocrystalline (SMC) (d ~ 0,4–0,5 μm) and microcrystalline (MC) (d ~ 5–8 μm) structures processed by severe plastic deformation via angular extrusion and following annealing are considered. Transformation of the deformation SMC structure into the MC annealed grain one leads to the change in the character of failure from predominantly brittle intercrystalline to ductile transcrystalline one.

The data on qualitative and quantitative analysis of crack formation and growth are discussed. In particular, it is shown that less resistance to crack formation in SMC structures is attributed to the earlier and stronger localization of plastic deformation in the alloys matrix due to the formation of coarse shear bands passing through hundreds of grains. It has been concluded that the main factor determining the alloys resistance to crack growth is the size of plastic deformation zone (PDZ) at the crack tip: the PDZ is the smallest in the SMC fragmented materials, while in the MC alloys it is the largest.

Keywords: severe plastic deformation, aluminium alloys, crack formation and growth, submicro- and microcrystalline structure.

UDC 669.293:539.2:621.777–973

Nanostructure of niobium after low-temperature quasi-hydrostatic extrusion. Mats A. B., Sokolenko V. I. – Problems of Materials Science, 2007, N 4(52), pp. 224–228.

The paper presents the results of electron microscope investigations of the niobium (99.89 %) structure after straining by quasi-hydrostatic extrusion (QHE) at 77 K in the range of the degree of strain ε = 2,25–6.91. The peculiarities of the processes taking place during structure self-organizing and fragmentation development are shown. The transverse size of fragments and the distance between contours amounts to 20–100 nm and disorientations of elongated large-angle boundaries are 8.5–34°.The instability effects of fragmented structure are revealed.

Keywords: niobium, cryogenic temperature, quasi-hydrostatic extrusion, nanostructure, instability.

UDC 669.12:539.2:621.77.016.2

Development of crystallographic texture and microstructure in Fe, subjected to equal channel angular pressing. Safarov I. M., Korznikova E. A., Korznikov A. V. – Problems of Materials Science, 2007, N 4(52), pp. 229–233.

The submicrocrystalline (SMC) structures that develop in commercial purity iron during equal-channel angular pressing have been investigated. It was shown that after four passes corresponding to the true strains ε = 4.7 the fragmented microstructure is formed which transforms to the granular SMC one in the

process of subsequent annealing. The processed SMC structure is characterized by high strength and ductility.

The structure studies of iron at ECA pressing have revealed the formation of shear mascrobands differing both by fragment sizes and their orientation in respect to the direction of shear deformation. The studies of texture also confirmed the non-uniform character of deformation at ECA pressing.

Keywords: submicrocrystalline structure, equal-channel angular pressing, shear mascrobands, texture.

UDC 669.15–194.56:[621.777+621.778]–973

Structure peculiarities and mechanical properties of austenitic steel after combined severe deformation by drawing and quasi-hydrostatic extrusion at cryogenic conditions. Volchok O. I., Kalinovsky V. V., Neklyudov I. M., Okovit V. S., Sokolenko V. I., Khaimovich P. A., Chernyak N. A., Chirkina L. A. – Problems of Materials Science, 2007, N 4(52), pp. 234–239.

Investigated a sequential combination of various methods of deformation at 77 K, at which different mechanical stress diagrams are realized and their influence on the mechanical properties of austenitic steel. The combination of drawing and quasi-hydrostatic extrusion (QHE) has shown, an increase in haredening to an extent nit attained with the use of separate types of deformation up to ε_f = 70%. The combined deformation qualitatively changes the internal-stress epure. This provides the realization of rotation modes of plastic deformation, the maximum completeness of $\gamma \rightarrow \alpha$ transformation, and the highest degree of phase cold working of steel. Magnetic measurements and internal friction data have shown that after drawing the volumetric content of the fine-dispersed α-phase is greater than that-after the QHE, and its maximum value is attained at a sequential combination of the two deformations.

Keywords: cryogenic, drawing, extrusion, martensite transformations, hardening, magnetic properties, internal friction.

UDC 539.2:548.4

Atomistic simulations of disclinated cracks at triple junctions in nanocrystalline metals. Wu M. S., Zhou K., Nazarov A. A., Lim B. K. – Problems of Materials Science, 2007, N 4(52), pp. 240–245.

This paper reports atomistic simulations of a disclinated triple junction in a cobalt nanowire consisting of three grains. The grain boundaries (GBs) are constructed according to the structural unit model. The simulations show that there exists a critical disclination strength ω_c to nucleate a triple junction crack, and that ω_c demonstrates a significant size effect at 0, 300 and 500 K. The crack size (length, opening) and overall shape depend on the disclination strength ω, the temperature and the GB structures. For the temperatures considered, the relaxation mechanisms observed are bifurcated crack nucleation on the GBs, amorphization competing with secondary GB crack formation at the crack front, and sub-grain formation. The bifurcated crack initially increases in length and opening as ω increases above ω_c. However, with a further increase of ω the bifurcated crack decreases its overall length and increases the opening on two of its branches, apparently affected by the initiation of other mechanisms.

Keywords: disclinated crack, triple junction, nanocrystalline metals, atomistic simulation.

UDC 548.4

Kinetic approach to the description of formation of misorientated crystal regions near disclinations. Sarafanov G. F., Perevezentsev V. N. – Problems of Materials Science, 2007, N 4(52), pp. 246–251.

Self-consistent dynamics of a dislocation ensemble in the elastic field of disclinations basing on kinetic approach is considered. It is shown, that disclinations assemble around themselves dislocation charge which create misorientation of the nearest crystal regions equal to one half of disclination power. Maximal density of dislocation charge arrange along zero level lines of disclination elatic field, screened by dislocation ensemble, perpendicular to existing system of dislocation sliding.

Keywords: diclocations, disclinations, sub-boundary, mesodefects, fragmentation.

UDC 681.3:548.4

Computer simulation of dislocation boundaries formation in the elastic field of disclinations. Perevezentsev V. N., Sarafanov G. F., Kasatkin D. A. – Problems of Materials Science, 2007, N 4(52), pp. 252–259.

The computer simulation of dislocation ensemble behavior in the elastic field of disclination and external stress during deformation is made. It is shown that disclination courses to a disturbance of laminar flow of dislocations and to the appearance of dislocation sub-boundaries which effectively shield the disclination elastic field. The processes of junction disclination formation and broken dislocation boundaries formation during plastic deformation of the model bicrystal and three-crystal are investigated.

Keywords: diclocations, disclinations, sub-boundary, mesodefects, fragmentation.

UDC 548.4:539.374:621.77.016.2

Mechanism of strain-hardening and formation of submicron dislocation structure in metals subjected to severe plastic deformation. Malygin G. A. – Problems of Materials Science, 2007, N 4(52), pp. 260–268.

In the frame of dislocation-kinetic approach based on the kinetic equation for a dislocation density the mechanism of strain-hardening and formation of submicron (cell block, fragmented) dislocation structure (SDS) in metals and alloys subjected to large plastic deformations is considered. It is shown that formation of high-misoriented SDS is the result of self-organization of geometrically necessary dislocations (GND). The initial origin of GND is the dislocation density and plastic strain gradients in cell dislocation walls formed at small and moderate strains. On the ground of derived theoretical relationships, the formation of dense dislocation walls (DDW′s) consisting of GN dislocations is simulated. The found relationships are also used for quantitative analyzing the strength and plasticity of Al and Al–Mg alloy after ECA pressing.

Keywords: severe plastic deformation, dislocation-kinetic approach, ECA pressing.

UDC 539.2:548.4:681.3

Atomistic simulation of disclinations in grain boundaries and junctions in metals. Nazarov A. A., Wu M. S., Zhou K., Murzaev R. T. – Problems of Materials Science, 2007, N 4(52), pp. 269–274.

The present report reviews the recent data of atomistic computer simulations of the stress relaxation mechanisms of disclinations and the effect of junction disclinations on the grain boundary diffusion in nano-structured metals. These simulations established the existence of a critical disclination strength above which a disclination can result in a crack formation. In Ti bicrystals the disclinations can relax also by competing mechanisms such as a new grain formation and amorphization; no transformations of such type have been observed in tilt grain boundaries in Ni. The disclinations can result in a more than two orders of magnitude increase of the GB diffusion coefficient in nanocrystals.

Keywords: disclination, crack, grain boundary diffusion, nanocrystalline metals, atomistic simulation.

UDC 548.4

Superdislocation and its transformations. Greenberg B. A., Ivanov M. A. – Problems of Materials Science, 2007, N 4(52), pp. 275–280.

Superdislocations are carriers of plastic deformation in intermetallics. A significant point is that blocked superdislocations, which are formed due to re-splitting of glissile superdislocations or rearrangement of the superpartial dislocation core, have the lowest energy. A new concept about the possibility of thermally activated blocking of superdislocations in the absence of external stresses (self-locking) was proposed. A sufficiently general thermally activated process, which causes the extension of a dislocation in a preferred direction and constitutes a necessary step in dislocation transformations leading to blocking, was revealed. By its nature, this process represents the flip of a dislocation from a shallow valley to a deep valley of the potential relief. Consecutive stages of this rearrangement of an initial dislocation: the formation of a double kink and its subsequent reorientation in a preferred direction. The driving force of the process was calculated and conditions for its realization in the cases of perfect, superpartial and partial dislocations were formulated. An experimental proof of the proposed concept was obtained.

Keywords: dislocations, plastic deformation, potential relief, shallow valley, deep valley, dislocation blocking, self-locking, no-load heating.

UDC 669.245: 539.2:539.374

The structure and mechanical properties of single crystals of Ni-superalloy CMSX-4 after plastic deformation. Neklyudov I. M., Azhazha V. M., Sverdlov V. Ya., Bogyslajev A.V., Klochikhin V. V. – Problems of Materials Science, 2007, N 4(52), pp. 281–287.

Microstructure and microhardness of Ni-superalloy CMSX-4 after plastic deformation by precipitation under temperatures 1065 and 1179°C have been investigated. Deformation level was up to $\varepsilon \approx 60\%$. Under certain deformation regimes one can observe reducing to fragments γ-phase up to dimensions 0.1–0.05 μm γ-phase particles take a spherical form, distributing in γ-matrix either isotropically, or textured. Microhardness of alloys increased from HV≈4000 MPa at initial state up to HV≈8000 MPa in a deformed one, correspondingly.

Keywords: Ni-superalloy, single crystal, plastic deformation, nanostructure.

UDC 669.017.165:669.017.3:539.374

Influence of the extreme conditions on the structure and properties of intermetallic compounds. Kazantseva N. V., Greenberg B. A. – Problems of Materials Science, 2007, N 4(52), pp. 288–293.

The review of the experimental data on the influence of large plastic deformation on the structure, phase transition, and properties of the nickel superalloys and new perspective titanium aluminides of the Ti–Al–Nb system is presented. It was found that in Ti–Al–Nb alloys the large plastic deformation gave rise to different phase transformations, the last one from that was transformation order-disorder type. New metastable phase A20 and B19 were found in these alloys.

The phase transition of the $L1_2$ superstructure to modulated tetragonal (c/a = 2.022) DO_{22} superstructure in nickel superalloy under shock-wave loading was found. The modulated superstructure was consisted of the alternating antiphase boundaries (APB). The structure phase transition $L1_2$–DO_{22} accompanied by the change in magnetic properties: the magnetic susceptibility changed on just about two orders as compared to initial state.

Keywords: severe plastic deformation, intermetallic compounds, structure, phase transformation.

UDC 669.245:669.017.3:539.374

The influence of high plactic deformation on properties and phase transformations of nickel base superalloy. Sergeyev V. I., Safarov I. M. – Problems of Materials Science, 2007, N 4(52), pp. 294–297.

Change of multi-phase nickel base alloy structure after severe plastic deformation and subsequent annealing were investigated. Deformation was done on Bridgemen anvils at room temperature. It was found that due to severe plastic deformation multi-phase structure transformed into single phase. Annealing leads to single phase decomposition and carbide and intermetallic particles precipitation.

Keywords: severe plastic deformation, nickel-base superalloy, phase transformation, solid solution.

UDC 669.017.165:539.2:539.374

Microstructure of the ordered alloys TiAl and CuPd upon deformation by shear under pressure. Antonova O. V., Volkov A. Yu. – Problems of Materials Science, 2007, N 4(52), pp. 298–303.

It is shown that the use of shear under pressure makes it possible to deform the intermetallic compound TiAl ($L1_0$ superstructure) and the alloy CuPd (B2 superstructure) to extremely high degrees of deformation with the result that a nanocrystalline structure with crystallite sizes down to 10 nm can be obtained. X-ray diffraction and electron microscopy were used to study the microstructure evolution in the course of plastic deformation and the specific features of the defect substructure. It has been established that the alloy fragmentation upon deformation occurs via stages of the formation of a banded structure, which is mainly caused by twinning in the TiAl, with subsequent loss of stability of its boundaries, and the formation of nanocrystalline structures. The formation of the localized deformation bands of the CuPd is accompanied by phase transformation B2→A1 on the first stages of deformation The TiAl deformation stimulates the $\gamma \rightarrow \alpha_2$ phase transformation in some parts of the sample. Under the extremely high degrees of deformation has been observed both in TiAl and in CuPd the formation of highly dispersed crystallites with the unknown structure.

Keywords: severe plastic deformation, intermetallic compounds, structure, phase transformation.

UDC 621.318.12:539.2:620.175

Formation of gradient nanocrystalline structure in Fe–Cr–Co system hard magnetic alloys during hot straining by complex loading. Korznikov A. V., Korznikova G. F. – Problems of Materials Science, 2007, N 4(52), pp. 304–310.

The evolution of the structure and microhardness of Fe–25Cr–15Co and Fe–30Cr–8Co hard magnetic alloys during complex two-stage upsetting–torsion under isothermal conditions at different temperatures is experimentally studied. It was revealed that the deformation leads to a strong refinement of initial coarse-grained structure in both alloys. However the generated structure is non-uniform through the body of the sample. In an active zone of deformation, near to mobile head, there is a microcrystalline layer with a grain size of about 5 μm in a single phase Fe–30%Cr–8%Co alloy and micro duplex structure with a grain size about 0.5 μm in a two-phase Fe–15%Co–25%Cr alloy. With removal from the active zone of deformation the grain size increases, and microhardness decreases.

Keywords: hard magnetic alloy, deformation, complex loading, gradient structure.

UDC 669.245:539.214:621.78

Formation of nanocrystalline structure upon severe thermomechanical processing and its effect on the superplastic properties of nickel base alloys. Valitov V. A. – Problems of Materials Science, 2007, N 4(52), pp. 311–316.

This paper is the systematic study of the mechanisms of structure formation of a wide range of nickel and nickel-iron based alloys with different types of strengthening ($\gamma + \gamma'$; $\gamma + \delta + \gamma''$; $\gamma + \gamma' + Y_2O_3$) in a wide temperature – strain rate interval of plastic deformation. Regimes of thermomechanical processing that provide stage-by-stage transformation of a coarse-grain structure into a microcrystalline (MC) one, and further to nanocrystalline (NC) structural state, have been established. The regularities of the effect exerted by the morphology of strengthening phase and processing conditions on the development of structure formation during hot, warm and cold deformation have been revealed. The correlation between the phase composition and the type of strengthening of superalloys with thermal stability of SMC and NC structures, and the possibility of manifestation of the effects of low temperature and high strain rate SP have been revealed.

Keywords: nanocrystalline structure, superplasticity, severe thermomechanical processing, nickel alloy.

UDC 539.2:548.4:539.374

Mesoscopic deformation mechanisms under high pressure conditions. Konstantinova T. E., Tokiy V. V. – Problems of Materials Science, 2007, N 4(52), pp. 317–322.

The high pressure effects are discussed in micro and mesostructure of deformed industrial alloys based on iron and titanium. At first microscale level high pressure role lie in dislocation mobility decrease, probability of dislocation accumulation increase and quality of crack create dislocations (type 100) reduce. At next mesoscopic level plastic deformation of some multicomponent alloys (Fe–17Ni–9Co–5Mo–1Ti, Fe–0,8C, Ti–5Al–5V–5Mo, Ti–40Nb) accomplished thought local dipole bends of crystal lattice, what are volumetric defect of mesolevel, the experimental method of parameters and dislocation model of new mesodefect are described. The deformation mode can be considered as bending ones along with rotation mode. High pressure encourage create high degree of smooth disorientation and sphere type local bend regions fact that increase of dislocation interaction. Fragmentation mechanism is discussed with theoretical model as transition from dipole dislocation change to dipole of disclination. It was shown, that deformation of Ti alloys can came from martensitic $\beta \leftrightarrow \alpha$ transition (rotary mode), what is reversible. Evolution structure of Ti alloys after equal channel multiangle pressing and hot twist extrusion is described.

Keywords: severe plastic deformation, high pressure, mesostructure, deformation mechanisms, bending mode, deformation martensite, fragmentation, iron and titanium alloys.

UDC 669.14.018:539.374:621.78

Structure evolution and mechanical properties of steel deformed with large plastic strains in austenitic-perlitic transformation zone. Kodjaspirov G. E., Rybin V. V., Drakatos P. A. – Problems of Materials Science, 2007, N 4(52), pp. 323–328.

The structure formation at the large plastic strains of the middle-carbon low alloyed steels in the temperature interval 1000–600 C under continuous air and water cooling are discussed. It's shown that result in the mentioned above conditions the multicomponent martensite-bainite-perlite-ferrite structure arised. The

processes of partial cementite coagulation in the pearlite component with the cellular and fragmented structure in ferrite at the dislocation density inside of cells and fragments in the interval 10^9–10^{10} cm^{-2} take place. The temperature lowering in the end of the deformation causes gradual increase of defects of both structure components with some growth perlite portion component.

It has been established the regularities between mechanical properties, structural components correlation and fine structure. The last one state allows to predict and control the yield strength for the TMP treated steels with the multicomponent structure.

Keywords: stainless steels, high temperature thermomechanical processing.

UDC 669.14.018:621.785.062.53

Structure and properties of low alloyed low carbon steel after thermo-mechanical treatment with accelerated cooling. Rybin V., Khlusova E., Nesterova E., Mikhailov M. – Problems of Materials Science, 2007, N 4(52), pp. 329–340.

The present paper offers results of microstructure examination of thick sheets of chromium nickel molybdenium martensitic-bainitic steel, microalloyed nickel-manganese ferritic-bainitic steel and microalloyed manganese ferritic steel after thermo-mechanical treatment (TMT), in connection with their mechanical properties. The paper is focused on the role of dynamic recrystallization and deformation induced fragmentation of the austenite in the formation in low alloyed low carbon steels of fine-grained isotropic microstructures. The dynamic recrystallization is shown as a way to change the bainite morphology from anisotropic acicular to more isotropic granular one. The austenite fragmentation keeps this tendency and results both in the formation of fragmented granular bainite and in the intensive ferrite grain size refinement. The complementary strengthening obtained by thermo-mechanical treatment of martensitic-bainitic steel is achieved due to the formation of fragmented granular bainite that inherits the deformation-induced microstructure of hot rolled austenite. The strengthening of ferritic steel is caused by ferrite grain size refinement and ferrite fragmentation. The net effect of the above strengthening mechanisms enables to keep high strength characteristics of ferritic-bainitic steel in spite of the TMT induced increase in ferrite quantity. The thermo-mechanical treatment of low alloyed low carbon steels along with the strengthening allows obtaining better resistance to brittle fractures up to -60°C.

Keywords: low alloyed low carbon steel, thermo-mechanical treatment with accelerated cooling, thick sheets, structure and properties.

UDC 669.3:539.2:620.178.7

Shock-induced turbulence and dissipative structures in copper. Meshcheryakov Yu. I., Zhigazcheva N. I., Divakov A. K., Makarevich I. P., Barakhtin B. K. – Problems of Materials Science, 2007, N 4(52), pp. 341–347.

A shock-wave loading under uniaxial strain conditions of polycrystalline M3 copper reveals a threshold nucleation of dissipative structures of 15–25 μm in diameter. Where observed the turbulent-like formations lie in the grains favorable oriented respectively shock wave propagation direction. Each structure, in turn, consists of networks of parallel or mutual perpendicular shear bands of 100–300 nm spacing, so the size of elementary cell restricted by shear bands in their scale belong to nanostructure. Macroscopically, momentum and energy expended on formation of the structures is quantitatively characterized by “deficit of particle velocity” – difference between impact velocity under symmetrical collision and free surface velocity of shock loaded plane target. There is a threshold strain rate higher which the deficit of particle velocity begins to grow very fast and simultaneously the hardness and spill-strength of material grow in the same manner.

Key words: shock wave, turbulence, nanostructure, shear bands, dynamic strength.

UDC 539.37:539.386

Eddy model of elastic-plastic flow with high-velocity strains: construction of kinetic equation, simple shear. Morozov V. G. – Problems of Materials Science, 2007, N 4(52), pp. 348–352.

Elastoplastic medium under high-rate strains is considered to be a mixture of particles which specifies two states: elastic and plastic. Such a model is adequate to current experimental concepts of heterogeneity of flow at mesolevel where transition to plasticity occurs due to originating of eddy plastic centers. A phenomenological equation of eddying concentration for a simple case, pure shear, is set up. The equation is solved in quasi-stationary approximation for shear band and for plastic boundary layer, and the area of plasticity is separated from the area of elasticity at this. Solutions are intended to describe centers of plasticity at mesolevel and will be used to construct a phenomenological macro-model of plastic flow. This approach is

supposed to be used to simulate low-velocity-actuated initiation of explosion of solid explosives. Heating of explosive in the centers of plasticity is the mechanism of actuation. According to the structure of equations, at high velocities the shear plastic flow changes to turbulent flow with transverse eddies.

Keywords: centers of plasticity, mesolevel, low-velocity actuation of explosive.

UDC 669.3:539.21:539.411.5

The condition of nanostructure formation in copper under high-strain-rate deformation. Atroshenko S. A., Ermolaev V. A., Frommert M., Hu W., Naumova N. S. – Problems of Materials Science, 2007, N 4(52), pp. 353–358.

This paper is devoted to nanostructure formation in copper under dynamic recrystallization during high-strain-rate deformation. Copper polycrystal specimens were used for investigations. Shock loading was realized under room temperature in the velocity range 66–210 m/s. The combination of local dynamic response registration of shock loaded specimens using two-channel laser interferometer with their microstructural investigation was used for carrying out these investigations of dynamic recrystallization. Spall strength of copper was determined in these experiments. Regions of dynamic recrystallization with nanostructure similar those which were described in [1–4] were revealed in shock-loaded copper specimens.

Keywords: shock loading, shear localization, nanocrystalline formation, dynamic recrystallization (DRX).

UDC 669.295:539.411.5

Transformation in two-phase titanium alloys under high speed mechanical loading. Skotnikova M. A., Krylov N. A., Motovilina G. D. Lanina A. A., Sorokina S. S. – Problems of Materials Science, 2007, N 4(52), pp. 359–365.

TEM, SEM-technique and X-ray diffraction analysis are used to investigate the structural and phase changes occurring in a material of planar targets – samples of VT-6 ($\alpha+\beta$) titanium alloy, tested over impact velocity range of 400 to 600 m/s. It is shown, that the compressing wave of plastic deformation modulates the material structure, breaking it on micro-blocks of 4–40 μm in size. Along the boundaries of blocks, the unloading wave produces the coordinated displacements of blocks relatively each other in such a way that the smaller block and the closer it to the center of rotation, the greater the mutual displacements of blocks. It is shown that on an input the loading wave resulting in decomposition β-phase and enrichment by a vanadium of α-phase up to formation soft orthorhombic of α''-phase, braking a shock wave was formed. The shock wave was reflected in an output from the back party and the unloading wave was formed. Here there was a change of the mechanism of plastic deformation, from shift to rotational. Thus there was an intensive heat-generating and return phase transformation, at which soft β-phase enriched with vanadium, inclined to decomposition down to formation of a brittle ω-phase was formed. Than the more the quantity of soft β-phase, the microhardness of opposite side material was less. From the moment when β-phase turned in brittle ω-phase, the hardness of sample material was raised. In this place the crack was formed.

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Keywords: TEM, SEM-technique, shock loading, titanium alloy, fracture, structural-phase changes.

UDC 669.018:539.2:539.37

Estimation of energy consumption supplied for deformation and fracture of metallic materials. Arutyunyan R. A. – Problems of Materials Science, 2007, N 4(52), pp. 366–371.

In recent years the new methods of introducing severe plastic deformation [1] into metallic materials are worked out. As a result of such treatment a pronounced fragmentation of grains, with a new submicrocrystalline structures and extraordinary strength, are obtained. While the problem of energy consumption supplied to produce metallic materials with new properties usually is not discussed. In this publication we will consider some aspects of the problem, in particular, the energy consumption for irreversible deformation and fracture of metallic materials. For example, such problem arises when the ductile creep fracture criterion for incompressible materials is formulated. In accordance with the Hoff's law [2] the metallic specimen is fractured when the value of deformation tends to infinity and so the infinite value of energy must be consumed. To clear up this question, the energy conservation law is applied [3] to formulate the creep fracture criterion. The received criterion contains a summary of heat and latent energies [4, 5].

Parameters of the proposed criterion are specified and the theoretical creep fracture curves are constructed. Assuming that the heat energy is given out so it has no effect on the fracture process, the creep fracture criterion is simplified. It is shown that this version of energy criterion gives the best fit to the experimental creep fracture curves received in creep and fracture experiments. The latent energy is supplied for the generation of irreversible creep deformation as a result of the dislocation mechanism so the assumption of incompressibility is well justified. For common case to make the real estimation of energy consumption the compressibility condition [6] is introduced and the ductile-brittle fracture criterion is formulated.

Keywords: Incompressible material, ductile fracture criterion, energy conservation law, strain energy, heat and latent energies, compressible material, ductile-brittle fracture criterion.

UDC 539.219.2

Internal long-range stress fields in ultrafine grained materials. Koneva N. A., Zhdanov A. N., Fedorischeva M. V., Kozlov E. V. – Problems of Materials Science, 2007, N 4(52), pp. 372–390.

Internal long-range stress fields play an important role in various processes that take place in ultrafine grained (UFG) materials, prepared by severe plastic deformation (SPD). These fields are not studied enough experimentally. Transmission electron microscopy (TEM) is one of the most suitable methods to study internal stress (IS) and the paper describes these techniques. The results of studies of grain and sub-grain structure and their boundaries in UFG Cu and Ni are presented. The sources of stress fields are revealed. The behavior of the IS amplitude with increased distance from their sources is studied. The scheme of the grain structure of UFG materials obtained on the basis of experimental data is presented.

Keywords: long-range internal stresses; UFG materials; grains; dislocations; disclinations; particles; boundaries.

UDC 669.71–416:539.2:621.771.016

Regulation of sheet material properties taking into account dynamic structure formation processes of aluminium alloy rolling. Grechnikov F. V.; Mikheev V. A.; Popov I. P. – Problems of Materials Science, 2007, N 4(52), pp. 391–397.

The article provides the reader with some data on the results of some special researches of high-rate rolling processes of thin tape from aluminium alloys with the purpose of obtaining texture with ordered morphology. It should be stressed that the technology is shown and some data on regulation of structure, properties and their anisotropy at the expense of temperature-rate and strain-force hot-rolling parameter changes are represented. Moreover, the technology of obtaining thin tapes with tasked properties and structure is examined.

Keywords: material structure, anisotropy, tape texture, recrystallization, temperature rolling.