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CONTENTS

ABSTRACTS OF PUBLISHED ARTICLES

UDC 669.15–194.2:539.2

Economically alloyed steels with nano-modified structure intended for operation in extreme conditions. Gorynin I. V., Rybin, V. V., Malyshevsky V. A., Hlusova E. I., Nesterova E. V., Orlov V. V., Kalinin G. Ju.– Problems of Materials Science, 2008, N 2(54), pp. 7–19.

In the work are shown the ways of receiving nano-structured states in steels of ferrite, beinite, martensite and austenite classes. Researches of structure by method of optical metallography and raster electronic microscopy are carried out. Correlation interactions of thermo-deformative parameters, mechanical properties with structure of steel in nano-scale level are established, and it is shown, that formation of nano-modified structure allows increase characteristics of steel.

Key words: steels of ferrite, beinite, martensite and austenite classes, nano-modified structure, optical metallography and raster electronic microscopy.

UDC 539.21: 539.374: 621.77

Deformation methods, multiscale structure and properties of nanostructured materials. Mulyukov R. R., Nazarov A. A., Imayev R. I. – Problems of Materials Science, 2008, N 2(54), pp. 20–32.

Fundamentals and technological efficiency of the basic deformation methods of nanostructuring of metals and alloys, viz, high pressure torsion, equal channel angular pressing and multiple isothermal forging, are analyzed. It is demonstrated that from the viewpoints of both the fundamental processes of structure formation and economical efficiency multiple isothermal forging is the most perspective method of fabrication of bulk nanostructured materials. Analytic review of the results of structural characterization of nanomaterials is done and basic principles of their structural model are formulated. Physical properties of bulk nanomaterials are described with a special emphasis on mechanical properties and their exploitation in the technology of manufacturing of products out of nanomaterials.

Key words: nanostructured materials, severe plastic deformation, high pressure torsion, equal channel angular pressing, multiple isothermal forging, structure, mechanical proerties, physical properties, superplasticity

UDC 2УДК 669.14.018.252.3:621.762

Powder high-speed steel with disperse structure. Girshov V. L. – Problems of Materials Science, 2008, N 2(54), pp. 33–42.

Results of the researches directed for increase of mechanical and functional properties of powder high-speed steel (PHSS) are submitted. The structure of the sprayed powders of 10P6M5 grade received at speeds of cooling 10^3–10^6 K/s is investigated. Defects of structure extruded powder feed stocks are revealed and degree of their influence on strength of powder steel at condition of high hardness is investigated. It is shown, that the most essential negative influence for strength of steel is rendered by the rests of oxide film, located in interpartial borders.

Key words: powder high-speed steel, defects of structure, oxide film.

UDC 669.295:539.214:539.374

Features of submicrocrystalline structure and its influence on mechanical properties of titanium alloys. Kolobov J. R., Golosov E. V., Ratochka I. V. – Problems of Materials Science, 2008, N 2(54), pp. 43–50.

The submicrocrystalline structure generated at deep plastic deformation, and its influence on deformation behaviour, strength and plasticity of titanium alloys of system Ti–Al–V are investigated. It is shown, that strength and plasticity of titanium alloy Ti–6Al–4V (BT6) can appreciably change even at presence concerning small irregularities in distribution on the sizes of elements grain-subgrain structures formed at deep plastic deformation.

Key words: titanium alloys, submicrocrystalline structure, grain-subgrain structure, superplasticity.

UDC 669.35: 539.214:539.37

Work hardening of a polycrystal with nanosize grain. Kozlov E. V., Trishkina L. I., Zhdanov A. N., Popova N. A., Koneva N. A. – Problems of Materials Science, 2008, N 2(54), pp. 51–59.

In this paper an analysis of modern state of a problem on stages of deformation for polycrystals with nanograins is carried out. Experimental data from literature and original data of the authors are in a base of the analysis. Main regularities of evolution of work hardening at deformation by press and tension are introduced for interval of average grain sizes of 20–200 nm. Difficulties of study of work hardening for nanograin polycrystals and methods of their overcoming are discussed.

Key words: work hardening, deformation stages, flow stress, nanograins size, localization of deformation

UDC 539.2:539.374.6

Structural aspects of twist extrusion. Pashinskaya E. G., Varyukhin V. N., Tkachenko V. M., Tischenko I. I. – Problems of Materials Science, 2008, N 2(54), pp. 60–70.

The process of metal structure evolution under strain ratio accumulation by the twist extrusion method has been considered. Pure commercial copper M1 deformed by twist extrusion with different number of paths was taken as an investigation object. Changes in structure were controlled by methods of optical and electron microscopy, X-ray structure and X-ray diffractometry analysis. The density and microhardness of the samples were determined past each deformation stage, then followed mechanical rupture tests. It is shown that during the strain ratio accumulation the structure changes in stages at the expense of the competing development of grain refinement and dynamic recrystallization. This results in submicrocrystalline structure of the mixed type with regions of small recrystallized and deformed grains. The material possesses high plastic characteristics and strength properties preserved at high enough level.

Key words: submicrocrystalline structure, twist extrusion, grain refinement, recrystallization, grain, mechanical properties.

UDC 669.715'6:539.21:621.891:539.374

Structure and tribological behavour of functional alloys Al–Sn, Al–Sn–Pb and Sn–Sb–Cu, subjected to intensive plastic deformation. Noskova N. I., Korshunov L. G., Vildanova N. F, Korznikov A. V., Churbaiev P. V. – Problems of Materials Science, 2008, N 2(54), pp. 71–80.

Changes of structure and mechanical properties of alloys Al + 30Sn, Al + 25Sn + 15Pb, Al + 5Sn + 35Pb and Sn + 12Sb + 5Cu weights of %, and also parameters of friction after equal ported angular pressing and at different stages of intensive deformation by shift at pressure are investigated.

It is shown, that transition in nanocrystalline condition occurs at a different degrees of plastic deformation, and hardness changes non steadily – at the beginning raises, and then falls. After intensive deformation ε = 6,4 and the subsequent ageing the scattering effect of alloys Al + 25Sn + 15Pb and Al + 5Sn + 35Pb to nanosize powder is found out.

It is established, that factor of dry friction after fast tempering from melt of alloys Al + 30Sn, Al + 25Sn + 15Pb, Al + 5Sn + 35Pb is equal to 0,33, in submicrocrystalline condition (after equal ported pressing) – 0.24, 0.32, 0.35 accordingly. Resistance to wear process in conditions of friction with smearing (in regime of boundary friction) at intensive frictional heating (speed of sliding is 4.5 km/s) of babbite, deformed by method РКУП, is appreciable (approximately in 2 times) above, than cast. Besides the factor of boundary friction of babbite deformed by РКУП is lower than cast in 1.6 times.

Key words: functional alloys, structure, tribological properties, equal ported angular pressing.

UDC 669.715:621.78

About formation of nanosize phases at heat treatment of cast alloys of Al–Mg–Li system. Abramov A. A. – Problems of Materials Science, 2008, N 2(54), pp. 81–84.

Data of research of the cast alloy of metallic system Al–Mg–Li are resulted. By the method of differential thermal analysis are determined characteristic temperatures of an alloy. The structure of an alloy after tempering and various regimes of ageing is investigated. Influence of nanosize elements of structure for mechanical properties of an alloy is shown.

Key words: cast alloy of system Al–Mg–Li, characteristic temperatures, heat treatment, nanosize phases.

UDC 669.018.4

Especially light heat resistant nano structured alloys on basis of Ni_3Al for aviation propulsion engineering and power machine building. Povarova K. B., Buntushkin V. P., Kazanskaia N. K., Drozdov A. A., Bazyleva O. A. – Problems of Materials Science, 2008, N 2(54), pp. 85–93.

Mechanisms of hardening which can be realized in alloys on basis of Ni_3Al in interval of working temperatures up to 1200–1250˚C are considered. Their application has allowed to create casting heat resistant materials of new generation on a basis of Ni_3Al metallids, alloyed by refractory (W, Re, Mo, Cr), reactionary- and superficially active metals (rare-earth metals, titanium). These are represented natural eutectic composites (γ'–Ni_3Al + γ–Ni), received by the directed crystallization which structure as against nickel superalloys does not degrade down to temperatures of prefusion. It is shown, that this thermostable structure-phase condition can be in addition stabilized by nano dimensions formations strengthening material and representing particles of ОЦК-phase (α-Mn) with variable contents of Cr, Mo, W, Ni (80–200 nanometers), particles Al_2La and Ni_3La (20–200 nm) on interphase borders, allocations of carbide lanthanum La_2C_3 (10–20 nm) and secondary allocations of α-phase (10–30 nm). Introduction of optimum quantities of rare-earth metals provides durability increase of alloys such as ВКНА at 1100°C in 3 times.

UDC 669.27:669.762.5

Heavy tungsten alloys on basis of nano powders. Povarova K. B., Alymov M.I., Drozdov A. A. – Problems of Materials Science, 2008, N 2(54), pp. 94–99.

From nano powders of heavy tungsten alloy of W–Ni–Fe–Co system (the size of particles about 100 nanometers), synthesized by process of hard-phase sintering, it is received a compact material with density of ~17.4 g/sm^3 and size of tungsten grain 2.4–4.6 μm. The tungsten alloy from nano powder has higher mechanical properties, than standard alloys: hardness by Vikkers of alloy from nano powders in 2.5 times higher than a factory alloy after liquid-phase sintering and in 1.4 times higher, than a factory alloy after additional strengthening processing. Yield strength and compressive strength at room temperature of fine-grained tungsten alloys received from nano powders by solid-phase sintering at 1350°C, accordingly on ~55 and ~35% is higher, than factory alloys.

Key words: heavy alloys, nano powders, synthesis, structure, size of a grain, border of grains, strength, hardness.

UDC 621.762

Application of Al_2O_3 nanopowder as grain growth inhibitor in WC–8%Co alloy. Nikolenko S. V., Verhoturov A. D., Dvornik M. I., Vlasova N. M., Pugachevsky M. A., Mihailov M. M., Krestjanikova N. S. – Problems of Materials Science, 2008, N 2(54), pp. 100–105.

Work is devoted to use of Al_2O_3 nanopowder as grain growth inhibitor in WC–Co hard alloys. In the work has been proved that Al_2O_3 do not interact and do not form solid solution with cobalt and tungsten carbide. After sintering Al_2O_3 exists in WC–Co hard alloy as separate phase and prevents WC grains growth during sintering. Introduction of Al_2O_3 in WC–Co of 5%(wt.) Al_2O_3 results in decreasing of grain average size from 2.4 micron to 0.84 micron and increasing of microhardness from 12.5 GPa to 17.8 GPa. Addition of Al_2O_3, prove, facilitates decreasing of pore size with simultaneous increasing of its number.

Key words: WC–Co hard alloys, Al_2O_3 nanopowder, grain growth inhibitor.

UDC 621.318.13:621.78

Magnetic properties and microstructure after special thermomagnetic processings of nanocrystalline magnetically soft alloys on basis of Fe and Co. Noskova N. I., Shulika V. V., Potapov A. P. – Problems of Materials Science, 2008, N 2(54), pp. 106–112.

Magnetic properties of amorphous and nanocrystalline alloys with magnetistriction of saturation, close to zero, with destabilized magnetic domain structure are investigated. Change of magnetic characteristics after two processings resulting to destabilization of domain structure is investigated: thermomagnetic processings in a high-frequency magnetic field of 80 кHertz and tempering in water. It is

shown, that destabilization both the first, and in the second way considerably improves magnetic properties of amorphous alloys. However, after tempering of amorphous alloy temperature-time instability of magnetic properties is observed. Tempering in water of researched nanocrystalline alloys results to deterioration of magnetic properties.

Key words: nanocrystalline magnetically soft alloys, magnetic properties, microstructure, thermomagnetic processing.

UDC 621.318.13:539.213:621.785.3

Effect of annealing conditions on crystallization kinetics and magnetic properties of nanocrystalline soft magnetic alloy of system Fe–Cu–Nb–Si–B. Kuznetsov P. A., Belyaeva A. I., Mikhailov M. S., Sergeeva O. S. – Problems of Materials Science, 2008, N 2(54), pp. 113–121.

Parameters of structure and magnetic properties of soft magnetic nanocrystalline alloy AMAG-200 (Fe–Cu–Nb–Si–B) during crystallization from amorphous state under different annealing conditions were investigated. Structure of the alloy was analyzed with transmission electron microscopy and scanning electron microscopy methods, diffraction method. Magnetic properties were studied with standard magnetometric method. As a result of the research, behavior of structural parameters and magnetic properties of the alloy against to annealing condition was defined and their relationship was established. Heat treatment condition of the alloy optimal for magnetic screening was defined.

Key words: soft magnetic materials, nanocrystalline alloy Fe–Cu–Nb–Si–B AMAG-200, annealing, structure, grain size, volume fraction of crystalline phase, coercitivity, permeability.

UDC 621.318.12: 539.213

Magnetically hard nanocrystalline Nd–Fe–B alloys with low Nd content. Koryagin S. V., Byakova A. V., Milman Yu. V. – Problems of Materials Science, 2008, N 2(54), pp. 122–131.

Producing the magnetically hard nanocomposite $Fe_3B/Nd_2Fe_{14}B$ under crystallization of amorphous ribbons based on melt-spun $Nd_{3.7}Fe_{80.3}B_{16.0}$-alloy with lower Nd and B content compared to known analogue was justified. Structural evolution induced by annealing the amorphous ribbons and magnetic properties such as residual flux density, B_r, coercivity, ${}_iH_c$, and density energy product, $(BH)_{max}$, were studied and determined by differential scanning calorimetric (DSC) analysis, X-ray diffraction (XRD) analysis, transmission electron microscopy (TEM), and measuring the magnetic properties. Crystallization process progressed in four stages as follows: (i) precipitation of magnetically soft Fe_3B phase; (ii) crystallization of the remaining amorphous phase into hard magnetic $Nd_2Fe_{14}B$ phase, soft magnetic Fe_3B phase, and intermediate soft magnetic $Nd_2Fe_{23}B_3$ phase, (iii) partial decomposition of $Nd_2Fe_{23}B_3$ phase to $Nd_2Fe_{14}B$ phase and Fe_3B phase, (iv) partial decomposition of the Fe_3B phase to α-Fe phase. Content of B reduced down to 16 at.% caused the impairing the glass formability, resulting in earlier ($T \approx 673$ K) precipitation of Fe_3B phase and promoting the further phase transformations to lower region of temperatures ($T < 903$ K). Mixture of three phases ($Nd_2Fe_{14}B$, Fe_3B, and $Nd_2Fe_{23}B_3$) and average grain size about 27 nm being close to that of the single domain-like grain was formed after crystallization of melt-spun $Nd_{3.7}Fe_{80.3}B_{16.0}$-alloy under optimal temperature ($T \approx 903$ K). High level of magnetic properties (B_r =1.2 T, ${}_iH_c$ = 258 kA/m, $(BH)_{max}$ = 109.5 kJ/m^3) together with quite good squareness ($S_q \approx 43\%$) of demagnetization curve was achieved due to strong exchange-coupling interaction between hard and soft magnetic phases. Because of negligible amount of α-Fe grains developed nanocomposite demonstrated improved magnetic properties, which were higher than those of known analogue characterised by very close grain size (30 nm) and larger content of Nd and B, and they were rather similar to those demonstrated by the alloyed nanocomposites with smaller grain size (12–17 nm).

Key words: NdFeB nanocomposite magnet, melt spinning, structure, magnetic properties

UDC 678.067:539.538:621.822.5:539.25

Elements of nano-technologies at creation of plane bearings from antifrictional carbon fiber-reinforced plastics. Anisimov A. V., Bahareva V. E., Nikolaev G. I., Rybin V. V. – Problems of Materials Science, 2008, N 2(54), pp. 132–147.

In CRISM "Prometey" within 30 years were carried out work on creation, research and modification of antifrictional carbon fiber-reinforced plastics for plane bearings. It is organized industrial production of blanks and parts of plane bearings from these materials.

Researches of friction process with using of power-force and raster electronic microscopy were carried out. It is established, that process of friction of carbon fiber-reinforced plastics in the established regime occurs at nano-scale level.

It is confirmed, that carbon fiber-reinforced plastic is nano-structured composite. Influence of structure of carbon fibres and polymeric matrix for wear process and surface state of friction of antifrictional carbon fiber-reinforced plastics are investigated.

It was proved by ACM method that at modification of carbon fiber-reinforced plastics on mezzo-(with powders of metals and alloys) and macrolevel (with graphite-filled ftuoroplastic)) on a surface of friction of carbon fiber-reinforced plastics are formed antifrictional nano films. The wide spectrum of nano-modifying agents is investigated.

Modified carbon fiber-reinforced plastics have found application in ship mechanisms, hydroturbines, pumps, crushers, fittings for pipelines, etc. For example, carbon fiber-reinforced plastic of ФУТ-Ф grade modified by nano ftuoroplastic of Ф4 grade, is applied in face seal of hydroturbines shaft of hydrostations "Teri" (India) and Ale-Kahon (Mexico), in face seal of pumps of nuclear ice breakers. Macromodified carbon fiber-reinforced plastic of ФУТ grade is applied in stern bearings ship shaftings of the big and small displacement. Carbon fiber-reinforced plastics ФУТ и УГЭТ mezo-modified by metals are applied in steering devices and steering machines of ships, fittings of pipelines, crushers.

Key words: nano-, mezo- and macromodification, antifrictional materials, carbon fiber-reinforced plastic, nanostructure, power-force microscopy, raster electronic microscopy.

UDC 678.067:544.723.5

The principles of intravolume nanotechnology of chemisorptions damp proofing and degradation of mechanical strength for filled structural polymeric materials (syntactic foams, glass-reinforced plastics). Sedletsky R. V., Nikolaev G. I. – Problems of Materials Science, 2008, N 2(54), pp. 148–162.

In order to increase the operating life of filled structural polymeric materials (FSPMs) high-efficiency damp proofing principles have been developed theoretically from a «reversible water mass transfer – wavy strength change» model and verified experimentally. A physicochemical blocking mechanism is realized during the molecular-chemisorption proofing of three-dimensional atomic-molecular network of polymeric matrix (directed synthesis of nanostructures) with bifunctional compounds and related to changes in energy equilibrium conditions at the three-phase boundary «water-steam-molecular polymeric network» for a system of liquid microminisci in the mesomicro capillary polymeric structure.

Experimental data base on molecular-chemisorption proofing pools positive results of investigations into a great number of compositions and FSPMs differing in chemical nature.

The chemisorption effect of blocking is provided at a level of micro concentrations of proofing chemical substance.

So, long-continued hydrostatic tests have shown that molecular-chemisorption-proofed syntactic foams of different types retain the level of damping is close to zero.

A wide spectrum of chemical bifunctional high-polarity compounds with using various processing versions of the directed synthesis of efficient chemical proofing structures within the mesomicrocapillary polymeric matrix system of FSPMs has been tested.

Key words: syntactic foams, glass-reinforced plastic, anisotropy, composites, synthesis of nanostructures, chemisorption, menisci of liquid.

UDC 621.793.184:621.438

Three-dimensional carbon nanomaterials. Gordeyev S. K. – Problems of Materials Science, 2008, N 2(54), pp. 163–174.

Methods of reception and properties of nano fragmentary materials – carbon composites from nano diamonds and nano-porous carbon materials received from carbides are considered. Dependences of

materials properties on conditions of their reception are resulted. Perspective scopes of three-dimensional carbon materials are considered.

Key words: nano diamonds, nano-porous carbon materials, properties, fields of application.

UDC 621.793.184:621.438

Nanostructural ion-plasma protective and strengthening coatings for the blades of gas-turbine engines. Kablov E. N, Mubojadzhjan S. A., Lutsenko A. N. – Problems of Materials Science, 2008, N 2(54), pp. 175–186.

Developments of VIAM in the field of ion-plasma technologies have allowed to create not having analogues in the world ion-plasma equipment with assisted deposition (installation MAP-3) for receiving of nanostructural and nano composite protective and strengthening coatings with thickness up to 120 microns and to develop technological processes of their receiving.

Feature of the offered technology are controlled energy of the particles interacting with a surface of machinable product in processes of assisted ion and modified sedimentation of nanostructural coatings. It will provide increase of strength and operational characteristics of machinable product due to improvement of composition and control of structural-phase transformations during formation of nanostructural coating.

Key words: blades of gas-turbine engines, protective and strengthening coatings, ion-plasma assisted sedimentation, nanostructural coatings.

UDC 621.793

Perspective nanostructured coatings for mechanical engineering. Kiryukhantsev-Korneev Ph. V., Sheveyko A. N., Levashov E. A., Shtansky D. V. – Problems of Materials Science, 2008, N 2(54), pp. 187–201.

Review of the modern state in the field of multifunctional nanostructured coatings for mechanical engineering is presented. Different types of nanostructured coatings (hard wear-resistant, low-friction, heat resistant, corrosion resistant) and the methods of their deposition are described.

Key words: nanostructured coatings, structure and properties, deposition methods.

UDC 669.27:621.762

Gas phase synthesis of dispersed particles on the base of W and their application. Kaidash E. A., Nesmelov D. D., Vasiljeva E. S. – Problems of Materials Science, 200, N 2(54), pp. 202–209.

Nano-sized W powders with the mean size of 6–25 nm were synthesized by chemical vapor condensation (CVC) process using tungsten carbonyl as precursor. Brief description of nanoparticles synthesis process was presented. In order to produce pure tungsten nanopowder the influence on experimental parameters on phase composition as well as mean size of product were studied. Preliminary characterization of as-produced nanoparticles was done by means of XRD, scanning and transmission electron microscopy. Sintering of W micron size powder was studied. Activation of sintering process was tried by vibration milling for 40h by W balls in W walled reactor and by additions of 20%W nanopowder of 15–20 nm in mean diameter, as well as combination of those techniques. W micron size powders after mechanoactivation blended with W nanopowders represented the good pressureless sintering behavior at low compaction pressure (300 MPa) and low sintering temperature. Mixed powders with 30% of nanoparticles showed much higher densification at the lower temperatures.

Key words: nanoparticles, tungsten, gas phase synthesis, phase composition, sintering.

UDC 621.763:621.762.4

Forming of Ti_3SiC_2 composite at mechanosynthesis. Kachenjuk M. N. – Problems of Materials Science, 2008, N 2(54), pp. 210–218.

Forming of composite on a Ti_3SiC_2 basis by mechanosynthesis and the subsequent hot pressing techniques is investigated. The kinetics of formation of titanium ternary carbide at mechanosynthesis in a planetary grinding mill 'SAND' is determined. The optimal parameters of synthesis providing forming of a composition powder, containing 30% Ti_3SiC_2 are determined. Average particle size of a powder is 3.5 μm. The subsequent hot pressing allows to form a material with porosity ~2%, containing 90% Ti_3SiC_2 and having a microcrystalline structure. Influence of mechanosynthesis on material compactibility at hot pressing is investigated.

Key words: titanium carbo-silicid, mechanosynthesis, hot pressing.

UDC 549.753.11:66.091:539.21

Mechanochemical synthesis of nanosized functional materials with the apatite-type structure. Chaikina M. V., Uvarov N .F., Ulihin A. S., Khlusov I. A. – Problems of Materials Science, 2008, N 2(54), pp. 219–232.

Apatite-type isomorphs of hydroxyl-apatite and lanthanum silicate were synthesized by direct mechanochemical reaction in planetary grinding mills for 10–35 min. The results of in vitro bioactivity tests are presented for hydroxyl-apatites substituted in cationic and anionic sublattices. Oxygen ionic conductivity is studied of lanthanum silicates containing different substituting cations as a function of the content of oxygen ions placed on the 6_3 axis of the apatite structure.

Key words*: mechanochemical synthesis, hydroxyl-apatite, bioactivities, lanthanum silicate apatite, oxygen ionic conductors.*