C O N T E N T S

CRISTALLOGRAPHIC ATTESTATION OF MESOSTRUCTURES

FORMATION OF STRUCTURAL INSTABILITIES AT MESOLEVEL (SHIFT LINES)

FORMATION OF MESOSTRUCTURES IN SURFACE LAYERS AND COATINGS

NONCONVENTIONAL APPLICATION OF THE VIEW MESOSTRUCTURES

ABSTRACTS OF PUBLISHED ARTICLES

UDC 548.4:539.2

Principles of the formation mesostructures in the process of a developed plastic strain. R y b i n V. V. – Problems of Materials Science, 2002, N 1(29), p. 11–33.

A review of the basic experimental evidence and theoretical concepts of mesodefects and mesostructures formation in the process of a large plastic strain is presented. A genetic interrelation between the formation of mesodefects and self-organization of an ensemble of interacting dislocations at their critical density values has been revealed. A classification of mesodefects and their interpretation in terms of partial and junction disclinations are given. A detailed consideration of fragmentation and analysis causes and acting forces giving rise to the phenomenon are presented. A large body of data on the statistics of fragment boundary distribution in the value and direction of a misorientation vector as well as the type of boundaries is given.

Key words: plastic strain, mesodefects, mesostructures, disclinations, fragmentation, theoretical experimental investigations.

UDC 539.21:539.415

Plastic strain and fracture of solids as an evolution of loss of their shear stability at different scale levels. P a n i n V. E. – Problems of Materials Science, 2002, N 1(29), p. 34–50.

A synergetic approach to problems of plastic strain and fracture of solids is discussed. Scale levels of shear stability loss for loaded solids are substantiated. A determinant role of different-scale stress concentrators in initiation and propagation of plastic shears is shown. Surface layers of loaded solids are classified as a leading mesocsopic structural strain level.

Key words: plasticity and strength, synergetics, scale strain levels.

UDC 669.017:539.21:539.38

Mesostructure parameters and mechanical properties of single-phase metallic materials. K o z l o v E. V. – Problems of Materials Science, 2002, N 1(29), p. 50–69.

The present-day situation concerning the nature of strain resistance of metallic materials is considered. An unconventional conception of physical strengthening mechanisms at high and low temperatures is stated. Their role at yield strength and high plastic strain values is discussed. A scale classification of factors of strengthening and loss of strength is given. A detailed consideration of all the main aspects of substructural strengthening at different structural levels is presented. A special attention is paid to the mesolevel. Static and dynamic strengthening mechanisms are highlighted. Attention is paid to polycrystalline strengthening effects. The present-day conception of strengthening metallic materials is discussed with regard to its successful solutions, problems to be solved, and further development.

Key words: metallic materials, strain resistance, strengthening mechanisms, mesolevel, polycrystalline strengthening.

UDC 548.4:539.382

Vicissitude of a strain hardening of polycrystals. F i r s t o v S. A., P e c h k o v s k y E. P. – Problems of Materials Science, 2002, N 1(29), p. 70–86.

In this work the opportunity of quantitative reflection of vicissitude of process of a strain hardening of polycrystals is shown. It grounded on presence of step-by-step regular change of one type of dislocation structure by another at strain, and also method of installation of temperature-deformation and temperature-power boundaries and areas of their existence. In a bottom of a method the rebuilding of strain curves in coordinates S–e^n (S and e — true stress and strain, n — index of a strain hardening) is which allows reliably and rather promptly to construct the diagrams of structural states of different views. The representation of results of mechanical tests of polycrystalline metals as such diagrams enables to check dynamic and to determine regularities of their mechanical and structural behavior, and also mechanisms of a plastic deformation and strengthening from its initial stages down to fracture in a practically unbounded interval of temperatures.

Key words: vicissitude of a strain hardening, type of dislocation structure, method of rebuilding of strain curves, diagrams of structural states.

UDC 669.018.45:539.2

The role of mesostructure in the formation of the refractory metals mechanical properties. M i l m a n Yu. V. – Problems of Materials Science, 2002, N 1(29), p. 87–103.

The formation of structure and mesostructure for Cr, Mo, W and their alloys in three temperature ranges of deformation: hot, warm and cold is considered. The optimal equiaxial dislocation cell structure is formed only in the upper part of the warm deformation range. It was shown that mesostructure determines the level of the main mechanical properties: strength, plasticity and ductile-brittle transition temperature as well as the appearance of main defects of refractory metals semiproducts: splitting, 45-degree brittleness and anisotropy of mechanical properties. The theoretical grounds for increasing cell structure stability due to dispersion hardening are considered. Recommendations for the choice of the optimal conditions for semiproducts production and sintering of powders are considered in connection with the concept of homological recrystallization temperature.

Key words: refractory metals, mesostructure, mechanical properties, 45-degree brittleness, splitting.

UDC 539.219.2

Internal stresses and their role in the mesostructure evolution. K o n e v a N. A. – Problems of Materials Science, 2002, N 1(29), p. 103–112.

In work the study of internal stresses (IS) of FCC metals and alloys of solid solutions is carried out by the method of transmission electron microscopy. The basic sources of IS are determined. Statistical data on distribution of IS in materials having different density

of defects and a different type of a substructure (mesostructure) organization are obtained. It is recognized that substructures originating during deformation are characterized by an correlated ordered arrangement of dislocations. It leads to screening an internal elastic field. On the base of the performed measurements the principal difference of an amplitude and homogeneity of internal field stresses in low-energy and high-energy dislocation structures (LEDS and HEDS accordingly) are shown.

Key words: deformation, dislocation substructure, mesostructure, internal stresses, electron microscopy.

UDC [666.3+621.7.011]:539.52

The role of mesodefects in structural evolution, plastic flow and fracture of superplastic alloys and ceramics. P e r e v e z e n t s e v V. N., R y b i n V. V. – Problems of Materials Science, 2002, N 1(29), p. 113–122.

Kinetics of evolution of mesodefects generating on the interface and intergranular boundaries (orientational misfit dislocations and products of their delocalization, systems of joint disclinations) during superplastic deformation is analyzed. The influence of mesodefects at strain induced grain grows, nucleation and growth of microcavities, rheology of superplastic flow is considered. Models based on this analysis describing experimentally observed regularities of mechanical behavior of superplastic materials with different chemical and phase composition are developed.

Key words: superplasticity, mesodefects, strain induced garin growth, cavity nucleation, physical models.

UDC 539.3

The structural and analytical theory of physical mesomechanics. M a l i n i n V. G., M a l i n i n a N. A. – Problems of Materials Science, 2002, N 1(29), p. 123–143.

This paper elaborates the methodology of the structural theory of strength and sets forth the methods of setting up the length equations of the structural and analytical theory of physical mesomechanics based on rational sinthesys of the main achievements of mechanics of continua, plasticity physics and strength of rigid bodies, materials technology, thermodynamics of irreversible processes and other adjacent subjects. The loaded material is treated as a multilevel system in which micro-, meso- and macrolevels are integrally interdependent. Each scale level is characterized by its mechanisms and regularities of strain, evolution of structure and abnormal conditions. On the mesostructural level the translation and rotation mechanism of mass transfer dominates and the abnormal condition structure progress.

Based on the postulate of macroscopic definability the set of equations of conservation of both the dynamic and geometrical character is derived followed by certain correlation`s for solving engineering problems in predicting the there mesomechanical properties of the real objects.

Key words: physical mesomechanics, micro-, meso- and macrolevels, destruction stpuctural and analitical theory.

UDC 548.4:539.31

Elastic fields of defects in solid crystalline structure. B r e c h k o T. – Problems of Materials Science, 2002, N 1(29), p. 143–156.

In work the experimental proof of existence of oriented residual stresses is submitted and their role in attenuation of the shape memory effect in alloys TiNi is discussed. On an example of a material of cubic syngony with spatial group Fm3m is shown, that the main vectors of residual stress tensor turn under irreversible deformation along a broken load trajectory. The experimental proofs of the tensor character of root-mean-square distortions $<e^2>^{1/2}$ measured by a X-ray method on mesolevel are submitted. Applying the received results to materials with SME, experimentally and by computer modeling is shown, that the durability of a shape memory effect can be predicted by change $<e^2>^{1/2}$ on process of be used of products from these materials.

Key words: oriented stresses, RMS micro-strains, shape memory, durability of a shape memory effect, computer simulations.

UDC 539.37

Influence of interaction of anisotropic grains on origin of plastic deformations and fracture in multiphase materials. B a g m u t o v V. P., B o g d a n o v E. P. – Problems of Materials Science, 2002, N 1(29), p. 156–163.

The results of simulation by a finite element method of processes of origin of plastic deformations and microcracks in materials consisting of phases with different types of a crystalline lattice are considered. The opportunity of plastic flow and strength of finite elements are connected tangential stresses in systems of slide and stress on crystallographic planes cleavage. The dependence of statistical parameters describing legitimacy of allocation of microstresses and deformations from stressed states and from relation of phases are given. The influence of phase make up on the form and sizes of initial surfaces of plastic flow and microfracture is shown.

Key words: finite element method (FEM), statistical approach, local deformation, microstress, yield criterion, fracture criterion.

UDC 539.3

The new approach to continued modeling of mesoskopic exchange processes. Z a k i e v S. E. – Problems of Materials Science, 2002, N 1(29), p. 163–167.

The formal fundamentalises of the concept everywhere intercontiguous of continuums are set up, which one, as against the known concept of interpenetrating continuums (grounding on a principle of local homogeneity) is more adequate to problems of the analysis of mesoscopic processes of an interchanging and transposition. The tendered means is new essentially, as rests and on concepts fractional integrodifferential calculus. It also allows effectively to detail model exposition indicated mesoprocesses. To number of its virtues concerns and originating favorable situation for “docking” simulation and continuum mesomodels. Because for the analysis of simulation models of heterogeneous systems frequently naturally selects fractional integrodifferential statistics. The means is demonstrated on build-up of model for systems of selfpropagating hightemperature synthesis.

Key words: reacting condensed systems, fractional derivative.

UDC 669.295:539.382.2

Peculiarities of mechanical behaviour and evolution of titanium submicrocrystalline structure under cold deformation conditions. S a l i s c h e v G. A., M i r o n o v S. Yu., M y s h l j a e v M. M. – Problems of Materials Science, 2002, N 1(29), p. 168–180.

Considers the influence of the grain size within the range 57–0.4 mm obtained by warm severe plastic deformation on mechanical properties of titanium during uniaxial tension at room temperature. The decrease in the grain size, significantly improves strength properties, leads to occurrence of a Luders strain, some decrease in strain hardening and rapid localization of deformation in a neck. The study of SMC structure evolution has shown that the most probable mechanism of deformation is dislocation slip. It has been revealed that the decrease in grain size sharply intensifies deformation processes at the initial stage of plastic flow, namely, rapid transition to collective modes of dislocation movement and formation of a fragment structure are observed. Due to gradual and consecutive structure evolution the deformation proceeds from micro- to meso- and macroscopic scale. The influence of the initial grain size on mechanical properties is neglected in this case.

Key words: grain size, submicrocrystalline structure, mechanical behavior, fragment structure, mesoscopic scale of deformation, titanium.

UDC 548.4:539.376

Formation of micro- and mesostructure at creep of monocrystals. B e t e k h t i n V. I., K a d o m t s e v A. G. – Problems of Materials Science, 2002, N 1(29), p. 181–192.

By means X-ray diffraction methods formation of the fragments at a stationary stage of creep of ionic and metal single crystal is discovered. Fragments are consisting several blocks and their disorientation is correlated. The dependencies of change of the block and fragmentary disorientation, connected, accordingly, with shift and rotational deformation, are investigated. The mechanism of formation of fragments and connection of disorientation with development of microcracks and strength is analyzed. It is supposed, that formation of fragments is display of formation of dissipate mesostructure.

Key words: disorientation, the block, a fragment, mesostructure, durability, creep, single crystal.

UDC 539.2:621.785

Role of the mesostructure at the thermomechanical processing. K o d j a s p i r o v G. E. – Problems of Materials Science, 2002, N 1(29), p. 193–199.

It is discussed the role of the mesostructure at the thermomechanical processing (TMP) of metallic materials. The fragmentation is the main mode of the structural transformations at the different TMP schemes realization. It is shown that vary the TMP parameters it is possible resulting the different mesostructure types at the quality and

quantity levels as well. The data confirmed the direct relationship between mesostructure and mechanical, technological, and functional properties are given.

Key words: thermomechanical processing (TMP), fragmentation, recovery, recrystallization, mechanical properties.

UDC 669.017.3:621.9

Structural transformations into metals at fast-track cutting. Skotnikova M. A., Kastorski D. A., Strokina T. I. – Problems of Materials Science, 2002, N 1(29), p. 199–215.

In this work with attraction of a transmission and scanning electronic microscopy the experimental result of change geometry, structure and microhardness of chip from alloys ВТ23, АМц, ХВГ in an interval of speeds of cutting treatment 2–6000 m/min are adduced. The laws of interplay of dynamic plastic deformation and destructions on macro-, meso- and mikrolevels are established.

Key words: cutting treatment, cuttings formation, microhardness, transmission and scanning electronic microscopy.

UDC 539.21:539.411.5

The microstructural evolution of metal phases and diamond intermetallics and composites synthesized by the method of shock wave loading. Greenberg B. A., Popov A. A., Romanov E. P., Shorokhov E. V., Guschin G. M., Ponosov Yu. S., Rodionova L. A., Rubshtein A. P., Trakhtenberg I. Sh. – Problems of Materials Science, 2002, N 1(29), p.. 216–226.

The microstructure of alloys, which were produced from powders of pure metals and superfine diamond (SFD) by the method of shock wave loading, was analyzed. A quasispherical loading scheme with a conservation chamber was used. The stress at the contact surface was 50 GPa. Alloys containing Ti–50 at.%Al, Ti–25 at.%Al, and Ni–25 at.%Al were prepared. The method used to synthesize the alloys had some specific features comprising superhigh heating and cooling rates, and a high deformation rate. Most characteristic phases and microstructures were pointed out among the observed multitude of phases and microstructures: dendritic structure, martensitic structure, and a vortex domain structure. Phases enriched with iron, whose particles were injected from the conservation chamber, were detected. The observed microstructures could serve as an indication to the effects taking place during shock wave loading. As a result, it was possible to reconstruct the time sequence of the synthesis processes. A composite compound was synthesized from powders containing Ti–25 at.%Al and SFD. The phase transformations included both intermetallic reactions and formation of carbides. It was shown that diamond was graphitized under the given experimental conditions. Graphite particles were examined in a scanning electron microscope. A Raman spectroscopic analysis showed that graphite had a nanocrystalline structure. The particle size estimates were close to those obtained from scanning tunnel observations of the surface relief. Some data pointed to the graphite intercalation.

Key words: powders of pure metals and superfine diamond, microstructural evolution, composites synthesized, shock-wave loading.

UDC 539.2:539.411.5

Kinetic of mesostructure and energy exchange between scale levels in shock waves. M e s c h e r i a k o v Ju. I. – Problems of Materials Science, 2002, N 1(29), p. 226–235.

Kinetic approach to mesostructure behavior in dynamically deformed heterogeneous media permits to understand a physical nature of non-steadiness of shock-wave propagation. It is shown theoretically and experimentally that the ratio of mesoparticle velocity dispersion and mean velocity is invariable in the steady shock fronts, whereas in the unsteady fronts that ratio currently changes. Under critical strain rate this results in break of the wave motion of medium. So, the strain-rate range can be subdivided by two regions where energy exchange between macrolevel and mesolevel is found to be different. Quantitative characteristic of intensity of this exchange is a mean velocity dispersion. The velocity dispersion itself takes only negligible part of internal energy — about 10% from total kinetic energy transferred from macrolevel to mesolevel. However, it plays a role of a trigger which initiates a more intensive energy exchange between macro- and mesolevels.

Key words: mesostructure, shock-wave, energy exchange, energy transferred, kinetic approach.

UDC 669.245.018.44:539.411.5

Study of the influence of the shock wave loading on the structure and the properties of a Ni3Al-based superalloy. K a s a n t s e v a N. V., G r e e n b e r g B. A., G u l y a e v a N. P., B a k h t e y e v a N. D., P o p o v A. A., S h o r o k h o v E. V. – Problems of Materials Science, 2002, N 1(29), p. 235–246.

The process of intensive deformation after shock wave loading of the monocrystal of a superalloy containing 90 per cent of Ni3Al intermetallic phase after applying the different types of loading have been studied. On the basis of the microstructure evolution analysis, X-ray diffraction investigations and microhardness measurements, the stages of the high-rate deformation proceeding for the alloy are determined. The microstructure observed at shock action likes to that obtained under quasistatic loading by torsion and cold rolling. From the X-ray analysis data it follows that at the impact by a plate (P = 100 GPa), loading in the explosion products (P = 20 GPa), and when the samples was placed into a shell which striked against a hard barrier (P = 10 GPa) the considerable breadth of X-ray lines is associated with density of dislocations. Due to the shock front attenuation the defects density changes from ~9×10^{12} cm^{-2} on the loading surface of the sample to 4×10^{11} cm^{-2} at the distance of 4 mm from it. It is noted that the intense deformation of the alloy induces a strong change in the degree of high order. After loading of the sample by the explosion products pressure equal to 20 GPa the degree of the order amounts to ~0.65, at the impact by the plate up to pressure of 100 GPa it amounts to ~0.3 and in the experiment with a shell – to ~0.45. By the TEM examination the essential change in the initial structure, namely, the fragmentation and band structure are revealed.

Key words: intermetallic, shock loading, intensive deformation.

UDC 539.21:539.411.5

Macro- and mesoscopic waves of elastic-plastic relaxation by collision of high-speed shock mechanism with metallic target. Barakhtin B. K., Savenkov G. G. – Problems of Materials Science, 2002, N 1(29), p. 247–253.

The light- and electron microscopy techniques revealed that zones where metal demonstrates properties of both uncompressable liquid and tough-elastic solid were generated as a result of high-speed (2–4 km/s) shock mechanism action in the target from the alloy XH75BMIO. Generating at a free surface the elastic-plastic shifts of relaxation are united in a standing soliton, oriented in the direction of tangential stresses action. At the mesoscale structural level the proposed non-linear kinetic model describes variations in ensembles of defects as a combination of intragranular sliding and sub-boundaries formation.

Key words: high-strength material, high-speed shock mechanism, target, structure distortion, light- and electron microscopy techniques.

UDC 548.4:539.415

Criston mechanism of a-martensite deformation formation in the presence of stress martensite. Kaschenko M. P., Semenovykh A. G., Chashina V. G. – Problems of Materials Science, 2002, N 1(29), p. 253–259.

Analysis of morfological indications wich confirms the advisability of application of cristons as carriers of threshold information at formation of a'-crystals in iron-based alloys.

Key words: deformation martensite, stress martensite, cryston mechanism.

UDC 539.21:620.187

Crystallographic attestation of deformation and martensitic origin mesostructu-res. Nesterova E. V., Rybin V. V. – Problems of Materials Science, 2002, N 1(29), p. 260–267.

Advantages of single reflection technique have been shown on examples of crystallographic attestation of deformation and martensitic origin mesostructures.

The influence of initial grain orientation and reorientation path on morphological and crystallographic features of deformation mesostructures has been studied in single phase and in heterogeneous materials. A technique of Bain axes reconstruction in martensitic structures has been offered. A method of accommodation interphase misorientation measurements in martensitic mesostructures has been worked out, and examples have been given for low carbon steels.

Key words: single reflection technique, crystallographic attestation, deformation and martensitic origin mesostructures.

UDC 548.4:539.415:620.187

Slip system and misorientations of shear microband formed in iron polycristal under ortogonal changing the strain-path. Zisman A. A., Nesterova E. V., Rybin V. V., Teodosiu C. – Problems of Materials Science, 2002, N 1(29), p. 267–273.

A shear microband, formed in an iron polycrystal under orthogonal changing the strain-path, have been studied by TEM. Localized dislocation activity is reconstructed by mesoscopic modeling from experimental misorientations on the microband interfaces and shear offsets in its intersection with the performed microstructure elements.

Key words: iron polycristal, shear microband, dislocation activity, mesoscopic modeling.

UDC 669.3:621.77.016.2:620.187

Crystal analysis of submicrocrystalline structure obtained by equal-channel angular pressing of high-pure copper. K o p y l o v V. I., M a k a r o v I. V., N e s t e r o v a E. V., R y b i n V. V. – Problems of Materials Science, 2002,N 1(29), p. 273–278.

The orientations of submicrocrystalline fragments formed in copper by equal-channel angular pressing (ECAP) were examined using TEM. The misorientation vectors on the boundaries of fragments were found and analyzed.

Key words: equal-channel angular pressing, submicrocrystalline copper, TEM, vector of misorientation.

UDC 669.71’72:621.77.016.2

An investigation on an opportunity of using the equal-channel angular pressing for producing the specified structure in massive semifinished products of aluminum-magnesium alloys. R y b i n V. V., K u c h k i n V. V., B a r a h t i n B. K., K o p y l o v V. I., O s o k i n E. P. – Problems of Materials Science, 2002, N 1(29), p. 278–284.

This paper presents the results of an investigation on an opportunity of using the equal-channel angular (ECA) pressing for producing massive semifinished products with high strength characteristics and the specified structure, directly from ingots of 1561, 1575 and AMr65 aluminum-magnesium high alloys. Specimens of these alloys underwent ECA pressing at temperatures from 280 to 290°C and from 370 to 380°C, the number of cycles made from 1 to 4. ECA pressing provides for obtaining high mechanical properties of investigated alloys under all selected pressing conditions. The leading part in forming the strength and mechanical properties of cast metals undergone ECA pressing play the pressed crystallites cohesive grain boundary forces. Dislocation density in the specimens undergone ECA pressing makes $2Ч10^{-11}$ cm^2. An increase in the number of cycles leads to the emergence of substructure and to secondary intermetallics dotted precipitation. Correlation between the ECA pressing fabrication characteristics and structural components was established.

Key words: equal-channel angular pressing, aluminum-magnesium alloys, texture, ellipticity factor.

UDC 548.73

Local X-ray diffractometry with advanced possibilities. K a l a b u s h k i n A. E., T i t o v e t s Yu. F. – Problems of Materials Science, 2002, N 1(29), p. 285–290.

The new possibilities of local X-ray diffractometry are considered: increasing of localization up to 100 microns and opportunity of sequential “magnification” of scale of the image of the separate filtered micropole figures up to desired values.

Key words: local X-ray technique, misorientation, micropole figures, plastic deformation, polycrystals.

UDC 669.71:548.735.6

Evolution of microtexture within grains of polycrystalline aluminum. Z o l o t o r e v s k y N. Yu., T i t o v e t s Yu. F., E r m a k o v a N. Yu. – Problems of Materials Science, 2002, N 1(29), p. 290–295.

Using X-ray local diffraction technique the evolution of microstructure within single grains of polycrystalline aluminium under compression up to 50% was carried out. It is shown that grains with close initial orientations of the compression axis exhibit different rotations. Generally accepted theoretical models, not accounting for plastic interaction of a grain with its local neighbourhood, are not able to predict rotation path of the grain. Besides grain lattice rotation as a whole, a spreading of orientations inside grains appears and then increases in the course of deformation. Analysis of the microtexture evolution indicates that the increase of orientation spreading within single grains is associated both with grain-scaled orientation gradients and with formation of organized misoriented substructure.

Key words: local diffraction technique, grains of polycrystalline aluminum, evolution of microstructure.

UDC 548.73

Application of micropole figures technique of substructure description of deformed polycrystals. T i t o v e t s Yu. F., D y a t l o v a G. Yu. – Problems of Materials Science, 2002, N 1(29), p. 296–301.

The systematization of micropole figures experimentally measured by local X-ray diffractometry method is given.

Key words: local X-ray technique, misorientation, micropole figures, plastic deformation, polycrystals, plastic deformation, substructure.

UDC 548.73

Application of X-ray local diffractometry to determine of orientation distribution function for ensembles of substructure elements within plastically deformed grains. E r m a k o v a N. Yu., Z o l o t o r e v s k y N. Yu., T i t o v e t s Yu. F. – Problems of Materials Science, 2002, N 1(29), p. 301–308.

The method for analysis of the microtexture, that is orientation distribution within individual grains of polycrystal, is described. The microtexture is evaluated on the base of X-ray pole distributions measured for separate reflections, referred to as microscopic pole figures (MPF). The procedure for treatment of experimental MPF and the following computation of orientation distribution function is described in detail. The precision of the microtexture evaluation and possible ways of its improvement are discussed. Using aluminum polycrystal deformed by uniaxial compression as example, it is shown that the method suggested allows to obtain quantitative data on the grain microtexture evolution in the course of deformation, including variation of dominant orientation (that is

represented within the grain with maximum probability) and orientation spreading inside grains.

Key words: X-ray local diffractometry, polycrystals, deformation, microscopic pole figures, method for analysis.

UDC 539.21:539.415

Formation of mesoscopic shear bands in nanocrystalline materials. N o s k o v a N. I . – Problems of Materials Science, 2002, N 1(29), p. 309–313.

Specific features of the deformation of pure metals and multiphase alloys in a nanocrystalline state were analyzed “in situ”. It was found that the deformation mechanism was replaced in pure nanocrystalline Ni and Cu: shear deformation modes were suppressed and rotational deformation modes were activated if nanograins were not over 30 nm in size. Internal stresses arising at triple joints of grains made a nanograin rotate relative to the neighbouring grains. Deformation of nanocrystalline titanium and the iron-based alloy was due also to the activation of rotational deformation modes. However, some co-operative operation of rotational modes was observed in alloys with nanograins not over 10 nm in size. This co-operative operation caused a mutual alignment of the nanograin orientations and led finally to a mesoshear at the boundaries of several nanograins having similar orientations.

Key words: nanocrystalline metals and alloys, deformation, shear deformation modes, rotational deformation modes, co-operative of rotational modes, mesoscopic shear bands.

UDC 548.4

A new mesolevel mode of the deformation and reorientation of a crystal lattice by the mechanisms of local phase transformations in stress fields. T y m e n t s e v A. N., L i t o v c h e n k o I. Yu., P i n z h i n Yu. P., K o r o t a e v A. D., S u r i k o v a N. S., G i r s o v a S. L., L y s e n k o O. V.– Problems of Materials Science, 2002, N 1(29), p. 314–334.

This paper summarizes the results of an electron microscopic examination of the strain localization bands (SLB’s) and strain twins that are formed in austenitic steels, in a complexly alloyed Ni_3Al-base intermetallic compound, and in monocrystals of a TiNi-alloy under various conditions of plastic deformation. In the steels and in the Ni_3Al-base alloy, a new type of SLB has been discovered with preferred orientation relations and misorientation vectors q » 60°<110>. To explain the mechanisms for the formation of SLB’s and strain twins in TiNi-base alloys, a new model has been proposed that treats the deformation and reorientation of the lattice as occurring due to direct and reverse (through alternative systems) nonequilibrium phase (martensitic) transformations in stress fields. The mechanisms for the atomic rearrangements in zones where the above deformation mechanism is realized have been analyzed with the use of the theory of martensitic transformations based on the concept of cooperative thermal oscillations of extended coherent objects (planes) in crystals. The origin, carriers, and principal physical factors providing for realization of the above deformation mode are discussed.

Key words: strain localization, mechanical twinning, martensitic transformations, austenitic steels, and titanium nickelide.

UDC 539.21:539.38

Mechanism of formation of localized-plastic deformation bands and their effect on mechanical properties of loaded solids. P a n i n A. V., S o n A. A., K a z a c h e n o k M. S. – Problems of Materials Science, 2002, N 1(29), p. 335–344.

Special features of plastic deformation of polycrystalline titanium VT1-0, titanium alloy VT5-1 and low-carbon steel St 3 specimens with ultrafine-grained structure in thin subsurface layer or in the bulk were investigated. It was shown that a set of meso- and macrobands of localized plastic deformation propagated along the direction of maximum tangential stresses is observed under loading. The deformation inside the mesobands is realised by consequent shear of the single lamellas relative to each other. The localized plastic deformation macrobands propagate along the specimen by the scheme of wave of total internal reflection. The correlation between meso- and macroband propagation and mechanical properties of studied materials was found.

Key words: surface, ultrafine-grained structure, STM, loading.

UDC 539.21:539.38

Peculiarities of strain-induced mesoscopic structure formation in coated materials under different loading schemes. P a n i n S. V. – Problems of Materials Science, 2002, N 1(29), p. 345–359.

Mechanisms of plastic deformation and fracture development in coated materials under static tension, cyclic bending and wear in friction pairs are discussed. Depending on relationship between physical-mechanical properties of coating and substrate, and also their thickness, mechanisms of mesoscopic plastic deformation development can considerably vary, that is accompanied by abrupt change of surface hardened materials macro-performance. The experimental research of nucleation and relaxations processes of stress mesoconcentrators and mesostructure formed carried out with use of television-optical measuring technique TOMSC has allowed to offer a number of recommendations on formation of composition possessing optimal operation properties.

Key words: physical mesomechanics, interface, stress concentrator.

UDC 669.14.018.8:539.312

Detection of translational energy conversion into internal one at the elastically compressed surface of steel in the corrosive medium. B a r a k h t i n B. K., M u s h n i c o v a S. Yu., R y b i n V. V., K h a r c o v A. A. – Problems of Materials Science, 2002, N 1(29), p. 360–363.

The experiments have been carried out using electron raster microscopy for the purpose of determening processes inducing corrosion of loaded metallic structures. The surfaces of specimens after exposure for E(-2)–6E(2) hours at 20°C in sea water, containing chlorine, and with pH3 (under the influence of both compressive and tensile stresses) were investigated. The kinematic processes in ensembles of meso-defects are determining ones for corrosion initiation. At the surfaces tested in the corrosive medium under compressive condition a periodical micro-relief was observed. It was induced by the conversion of lattice defects energy into the internal one.

Key words: metallic structures, both compressive, tensile stresses, corrosion, lattice defects, conversion of energy.

UDC 539.388.1

The influence of surface coating on the statistic character of irreversible middeformations and metals' damage by cyclic loading. B a g m u t o v V. P., S t o l y a r c h u k A. S., A r i s o v a V. N. – Problems of Materials Science, 2002, N 1(29), p. 364–372.

The process of diphase polycrystal's cyclic creep was investigated on local areas by room's temperature and coefficient of cycle's skewness $R = 0$ with application of regression and correlation examinations. The scale of measurement of creep's deformations varied from the midlevel (intragranular, intergranular) to macrolevel. The determinate-stochastic character of deformations' spreading on surface and their role in damage of the volume are discussed. The comparison of process' speeds was made on various scale's levels by some technologies of metals' surface reinforcement.This comparison confirmed control action of surface coating on cyclic creep of the whole material's volume.

Key words: middeformation, damage, cyclic creep, surface coating, technology of surface reinforcement.

UDC 539.211:620.18

Mesomechanical study of metal-polymer coatings. S h i l k o S. V., O s t r i k o v O. M., S e m e n o v a T. V., P l e s k a c h e v s k y Yu. M. – Problems of Materials Science, 2002, N 1(29), p. 372–377.

Numerical analysis of contact loading process of granulated metal-polymer coating by rigid cylindrical indenter is presented. Finite element models of composite fragment with some periodic cells have been developed. Then calculations of the it's stress-strained state had been performed. Numerical simulation results were experimentally tested with a photoelasticity method. It was established that near the plastic contact region the wavy moving of surface takes place, which characterizes the heterogeneous structure of material on the mesoscale level.

Key words: metal-polymer composites, indentation, mesoelement, stress-strain state.

UDC 669.15–194.55:539.211

Influence topographic structure of surface on mechanical properties of maraging steel 00H16К4M4T2Ю. G e r o v V. V., K o l m a k o v A. G., T e r e n t j e v V. F. – Problems of Materials Science, 2002, N 1(29), p. 378–383.

The evolution of topographic structure of surface of high-strength maraging steel 00H16K4M4T2Ю is described on the basis of multifractal formalism by an original technique of structure parameterization. It was found, that with the improvement of surface roughness the tensile strength increases by 80% and the fatigue life increases in 2,5 times. A very good correlation ($K > 0{,}98$) between multifractal characteristics (uniformity and degree of order indices) and mechanical properties of steel.

Key words: topographic structure of surface, multifractal parameterization of structures, index of uniformity, index of degree of order.

UDC 539.23:539.4.015.2

Receiving of mesostructures with prescribed catalytic properties for high-capacity sources of a current and systems of chemical heat regeneration. V i n o g r a d o v a T. S., R y b i n V. V., U l i n I. V., F a r m a k o vs k y B. V. – Problems of Materials Science, 2002, N 1(29), p. 384–391.

The results of the research in the area of creation of complex metal and oxide systems with controlled porous structure and high catalytic activity are presented. Such systems, received with the use of base technology of plasmochemical synthesis, are perspective for creation chemical sources of current and systems of steam conversion of fuel.

The technology of mesostructure manufacturing is developed. This technology includes high-energy impact-activation treatment, high-speed plasma spraying in controllable gas environments and final thermal-chemical treatment.

Influence of the factors, which effect mostly mesostructure formation, is investigated. These factors are temperature, speed and distance of spraying, structure of gas environment, nature of a material, size and aggregative state of a particle.

It is shown that the directed formation of mesostructure can be reached in two ways: by deleting the components of catalytic material in the process of thermal-chemical treatment and appearance in matrix the materials of intermediate phases which change their volume during formation or decomposition, for examples intermetallids.

Key words: catalysts, mesostructure, plasma-spraying method.

UDC 669.14.018.8:669.017.3:539.388.1

Structural-phase transformations in stainless steel at electrostimulation low-cycles fatigue on mesolevel. S o s n i n O. V., I v a n o v Yu. F., G r o m o v V. E., T s e l l e r m a e r V. V., K o z l o v E. V., K o v a l e n k o V. V., K o n o v a l o v S. V. – Problems of Materials Science, 2002, N 1(29), p. 392–398.

The purpose of work was the research of a physical nature of structural-phase transformations in stainless steel and partial restoration of its resource in conditions of stimulation of current pulses at low-cycles fatigue.

Measurement of grains and subgrain structures of steel, the behavior of the second phases, the analysis of structure, of surface of destruction are carried out by methods of optic metallography, scanning electronic and electronic diffraction microscopy.

In work it is shown, that during fatigue there is finish of formation and evolution of mesoscopic substructures. Electrostimulation has significant influence on structure and a substructure both initial, and subjected fatigue loading of steel, namely results in reorganization of grain structures; to change of kinetics of self-organizing dislocation substructures; to initiation of disintegration of a firm solution with allocation of carbide particles the titan; to suppression of martensitic g®e deformation transformation etc. They of electrostimulation brakes evolution of dislocation substructures.

Key words: electrostimulation, low-cycles fatigue, dislocation substructure, stainless steel.

UDC 539.388.1

Electroplastic deformation: fatigue. P e t r u n i n V. A., T s e l l e r m a e r V. Ya., G r o m o v V. E., K o n o v a l o v S. V., S o s n i n O. V. – Problems of Materials Science, 2002, N 1(29), p. 398–402.

The multicyclic fatigue and influence on it of electroplastic deformation is considered. The carried out theoretical analysis (in terms of deformation and displacement of a material) may be carried out up to the finished only in one modes approximation. Use of expression for effective stress of an electronic wind allows to receive the consent with experimental dates.

Key words: electroplastic deformation, multicyclic fatigue, electronic wind.

UDC 534.222.2; 669.295'784:536.46

Carbon black mesostucture and Ti–C-mixture reactivity. V e r e t e n n i k o v V. A., Z a k i e v S. E., P o p o v V. T., P o p o v K. V. – Problems of Materials Science, 2002, N 1(29), p. 403–406.

The rates of reactive heating Ti–C-mixtures were estimated by electric-thermal explosion techniques (ETV). The differences in heating rates for mixtures of the certain-make titanium and carbon blacks with various structures were found to be in several orders. The correlation between a measured heating rate and a particular complex of micro- and mesostructural parameters of carbon black offered a possibility to compare carbon black reactivity quantitatively.

Key words: mesostructure, reactivity, electric-thermal explosion, correlation between structure and reactivity.

UDC 548.736.372.2:539.41

Examination of structural strength and fractal properties of SHS corundum at a mesoscopic level. P e s o t s k a y a N. S., Z a k i e v S. E., V e r e t e n n i k o v V. A., B e l o u s o v a O. V., M o r o z o v Yu. G. – Problems of Materials Science, 2002, N 1(29), p. 406–409.

Structural strength characteristics of aluminium oxide powders obtained by a method of self-propagating high-temperature synthesis (SHS) with a particle size ranging from 100 to 800 mm have been investigated on the basis of a stochastic material fracture model (Weibull model). The measurements made as well as subsequent statistic and fractal analyses allowed the following model parameters to be evaluated: *K* (the strength of particles of a specified size fraction), and m (the Weibull modulus) — the structure sensitive property of a material reflecting the hierarchy of structural fracture levels, topological features and the change of a fracture mechanism at a specified mesoscopic scale. Statistic self-similarity limits and fractal dimensions of forming fracture surfaces related to these limits have been evaluated. A strength dispersion oscillation effect depending on the size of particles and a hierarchy of "preferred sizes" related to the effect have been revealed as well. The results obtained point to the automodel and multistage nature of the brittle fracture process at the mesoscopic level as well as the scale invariance and fractality of the material structural strength properties.

Key words: SHS, Weibull statistics, "preferred sizes", fractal dimension, doped corundum.

UDC 678.067–419:669.046.44

Functionally gradient piezocomposite based PZT ceramic, synthesized by selective laser sintering method. Tarasova E. Yu., Shishkovski I. V., Petrov A. L. – Problems of Materials Science, 2002, N 1(29), p. 409–415.

In this paper, fundamental availability of selective laser sintering (SLS) method for preparation of porous piezoelectric composite based piezoceramic (PZT ceramic) and piezopolymer (polyvinilidene fluoride), are discussed. Depending on spatial arrangement and connectivity of ferroelectric phases and by a variation of SLS process parameters, it is possible to generate a gradient of properties of the future device. Theoretical approach and computer modeling of mesoscale of structure at a stage of designing allows to create electronic devices (sensors, transducers, actuators, MEMS devices) with the unique physical characteristics.

Key words: functionally gradient piezocomposite, PZT ceramic, selective laser sintering method.

UDC 539.128.417:621.762.34

Thermal neutrons absorbing structures produced by mechanical alloying. Freidin B. M., Kuzmich Yu. V., Serba V. I., Kolesnikova I. G., Arutyunyan L. A. – Problems of Materials Science, 2002, N 1(29), p. 415–417.

The study shows new powder aluminum-based materials production in high-energy mills by mechanical alloying. The alloying components of the composite powders produced are boron, lanthanide`s and lanthanide oxides. The alloying component concentration was as high as 20 w.%. The composite powder materials produced can be used in fabrication and operation of transport containers used for spent nuclear fuel storage.

Being tested, the compacted samples made of the powder materials produced have shown reliable performance and operating characteristics.

Key words: boron, lanthanides, lanthanide oxides, composite powder material, mechanical alloying, thermal neutrons absorption.

UDC 669.017.165:66.091

Application of the mechanical activation and self propagation high temperature synthesis for preparation of monophase ultrafine intermetallic compounds. Korchagin M. A., Grigorieva T. F., Bokhonov B. B., Barinova A. P., Lyakhov N. Z. – Problems of Materials Science, 2002, N 1(29), p. 418–423.

In this work we demonstrate that when we used during mechanical activation (MA) for the preparation of the monophase ultrafine intermetallic compounds as the initial component the mixture of the powders after of self propagation high temperature synthesis (SHS) the time of the formation of final products decreasing more than ten times. Investigation of influence of the preliminary mechanical activation of the powder mixture on the basic parameters SHS allow us find conditions when SHS products has ultrafine grain size. The results of this investigation can be used for the development of industrial and technological application in combination MA- and SHS-process for preparation of ultrafine intermetallic compounds.

Key words: mechanical alloying, self propagation high temperature synthesis.

UDC 678.5:66.085.3:539.375.5

Physical mesomechanics of polymer failure at UV exposu. K o r e t s k a y a L. S., P l e s k a c h e v s k y Yu. M. – Problems of Materials Science, 2002, N 1(29), p. 423–428.

Photoplastic mechanism of polymer failure at a mesostructural level under UV radiation has been studied in the present work. The failure was found to occur due to nonconformity between thermal deformation values at a solid interaction with UV or IR radiation. Investigations in dynamics of photoplastic deformation have visualized a clear cut dichroism of mesobands. This fact proves anisotropy of properties of structural elements and interfaces included into the mesobands. Being a flux of flaws the mesobands promote crack propagation and breakdown of the whole polymer. Proceeding from scientifically grounded data on transformation of polymer mesostructures at UV exposure, means of strengthening surface of polymer composites are discussed based on imparting higher resistance to shear strains.

Key words: photoplastic deformation, UV radiation, compression, shear, mesobands, polymer failure.

UDC 539.211

A fracture ranging based on a structurally-linguistic analysis of mesorelief. K u d r y a A. V., B o c h a r o v a M. A., S u k h o v a V. G. – Problems of Materials Science, 2002, N 1(29), p. 428–435.

In this paper, the structural-inguistic method of the analysis of mesorelief fractures is offered. For this purpose, the informative parameters of the fracture mesogeometry with different morphology are chosen. The universality of fracture profiles has stipulated an opportunity of formalization of their description, where one of three letters **A**, **B** or **E** (capital or small case) are appointed to each element of profile depending on its size and arrangement concerning to the line of symmetry. In result, each profile was represented as the proposition. The opportunity of steel ranging on the fracture and comparison of fracture mechanisms of steels are originated from the analysis of their statistics.

Key words: structure-linguistic analysis of mesorelief, fracture surface ranking.

UDC 550.344

Rotation and elasticity. V i k u l i n A. V., I v a n c h i n A. G. – Problems of Materials Science, 2002, N 1(29), p. 435–441.

It developed the model which the properties of elastic seismotectonic field in Earth's crust connected with planet rotation. It shown, that such model been able useful in the event of the explanation of solid body durability connecting with collective interaction of dislocations.

Key words: seismotectonic process, block of Earth's crust, dislocation, elastic fields.