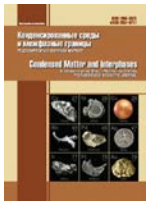

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Аннотации на английском языке

Review

Review article
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Zinc-nickel alloy coatings: electrodeposition kinetics, corrosion, and selective dissolution. A review

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Abstract

A review of the literature is devoted to the patterns of the electrodeposition of zinc-nickel alloys including the kinetics of cathodic reduction of zinc, nickel, and zinc-nickel alloys in ammonium chloride, sulphate, and glycinate deposition electrolytes. We studied the data on the effectiveness of the corrosion resistance of zinc-nickel coatings and summarised the principal patterns of selective dissolution of the Zn-Ni alloys. The role of the addition of glycine to an ammonium chloride deposition electrolyte was determined in the modification of the morphological and anticorrosive properties of the coatings.

Keywords: electrodeposition, kinetics, zinc-nickel coatings, ammonium chloride electrolyte, glycine, current efficiency, corrosion, selective dissolution, voltammetry, chronoamperometry

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Original articles

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Liquidus surface of the quasi-ternary system Cu_2S–In_2S_3–FeS

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Abstract

A projection of the liquidus surface of the quasi-ternary system Cu_2S-In_2S_3-FeS was constructed as a result of experimental studies of quasi-binary and non-quasi-binary sections and based on the data on binary systems comprising a ternary system. Each section (six quasi-binary and four non-quasi-binary ones) was studied separately using complex methods of physicochemical analysis: differential thermal analysis, X-ray phase analysis, and microstructural analysis.

It was found that the quasi-ternary system Cu_2S-In_2S_3-FeS has six fields of primary crystallisation of separate phases and eleven monovariant equilibrium curves along which two phases are co-crystallised. Non-variant equilibrium points were obtained through the extrapolation of the direction of monovariant equilibrium curves.

The quasi-ternary system Cu_2S-In_2S_3-FeS is characterised by 17 non-variant equilibrium points, where E_1-E_5 are triple eutectic points.

The projection diagram of the liquidus surface is characterised by three crystallisation fields of the initial components (Cu_2S, In_2S_3, FeS), four fields of binary compounds, and one field of a complex compound ($CuFeIn_3S_6$).

Since complete solubility of the initial components in liquid and solid states is observed in the quasi-binary section $CuIn_5S_8$-$FeIn_2S_4$, the fields of primary crystallisation of $CuIn_5S_8$ and $FeIn_2S_4$ are absent; they are replaced by an unlimited solid solution based on these components.

The fields of primary crystallisation of Cu_2S, FeS, and $CuInS_2$ are the most extensive in the ternary system Cu_2S-In_2S_3-FeS.

The reactions occurring at monovariant equilibrium points are presented.

Keywords: system, quasi-ternary, eutectic, liquidus, section

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Original articles

Original article
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Spectral manifestations of the exciton-plasmon interaction of Ag_2S quantum dots with silver and gold nanoparticles

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Abstract

The purpose of our study was to develop methods for creating hybrid nanostructures based on colloidal Ag_2S quantum dots, pyramidal silver nanoparticles, Au nanorods, and to determine the spectral-luminescent manifestations of exciton-plasmon interactions in these structures. The objects of the study were Ag_2S quantum dots passivated with thioglycolic acid (Ag_2S/TGA QDs) and 2-mercaptopropionic acid (Ag_2S/2-MPA QDs), gold nanorods (Au NRs), silver nanoparticles with pyramidal geometry (Ag NPs), and their mixtures. The spectral properties were studied using a USB2000+ with a PMC-100-20 photomultiplier system (Becker & Hickl Germany). The article considers the transformation of the luminescence spectra of colloidal Ag_2S/TGA QDs and Ag_2S/2-MPA QDs in mixtures with pyramidal Ag NPs and Au NRs. The study demonstrated the presence of the effects of the contour transformation of the luminescence spectra due to the Fano effect, as well as the luminescence quenching following direct contact between QDs and NPs.

Keywords: silver and gold nanoparticles, silver sulfide quantum dots, hybrid nanostructures, luminescence spectrum

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Original articles

Original article
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Phase relations in the Tl_2Te–$TlBiTe_2$–$TlTbTe_2$ system

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Abstract

The phase equilibria in the Tl_2Te–$TlBiTe_2$–$TlTbTe_2$ concentration area of the Tl–Bi–Tb-Te quaternary system were investigated by using the differential thermal analysis and powder X-ray diffraction techniques. The diagram of the solid-phase equilibria of this system at room temperature was constructed. It was established that the Tl_9BiTe_6–Tl_9TbTe_6 section divides the Tl_2Te–$TlBiTe_2$–$TlTbTe_2$ system into two independent subsystems. It was found that the Tl_2Te–Tl_9BiTe_6–Tl_9TbTe_6 subsystem is characterized by the formation of a wide field of solid solutions with a Tl_5Te_3 structure (δ-phase) that occupy more than 90% of the area of the concentration triangle. The results of X-ray phase analysis of alloys of the Tl_9BiTe_6–Tl_9TbTe_6–$TlTbTe_2$–$TlBiTe_2$ subsystem showed the formation of wide regions of solid solutions based on $TlTbTe_2$ and $TlBiTe_2$ along the section of $TlTbTe_2$–$TlBiTe_2$ ((β_1- and β_2-phases) and made it possible to determine the location of the heterogeneous phase regions in this subsystem. The parameters of crystal lattices of mutually saturated compositions of the β_1-, β_2-, and δ-phases are calculated from powder diffraction patterns.

The paper also presents some polythermal sections, isothermal sections at 740 and 780 K of the phase diagram, as well as projections of the liquidus and solidus surfaces of the Tl_2Te–Tl_9BiTe_6–Tl_9TbTe_6 subsystem. The liquidus surface consists of three fields of the primary crystallization of α (Tl_2Te)-, δ- and β_1-phase. The constructed isothermal sections clearly demonstrate that the directions of the tie lines do not coincide with the T–x planes of the studied internal sections, which is characteristic of non-quasi-binary polythermal sections. The obtained new phases are of interest as potential thermoelectric and magnetic materials.

Keywords: Tl_2Te–$TlBiTe_2$–$TlTbTe_2$ system, phase equilibria, solid solutions, powder X-ray diffraction, crystal lattice, topological insulators

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Original articles

Original article
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Features of the two-stage formation of macroporous and mesoporous silicon structures

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Abstract

The aim of this work was the formation of multilayer structures of macroporous silicon and the study of their structural, morphological, and optical properties in comparison with the properties of multilayer structures of mesoporous silicon.

The paper presents the results of the development of techniques for the formation of multilayer structures of porous silicon *por*-Si by stepwise change in the current with two-stage modes of electrochemical etching.

The data on the morphology, composition, and porosity of macroporous and mesoporous silicon samples were obtained using scanning electron microscopy, IR spectroscopy, and X-ray reflectivity. It was shown that with the two-stage growth of porous silicon layers, the depth of the boundary between the layers of the structure was determined by the primary mode of electrochemical etching, while the total layer thickness increased with an increase in the current density of electrochemical etching.

A comparative analysis of the relative intensity and fine structure of vibrational modes of IR spectra indicated a significantly more developed specific pore surface and greater sorption capacity of mesoporous silicon as compared to macroporous silicon.

Keywords: macroporous silicon, mesoporous silicon, electrochemical etching, porosity, IR spectra, X-ray reflectivity

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Original articles

Original article
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Luminescent properties of colloidal mixtures of $Zn_{0.5}Cd_{0.5}S$ quantum dots and gold nanoparticles

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Abstract

The aim of the study is to establish spectral-luminescent interaction effects in mixtures of colloidal $Zn_{0.5}Cd_{0.5}S$ quantum dots passivated with 2-mercaptopropionic acid and Au and Au/SiO_2 nanoparticles. The studied samples of $Zn_{0.5}Cd_{0.5}S$ quantum dots, Au and Au/SiO_2 nanoparticles and their mixtures were obtained by methods of colloidal synthesis and were characterised using transmission electron microscopy. The absorption, luminescence and time-resolved luminescence spectroscopy were used as the main investigation methods. The measurements were carried out at temperatures of 77 K and 300 K. The spectral-luminescent properties of "free" $Zn_{0.5}Cd_{0.5}S$ quantum dots and those interacting with Au and Au/

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SiO_2 nanoparticles were compared. It was found that the luminescence properties of $Zn_{0.5}Cd_{0.5}S$ quantum dots can be controlled under conditions of changing plasmon-exciton coupling achieved during the formation of a dielectric SiO_2 shell on the surface of Au nanoparticles as well as a result of a polymer introduced into the colloidal mixture.

Keywords: $Zn_{0.5}Cd_{0.5}S$ quantum dots, gold nanoparticles, core/shell, silicon dioxide (SiO_2), extinction spectrum, plasmon-exciton interaction

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Original articles

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Ozone detection by means of semiconductor gas sensors based on palladium (II) oxide

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Abstract

Thin film semiconductor sensors based on palladium oxide were produced to analyse the concentration of ozone in the air. The palladium oxide films were obtained by means of thermal oxidation of ~ 20-30 nm metal in air at various temperatures. The oxide films were studied using electron microscopy and reflection high-energy electron diffraction. The optical, electrophysical, and gas sensitivity properties of the films were investigated. The study determined the optimal oxidation annealing temperature that ensures the uniform composition of the films and absence of electrical noise affecting the gas detection process. The article explains that electrical noise in ultrathin films is caused by their fragmentation during oxidation annealing. The study demonstrated the high sensitivity of the obtained films to oxide.

Keywords: Palladium oxide, Ultrathin films, Electron microscopy, Reflection high-energy electron diffraction, Phase composition, Electrical noise, Gas sensitivity properties, Ozone

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Original articles

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Calculation of the nonstoichiometry area of nanocrystalline palladium (II) oxide films

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Abstract

Nanocrystalline palladium (II) oxide films were synthesised using thermal oxidation in the oxygen atmosphere of the initial ultradispersed metal palladium layers with a thickness of ~ 35 nanometres that were obtained on SiO_2/Si (100) substrates using the method of thermal sublimation in high vacuum. Using X-ray analysis, it was established that during thermal oxidation in the oxygen atmosphere within the temperature range T = 670–970 K the values of the a and c parameters of the tetragonal lattice as well as the unit cell volume of nanocrystalline PdO films increased monotonously with the rise of the temperature reaching the maximum values at T = 950–970 K. It was found that the parameters of the tetragonal lattice and the unit cell volume of nanocrystalline PdO films decreased as the oxidation temperature increased up to T > 970 K Based on the ratio of the c/a parameters, it was shown that the main contribution to the deformation phenomena of the tetragonal lattice were mostly due to the increase in the elementary translations along the coordination axes OX and OY. Based on an assumption that the ionic component of the chemical bond is essential to the palladium (II) oxide structure, we suggested a method for the calculation of the range of the nonstoichiometry area for nanocrystalline PdO films, using the reported data on the radii of cation Pd^{2+} and anion O^{2-} taking into account their coordination environment. The results of the calculations showed that nanocrystalline PdO films synthesised with an oxygen pressure of ~ 105 kPa are characterised by the two-sided homogeneity region in relation to the stoichiometric ratio of the components. The homogeneity region of nanocrystalline PdO films is characterised by the retrograde solidus line in the range of the temperatures T = 770–1070 K.

Keywords: Palladium (II) oxide, Nanostructures, Thermal oxidation, Crystal structure, Nonstoichiometry, Point defects, Gas sensors

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Original articles

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New compounds $Li_3Ba_2Bi_3(XO_4)_8$ (X = Mo, W): synthesis and properties

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Abstract

New compounds $Li_3Ba_2Bi_3(XO_4)_8$ (X = Mo, W) were obtained by the ceramic technology. Those are the first representatives of the ternary molybdates and tungstates $Li_3Ba_2R_3(XO_4)_8$ family, which contain different from the rare earth elements trivalent metal. The sequence of chemical transformations occurring during the $Li_3Ba_2Bi_3(WO_4)_8$ formation has been established. The primary characterization of the obtained phases was carried out and their ion-conducting properties were studied. The synthesized compounds are shown to melt incongruently, isostructural to the lanthanide-containing analogues (structural type of $BaNd_2(MoO_4)_4$, sp. gr. $C2/c$) and crystallize in the monoclinic crystal system with unit cell parameters a = 5.2798(1), b = 12.8976(4), c = 19.2272(5) Å, β = 90.978(2)° (X = Mo), a = 5.2733(2), b = 12.9032(4), c = 19.2650(6) Å, β = 91.512(3)° (X = W). $Li_3Ba_2Bi_3(XO_4)_8$ are found to undergo the diffuse first-order phase transitions at 441°C (molybdate) and 527°C (tungstate), after that their conductivity reaches values of 10^{-3}–10^{-4} S/cm.

Keywords: triple molybdates and tungstates, solid-state synthesis, powder X-ray diffraction study, thermal properties, ionic conductivity

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Original articles

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Vapour-liquid phase equilibria and thermodynamic properties of solutions of the ethylbenzene and n-alkylbenzenes binary systems

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Abstract

The methods of theoretical description of the patterns of changes in thermodynamic properties depending on the composition and structure of solution components are a priority direction in the development of the theory of solutions. This article is devoted to the establishment of relationships between the thermodynamic properties, composition of solutions, and the structure of their components. The study of the thermodynamic properties of binary solutions formed by a common solvent (ethylbenzene) and substances of the homologous series of n-alkylbenzenes contributes to the establishment of the aforementioned relationships. In the production of ethylbenzene and its homologues, solutions based on n-alkylbenzenes are quite common. Alkylbenzenes are widely used in various fields of science and chemical technology as solvents, extractants, and plasticisers.

Using the ebuliometric method, we measured the boiling points of solutions of four binary systems formed by ethylbenzene and n-alkylbenzenes under various pressure values. Compositions of equilibrium vapour phases of the binary systems were calculated using the obtained isotherms of saturated vapour pressure of the solutions. Using the Runge-Kutta method, the composition of the vapour phases of the solutions of the systems was calculated by the numerical integration of the Duhem–Margules equation on a computer. The obtained data on the vapour-liquid equilibrium became the basis for calculating the thermodynamic functions of the systems' solutions. The Gibbs and Helmholtz energy values, the enthalpies of vaporisation and mixing, the internal energy, and entropy of solutions were calculated. The thermodynamic properties of the solutions were calculated using a comparison of the values based on two standards: an ideal solution and an ideal gas.

It was found that the values of the Helmholtz energy linearly depend on the molar mass of the substance (the number of $-CH_2-$ groups in a molecule) in the homologous series of n-alkylbenzenes. An increase in the Helmholtz energy values for n-alkylbenzenes in the homologous series is associated with a linear increase in the molar volume of liquid substances and an exponential decrease in the saturated vapour pressure of substances. For binary solutions of constant molar concentrations formed by ethylbenzene and n-alkylbenzenes, the Helmholtz energy linearly depends on the molar mass (number of $-CH_2-$ groups in the molecule) of n-alkylbenzene in the homologous series. We obtained an equation that makes it possible to predict the thermodynamic properties of solutions of binary systems with high accuracy. The equation accelerates the process of studying vapour-liquid phase equilibria and thermodynamic properties of solutions of binary systems by 300 times. The determined patterns confirm the hypothesis of the additive contribution of functional groups to the thermodynamic properties of solutions. This hypothesis underlies the statistical theory of group models of solutions. The thermodynamic patterns determined by this study can also be used to solve a wide range of technological issues in the chemical industry.

Keywords: Solutions of binary systems, Vapour-liquid phase equilibria, Gibbs and Helmholtz energies, Enthalpies of vaporisation and mixing, Internal energy and entropy of solutions

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Original articles

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Synthesis of bismuth ferrite nanopowder doped with erbium ions

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Abstract

The potential for the practical application of bismuth ferrite (BFO) in information storage, microelectronic, and spintronic devices and in medical sensors of various purpose is limited by the presence of a spin cycloid. Its destruction, including destruction due to doping with rare earth elements and the transfer of BFO to a nanoscale state, contributes to the occurrence of ferromagnetism and the manifestation of the magnetoelectric effect. The study was aimed at the synthesis of bismuth ferrite nanopowder doped with erbium ions.

By spray pyrolysis at a temperature of 760 °C, we synthesised BFO samples with a nominal degree of doping with erbium ions from 0.05 to 0.20. The data of X-ray diffraction analysis show that there is a small amount of $Bi_{25}FeO_{39}$ and $Bi_2Fe_4O_9$ in the doped samples. The shift of the BFO reflections on diffraction patterns towards larger 2θ angles is representative of the incorporation of erbium ions into the crystal lattice of $BiFeO_3$. The morphological characteristics of the samples were determined using transmission electron microscopy. According to the data of electron probe X-Ray microanalysis, the real composition of the doped $Er_xBi_{1-x}FeO_3$ samples is very close to the nominal.

The particles of $Er_xBi_{1-x}FeO_3$ powders synthesised by spray pyrolysis have a nearly spherical shape, the particle-size distribution is in the range of 5–300 nm, the predominant number of particles have a size in the range of 50-200 nm, and the agglomeration is weak. The decrease in the crystal lattice parameters and the unit cell volume of $Er_xBi_{1-x}FeO_3$ and an increase in the degree of doping with erbium ions confirm the incorporation of Er^{3+} into the BFO crystal lattice to the bismuth position.

Keywords: Nanopowders, Bismuth ferrite, Multiferroics, Doping

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Original articles

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Growth and physical properties of $CaSrBaF_6$ single crystals

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Abstract

Using the Bridgman-Stockbarger method, crystals of triple fluoride CaF_2-SrF_2-BaF_2 were grown in a composition range similar to that of $CaSrBaF_6$. The crystals were 10-12 mm in diameter and 50–60 mm in length. The $CaSrBaF_6$ crystal is a new optical material which is transparent in the mid-IR, visible and UV ranges. The uneven distribution of the components along the length of the crystal did not exceed 10 %. The edge of the absorption band in the IR range was 14.3 μm, and the optical absorption at the wavelength of 200 nm did not exceed 18 % (less than 0.2 cm^{-1}). The refraction indices were 1.4527, 1.4488, and 1.4458 for the wavelengths of 633, 969, and 1539 nm respectively. The crystal melts in the temperature range of 1150–1210 °C. The $CaSrBaF_6$ composition is an appropriate matrix for doping with rare-earth ions in order to obtain functional single-crystal and ceramic materials of the visible and IR ranges.

Keywords: Calcium fluoride, Strontium fluoride, Barium fluoride, Fluorite, Solid solution, Isomorphism, High entropy alloys

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Original articles

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Synthesis and experimental study of liquid dispersions of magnetic fluorescent polystyrene microspheres

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Abstract

Multiplex microsphere-based immunofluorescence assay is a reliable, accurate, and highly sensitive method for the detection of various biomolecules. However, for the moment, the wide application of the method in clinical practice is prevented by the high cost of reagents for analysis - magnetic spectrally encoded microspheres. Therefore, an urgent task is the development of new methods for the synthesis of microspheres with the required properties. The aim of this study was the creation of new magnetic fluorescent microspheres suitable for use in multiplex immunoassay.

Samples of magnetic fluorescent polystyrene microspheres were synthesized by dispersion polymerization and two-stage swelling methods. Experimental studies of geometric parameters, fluorescence, magnetic properties of the synthesized microspheres have been carried out.

The results of the studies have shown that microspheres synthesized by dispersion polymerization are promising for the use in immunofluorescence analysis. The obtained results can be used for the development of new diagnostic multiplex test systems based on spectrally encoded microspheres.

Keywords: Immunofluorescence assay, Planar immunoassay, Microspheres, Fluorescence, Dispersion polymerization, Two-stage swelling

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Original articles

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Synthesis, structure and superconducting properties of laminated thin film composites of $YBa_2Cu_3O_{7-\delta}/Y_2O_3$ as components of 2G HTS wires

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Abstract

2G HTS wires are capable of transferring huge amounts of electrical energy without loss. An increase in the current-carrying capacity in these materials is possible due to an increase in the thickness of the superconducting layer; however, there is a problem with the appearance of impurity orientations and other defects with increasing thickness. We have proposed a solution of this problem by increasing the thickness of the superconducting layer by the MOCVD method using interlayers of yttrium oxide.

The aim of this study was the production of thick composite films with yttrium oxide interlayers and high critical current density. In addition, we want to show the effectiveness of the approach of introducing yttrium oxide interlayers for the reduction of the number of parasitic orientations and defects with an increase in HTS film thickness.

The deposition of $YBa_2Cu_3O_{7-\delta}$ and Y_2O_3 films was carried out layer by layer using reel-to-reel MOCVD equipment. A 12 mm wire of the following architecture was used as a substrate: 200 nm $CeO_2(Gd_2O_3)$/30–50 nm $LaMnO_3$/5–7 nm IBAD-MgO/50 nm $LaMnO_3$/50 nm Al_2O_3/60 μm Hastelloy 276. The resulting films were annealed in oxygen for obtaining the orthorhombic YBCO phase.

$YBa_2Cu_3O_{7-\delta}/Y_2O_3$ composites were obtained. In these composites, obtained using the MOCVD method, the amount of side ($c_{\parallel}$) orientation of the HTS layer was reduced and high values of the critical current density, exceeding 1 MA/cm at a thickness of > 2 μm remained. The efficiency of the approach of introducing yttrium oxide interlayers for the increase in the current characteristics with increasing film thickness was shown. It was found that further thickening of films with interlayers is prevented by the formation of nanopores, reducing the critical current density.

Keywords: YBCO, MOCVD, Heterostructures, Buffer layers, Y_2O_3, HTS, Superconductor

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Аннотации на английском языке

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