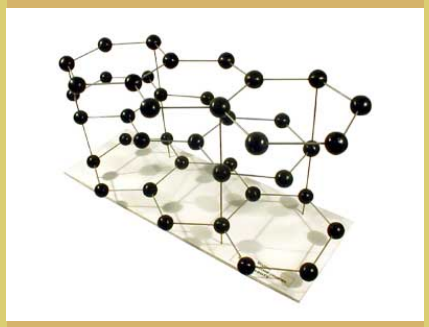


INNOVATION PROCESSES IN ICSTI COMMUNITY

Issues of modern applied materials science

2012

Innovation processes in ICSTI community
Issues of modern applied materials science

2012

V. Kodola
ICSTI Director

In accordance with the resolution of the 62nd sitting of the Committee of Plenipotentiary Representatives of ICSTI member states, ICSTI headquarters would like to present an international information and analytical collection «Issues of modern applied materials science», the fifth edition within the series «Innovation processes in ICSTI Community», featuring papers contributed by researches from ICSTI member states.

The relevance of the subject chosen for the collection is evident. Modern material science as an interdisciplinary discipline is called to support scientific and technological progress and sustainable development of economies through introduction of novel high-quality materials with increased operational reliability, contributing to increased application of energy-saving technologies, resource base expansion, development of equipment with improved characteristics.

The last decades are distinguished by significant progress in several new technology sectors, requiring development of metallic and non-metallic materials with enhanced or fundamentally new physical, chemical and mechanical properties. Thus, material science is one of the key areas, providing for scientific, technical and innovative progress of national economies, and its high level of development places a country among the global technological powers.

The collection presents analytical materials and research results in material science provided by experts from scientific, educational and innovative organizations in ICSTI member and partner countries: Azerbaijan, Belarus, Georgia, Moldova, Romania, Russia, Ukraine, South Africa, Slovakia, and the Czech Republic.

It is important to note that the authors of submitted articles highlighted issues close to their research interest and related to progress in particular areas of science and technology achieved in their countries.

For example, Azerbaijan presented developments in the field of new materials in petrochemical industry, Belarus provided a considerable spectrum of papers in applied material science in microelectronics and surface finishing of parts with a complex shape, publications from Romania concentrate on study of fundamental properties of advanced materials; an interesting range of articles on novel materials was contributed by Moldova, Russia and Ukraine. A publication from Georgia is devoted to the aspect of using new materials in medicine. The article from South Africa devoted to the seminar «Issues of nanotechnology and advanced materials», which was organized in Pretoria by ICSTI and the Department of Science and Technology of South Africa with participation of the Joint Institute of Nuclear Research (Dubna) attracts special attention. There is a substantial contribution of papers from the Czech Republic and Slovakia in the collection. The first paper presents a brief overview of Slovak organizations working in the field of material science. The information from the Czech Republic concerns developments in modern material science, which won awards during the Week of Research, Developments and Innovations annually held in Prague by the Association of Innovation Entrepreneurship of the Czech Republic.

The compilers of the collection hope that this publication will appeal to the interests of readers in terms of providing new knowledge, as well as facilitate expansion of scientific and technical cooperation between ICSTI member and partner countries.

REPUBLIC OF AZERBAIJAN

The developments are presented by CSRI NASA

Material Science

AZB-01

Perspectives for the use of a «fluidized bed» reactor for continuous production of chlorocarbons and nanostructured carbon clusters

Purpose

Manufacture of high-quality materials with increased service reliability

Description

Obtainment of high-quality materials with high service reliability requires creation of effective technological reactors, including a vertical cylindrical «fluidized bed»-type one, which broadly used for continuous production of gaseous, liquid and solid products, separation of fine-dispersed particles with different geometrical parameters, effective removal of exothermic heat that is necessary for some chemical processes. A significant feature of such reactor is efficiency of vapour-phase oxidizing halogenation of hydrocarbons with the use of waste by-products of some chlorination and bromination processes, hydrogen chloride or bromide, as an initial agent.

For the first time the authors showed the possibility to use natural minerals – perlite and obsidians. The use of these minerals as a fine-dispersed catalyst in the «fluidized bed» reactor provides effective catalytic high-output obtainment of such chlorolefines, as vinyl chloride, chlorallylene and isocrotyl, feeding in the reactor a mix of hydrocarbons (ethylene, propylene, and isobutylene), chloride hydrogen and air in a required molar ratio. Modes (feeding rate, temperature, molar component ratio) for laboratory (glass) and pilot (metal) reactors have been determined. The possibility to carry out non-waste non-polluting processes for production of industrially-used monomers and others chlororganic compounds has been shown.

One more «fluidized bed» reactor's advantage is the possibility to use a principle of a semi-through stream of fine-dispersed particles of solid powders (carriers).

Usually a seeder's method is widely applied to obtain solid materials fine-dispersed particles used as catalysts, polymeric compositions fillers in powder metallurgy and other loose materials. Disadvantage of the method is low productivity and obtainment of disperse materials with a different geometrical form and density. By simple change of diameter and height of a reactor's cylindrical part the authors managed to use these designs for separation of fine-dispersed powders by density and particles geometry. As a result a patentable classifier (Fig.) of loose materials for the experimental-industrial usage, which allows to separate spherical powder particles from particles of other form, has been

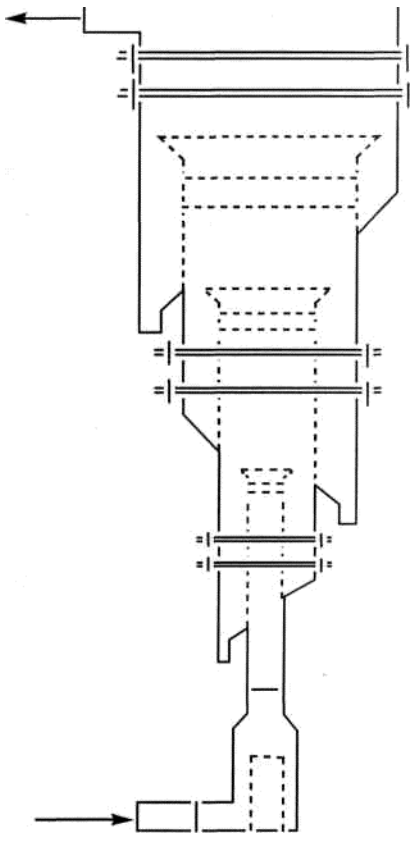


Fig. Separator for loose materials

proposed. It was shown that application of such powders in the «fluidized bed» reactor provides more stable process of hydrocarbons chlorination and oxychlorination, and also increases the total reactor's operation time.

Thus, the purpose of the «fluidized bed» reactor use for effective production of chlorocarbons, chlorolefines, nanostructured carbons, solid materials (catalysts, powder metals) has been achieved.

Advantage in comparison with analogues

1. Chlorination reactions, including high-temperature once (substitutive, attachment, destructive, exhausting), take place without explosions due to effective removal of exothermic heat through a reactor wall.
2. Continuous obtainment of mono-, di-, three and polychlorinated hydrocarbons (including chlorocarbons) in one stage with high output of target products.
3. Possibility to change a number and ratio of reacting components, time of their contact.
4. The use of fine-dispersed heat-carriers and catalysts of different configuration (form) influencing behavior of chlorination reaction as a whole.
5. Variation of reaction temperature and maintenance of the process taking into account exothermic character of such chlorination reaction.
6. Wide variation of «fluidized bed» height by changing of a feeding rate and reacting components ratio necessary for optimization of reaction parameters (temperature, pressure, contact time).
7. Possibility of reactor's design parametrization by optimization of its height and diameter, and also selection a of dispersiveness degree and powder contacts geometry.
8. Achievement of mono-, di-, poly- and exhaustive chlorination in a single reactor by changing of process parameters.
9. Carrying out of individual or net reactions (substitutive, attachment, destructive, aromatization, cyclization, etc.) in a single stage.
10. Possibility to carry out on special catalysts (natural minerals - perlite and obsidians) non-waste reactions by oxidation of chloride hydrogen in chlorine or oxidizing chlorination of hydrocarbons using chloride hydrogen, air or chlorine, hydrocarbon and air.

Development stage

Azerbaijan's patent is available
Ready for introduction

Cooperation proposals

Sale of patents
Sale of licenses
Sale of technical documentation

Contact information

Institute of Polymeric Materials of the NASA
Salahov M.S., Bagmanov B.T.
salahov_mustafa@mail.ru

Material Science

AZB-02

Thermomechanical stamping austenitic heat-strength steel with a nanosized structure

Purpose

Manufacture of automatic mill's mandrel with high wear resistance and thermal stability.

Description

A mode of thermomechanical treatment of products by stamping has been developed with the aim to obtain austenitic heat-strength steel with a nanosized structure.

For this purpose the following operations have been carried out: quenching + cold stamping + tempering. It was established that two processes take place in the steel: low-temperature (at 200°C) and high-temperature (at 700°C) ones.

Research was carried out on samples of industrial steel with the following composition: 0.45% C; 14.5% Cr; 14.2% Ni, 2.1% Nb; 0.38%Mo; 0.6% Si; 0.3%Mn.

As a whole, it is to note:

- continuous fining of coherent dispersion zones with increase in a deformation degree at cold stamping that can be explained by occurrence of particles of different phases during deformation. It leads to fining of the substructure and, probably, fragmentation during dynamic recovery;
- increase in non-uniform microdistortion after moderate deformation at high-temperature ageing - such distortions decrease after ageing with the growth in reduction degree because of intensive fining of the substructure;
- taking place of two processes in steel: low-temperature (at 200°C) connected with formation of the local ordered state, and high-temperature (at 700°C) preconditioned by ageing (tempering) processes;
- comprehensive X-ray structure analysis is necessary to study fine ageing process.

Development stage

Research has been carried out.

Mastering of the process is needed.

Cooperation proposals

Sale of engineering documentation

Contact information

Azerbaijan Technical University,
«Metallurgy and Metallurgical Science» Faculty
Gusejnov B.G., Namazov S.N., Babanly M.B.
E-mail: salahov_mustafa@mail.ru

Material Science

AZB-03

Novel nitrogen-containing alkylphenolate additives to motor oils

Description

Creation of new equipment puts forward increasing requirements to quality of used lubricant oils. Development of technical equipment requires also their constant improvement. For this, as a rule, the coordinated actions are needed.

Obtainment of motor oils of different functional purpose with high working parameters is impossible without the usage of additives.

One of promising directions in the field of development and application of such additives is obtainment of compounds of multipurpose action.

Alkylsalicylate additives possessing high washing and thermal-oxidative properties increasing with the alkalinity growth have found wide application in the state-of-the-art lubricant compositions composition. However, such additives in the industry are produced using a multiphasic and complex technology.

The article shows results of synthesis and research of new additives IHP-150 and IHP-156, whose composition like alkylsalicylate additives has carboxyl-containing and alkylphenolate groups, but unlike of them contain also a nitrogen atom.

Additives IHP-150 and IHP-156 are carbonated calcium salts, which are a product of condensation of alkylphenol with formaldehyde and aminoacetic acid or p-aminobenzoic acid, with alkalinity of 145-165 mgKOH/g. The additives are produced using a simple and non-polluting technology.

The presence of nitrogen atom and carboxyl-containing groups and also calcium cation in their molecule provides high working properties of additives.

*И*ХП-150 and *И*ХП-156 surpass commodity MASK and VNIINP-714 additives by anticorrosive properties. Their high efficiency has been proved by laboratory research results both as in isolated form and in motor oil composition.

Multipurpose additives IHP-150 and IHP-156 were investigated in composition of М-10Г2 *и* М-12ВБ motor oils. Laboratory research results have shown that the developed experimental oils meet to standards norms by physical, chemical and functional properties and are not inferior to Shell firm's foreign analogues by working parameters.

The technology for production of the specified additives has been mastered at trial installation of the Institute and can be used in the petrochemical industry for creation of effective motor oils.

Industrial production of these additives can be carried out jointly with employees of the institute and oil refining factories of Russia, Ukraine and other interested countries.

The work has been carried out at financial support of the Science Development Fund at President of the Azerbaijani Republic - Grant №EİF-2011-1 (3)-82/57/4.

Contact information

Kyazim-zade A.K., Nagieva E.A., Mamedova A.H., Mamedova R.A., Nasirova S.I.
Kuliev Institute of Additives Chemistry of the NAS of Azerbaijan
Baku, Beyukshorskoe Highway, quarter 2062
Phone: 514-96-12, fax: 214-96-10
E-mail: aki05@mail.ru

Material Science

AZB-04

Fig. 1 Classifier for loose materials

Wear process of nanosurfaces of a self-lubricating friction bearing

Purpose

Solution of contact tasks taking into account wear process of self-lubricating nano-and macrosurfaces

Description

Friction bearings (FB) are one of the most important units of the state-of-the-art machines and mechanisms. FB functions in conditions of relative sliding of pivot surface on a bearing insert and are one of heavy-loaded connections.

Self-lubricating materials are recommended to use for manufacture of crucial FB parts working in extreme conditions. Their selection for FB has great scientific and practical significance and provides its reliable work.

FB work in a self-lubricating mode is provided by oil in pores of sintered material, which is put in the article by impregnation after its sintering. Such bearings have advantage at work in places difficult to feed greasing. At such task description self-lubricating FB can work in a boundary friction mode.

Solution of a contact task in view of wear process of FB nano-and macrosurfaces has great significance for forecasting of their durability.

Approaches of mathematical modeling of wear process of the FB insert made of self-lubricating material have been considered in view of contact deformation. A differential equation for a contact condition of this bearing has been derived. A method for determination of wear process intensity for the FB insert made of self-lubricating material has been developed.

The developed method for estimation of FB wear process intensity allows to control bearing's wear process. Research shows that at intensive wear process of FB moving interface dynamic loadings, vibration and noise start to increase significantly from a certain size of a gap. Finally, it influences on its durability.

On the base of the developed method it is possible to determine optimum value of the wear and gap, at which reliable work of the FB will not be disturbed.

Development stage

Research on computer modeling has been carried out.

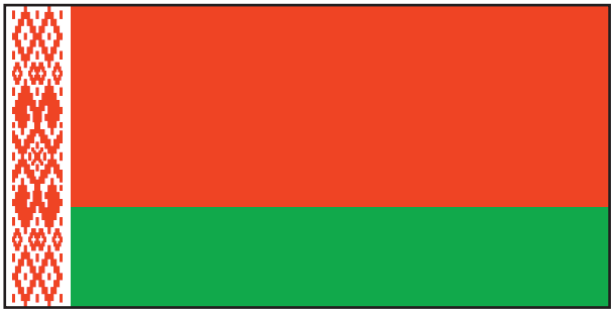
Cooperation proposals

Sale of engineering documentation.

Contact information

Azerbaijan Technical University
V.I.Bakhshaliev
E-mail: v_bakhshaliev @mail.ru

REPUBLIC OF BELARUS



Development of applied materials science in the Republic of Belarus

**I. Voitov,
D. Sc., Chairman of
SCST of RB**

**A. Busel, D. Sc.,
Professor, Director
of BelISA**

**I. Plyshchevsky
Ph.D., Senior
Researcher, BelISA**

The main aim of works in the field of materials science in the Republic of Belarus is increasing of a technical level and competitiveness of national production, providing import substitution due to creation of promising metallic, ceramic, polymeric, composite and other materials using high-efficiency technologies and equipment to produce articles and coatings with required set of functional properties.

Development physical and chemical science allowed to work out methods for purposeful regulation of structure formation in heterogenic systems, which include most state-of-the-art composite materials. Intensity of bonds at the boundaries of structure elements in such materials is determined by a technological mode for processing initial components using physical influencing factors and chemical reagents.

Non-reagent treatment consists in transformation of mechanical, heat, electrical and other kinds of energy in potential physical and chemical one of future structure elements. Usually, such energy is concentrated on a surface preconditioning a level of interaction in a contact zone. As resistance of composite materials to external actions is determined, mainly, by a degree of structure elements interconnection, it is possible to control properties of materials and articles on their base changing treatment modes.

Surface properties of structure elements can be changed also by chemical treatment using special reagents and surfactants. New compounds capable of actively interacting with formation of strong bonds are formed in the contact zone. As above-mentioned processes proceed, mainly, at a molecular level, nanotechnology becomes of high priority providing strengthening of the contact zone using different compounds, for example, fullerenes, synthesis of novel structures at a submicron level, surface treatment of ultradispersed powders by activating radiation.

The tasks of material science in Belarus are solved executing state scientific and technical programmes: «Crystal and molecular structures», «Nanomaterials and nanotechnologies», «Mechanics», «Materials in techniques», «Polymer materials and technologies», «Novel materials and technologies», «Microelectronics», «Optotech», «Mechanical Engineering», «Chemical reagents and materials», «Metallurgy».

Different scientific and technical projects financially supported by the Belarusian Republican Foundation for Fundamental Research are carried out. There are traditions in technical science in the field of development and production of novel materials and technologies. It is to single out academic establishments among main executors, for example SSI Powder Metallurgy Institute having formed the Institute of Welding and Protective Coatings, as well the Institute of Impulse Processes within its

walls, Physical-Engineering Institute, Metal Polymer Research Institute, Joint Institute of Mechanical Engineering, as well Scientific and Practical Materials Research Center recently created on the base of the Institute of Solid State Physics, which includes Institute of Applied Physics, Institute of Chemistry of New Materials, Institute of Technical Acoustics, Institute of Metal Technology, EP RUE «Ferrit», RUE «SKTB Metallopolimer», SI RUE «Elkerm», RSE UE «Diatech», RE UP «Technomag».

The Center's main aims are carrying out of research works and R&D in the field of physical and physicochemical material science. The tasks are solved on creation of novel magnetic, ferroelectric, semiconductor, metallic, superconducting, superhard and optical materials in the form of crystals, ceramics, disordered systems, nanomaterials and nanostructures. Developed are methods and technologies to obtain composite organic and inorganic materials and articles on their base, methods and devices for non-destructive testing and technical diagnostics of materials and articles.

High-productivity and low-energy separators for ore and nonmetallic material purification and concentration at ore-dressing and processing enterprises, glass and ceramic factories, in plants for secondary raw materials treatment, food industry were created on the base of a technology for obtaining strong permanent magnets developed in the Center. A unique machining tool based on high-quality superhard materials (synthetic diamonds and cubic boron nitride) was developed. Novel ceramic and ferroelectric materials and elements were created. Proprietary technologies for obtaining synthetic precious stones (emerald crystals) were developed, that allowed to organize small-batch production of jewelries.

Ultradispersed diamonds forming at rapid cooling of explosives detonation products are developed in the field of nanotechnology. Detonation synthesis in explosion chambers is the most cheapest and manufacturable method of industrial production of diamonds. Such diamonds are used to modify structure and enhance properties of galvanic, ion-plasma and microarc oxide coatings, for superfinishing processing and lubrication. Uniqueness of nanodiamonds having a round shape, diameter of 4-7 nm and specific surface of 300±30 m^2/g consists in combination of a diamond structure, hardness and chemical resistance with aggregative and sedimentation stability.

Using impulse cathode arc spraying method, a technology and equipment were developed to obtain high-quality wear-resistant diamond-like nitrogen-containing coatings for friction pairs and production tooling. The usage of electromagnetic carbon plasma separator provides removing microparticles with the size of ≥6μm from a film surface and reducing 1-5 μm particle quantity by 20-25 times. It allows to apply quality coatings with thickness of 165 nm for 1000 impulses with speed 3 times higher than speed of deposition in vacuum. Friction coefficient ($\varphi \approx 0.09$) of nitrogen-containing coatings is significantly lower in comparison with hydrogen-free and hydrogenised ones. It is connected with a surface layer enriched by a nanosized graphite-like phase. Coatings allow to increase friction units' service life three-fold. Their usage in a technological tooling provides high antistick properties at plastic production and ten-fold increase its service life in comparison with a chromic electroplating.

Methods for nanocladding of cubic boron nitride and diamond powders by boron, titanium, silicon and amorphous carbon, obtaining diamond polycrystals from nanodiamonds, forming superhard materials from them for processing nonferrous metals, hard steel and ceramics were developed at the Joint Institute of Mechanical Engineering of the NAS of Belarus.

The use of nanostructured materials, first of all, based on detonation synthesis of nanodiamonds, whose industrial production was mastered at SE JSC «Sinta» in the form of eight ultradispersed diamond modifications differing in phase composition, purification degree, value and sign of surface charge. Successful mastering of nanodiamond production allowed to transform laboratory technologies in industrial ones for the usage of this material in key for the Republic branches.

Among works conducted in the Scientific and Practical Materials Research Center, it is to single out a fundamentally new technology to obtain highly dispersed conditioning agents for microstructure modification of workpieces made of steel, iron, brass, bronze and silumin. Such cast conditioning agents are cheaper, as they are produced from secondary raw materials and contain fewer active elements.

A set of import-substituting and export-oriented polymer composite materials for mechanical engineering, electrotechnical industry, general technical purposes was created. Heat-resistant low-

nickel steel was introduced at RUE «Minsk Tractor Plant». Pallets made of this steel for heat-treatment furnaces passed successfully production tests.

Methods for diagnostics of critical technological equipment based on the use of acoustic-emission, magnetic, ultrasound and capillary non-destructive control techniques were introduced at JSC «Mozyr Oil Refinery». Shape memory alloys, hip prosthesis were developed for Ministry of Health of the Republic of Belarus.

Achievements in the field of highly effective solar elements and modules, electronic sensors, new technological solutions on creation of multilayer electromagnetic screens for protection of space vehicles` on-board equipment enabled the Center to begin cooperation with the Space Research Institute of the RAS (Moscow) within the framework of the Common State's programme «Kosmos-NT».

Works of a number of research organizations in the field of material science are connected with development of new materials for powder metallurgy, ceramics, composite, nanosized and superhard composite coatings, welding, including the use of dynamic and impulse loading methods. Technologies for applying of protective, strengthening, wear-resistant and biocompatible coatings are being developed; multifunctional special and multicomponent materials based on thermodynamically stable compounds are being created. Scientific and technological fundamentals for creation and processing new structure materials, including the use of high-energy sources, are being developed.

It is to note the following directions:

- scientific approaches with the use of computer simulation to control properties of composite powder materials with a metallic base with inclusions of a hard (soft) phase, peculiarities of their microstructure and behavior at external force and temperature actions;
- principles for creation and control of microstructure and properties of nanocrystalline composite materials for different purposes;
- creation of permeable materials with an organized structure obtained by powder metallurgy methods for combustion, filtration and catalysis processes;
- investigation of heat and mass transfer in porous powder materials with a irregular porous structure;
- obtainment of composite powders with a preset composition by mechanical alloying, granulation, self-propagating high-temperature synthesis (SHS), applying of functional protective coatings from powder materials;
- theoretical and technological fundamentals for material modification by microplasma-spark methods in conditions of a control electric discharge;
- valid approaches for creation of novel composite electrode materials on current-conduction substrates by microplasma-spark methods;
- investigation of strengthening mechanism of gas-thermal composite coatings at treatment by high-concentrated energy flows;
- physical and chemical interphase interaction at high-speed shock and impulse action, theoretical fundamentals of high-speed shock dynamics and deformable solid mechanics on the following lines: explosion welding, explosion compaction, shock wave focusing, structural failure;
- novel materials, including laminated composite, ceramics, construction, powder ones, technological processes and equipment for their synthesis by explosion at high pressures, temperatures and loading speeds.

Research in the field of laser and electron-beam surface treatments, effective methods for strengthening, which allows to obtain micro- and nanostructured materials in a surface layer make a great contribution in development of material science and technologies. A spectrum of technologies for laser and electron-beam surface modifying is broad and enables to improve practically all working characteristics of machine parts surfaces. Target parameters (hardness, wear-resistance, etc.) can be increased by 2 and more times.

It is to note developments of the Institute of Powder Metallurgy generally recognized in the Republic and world. The Institute is a head organization on realization of the scientific and technological programmes «New materials» and «Resource-saving». Material compositions and different technologies of their obtainment and application are developed within the framework of these programmes. In

particular, it is possible to provide the following examples: copper coating formation by the magnetron sputtering method on friction discs workpieces; composite antifriction and protection layers on surfaces of cultivators` spherical body supports, antifriction layers on hinged joints; high-density bimetallic coatings on friction units parts of machine hydrosystems using hypersonic metallization; friction units parts of «rotor» and «pivot» rotor groups for axial-piston pumps; applying of multilayer protection layers in vacuum on linings of gas consumption sensing devices for ultrasound counters; formation of coatings with a complex strengthening effect by the microplasma-spark alloying method with ultrasonic modification of a surface of parts for machine engineering; production of an antifriction consistent lubricant for tribological surfaces protection based on vacuum oil distillates and paraffin oil production drips.

Compositions being developed are used for deposition of wear-resistant, anticorrosive and heat-shielding coatings by high-velocity oxygen-fuel (HVOF) spraying. In particular, chrome and titanium carbide-based powders allow to form coatings working in conditions of abrasive and erosive wearing, corrosion up to 7000C. They are recommended for protection of energy equipment parts, forging tooling, crushing roles, dies for hot pressing, bearing inserts.

Nickel aluminide-based powders allow to use a technology for deposition of protection coatings resistant to erosion wearing at increased temperatures in conditions of low- and high-temperature corrosion in presence of chlorides for protection of energy equipment, parts used in production and re-use of chemical fibers, recovery and protection of salt-mining equipment against corrosion and wear. Iron aluminide-based powders are intended for applying coatings resistant to erosion wearing at elevated temperatures in sulfur-containing atmosphere. They are recommended for protection of energy equipment, parts for coal gasification units, mechanisms working with salt melts. High-technology products of the Institute are the following:

- construction, tribotechnical and special materials and articles on their base (starter inserts, friction bearings, guide bushes, antifriction materials of different application, friction discs, parts of mechanical and steam-mechanical nozzles, synchronizing rings for gear boxes);
- materials and articles for electrical engineering and radio electronics, technical ceramics;
- tool based on superhard materials, nature and synthetic diamonds (drills, mills, wheels, discs, segments, roles);
- porous filtering and capillary - porous materials, articles on their base (metal foam, filters for melts, separators, heat tubes);

- materials and technologies for production of implants (maxillofacial prosthetics, electrodes for heart electrostimulation, cervical and thoracic vertebrae, dental and ophthalmologic composite implants);
- materials and technologies for applying coatings;
- welding materials, technologies and equipment.

In the field of construction material science, composite materials resistant to sign-changing temperatures typical for conditions of the Republic are developed. Modified concretes with high frost and corrosion resistance for monolithic and assembled concrete and reinforced concrete articles and structures of bridgeworks and coverings subjected to action of chemical deicing agents and other aggressive external environment factors are developed in the Belarusian Road Traffic Research Institute. Concrete compression strength is B30-B70, frost-resistance is F150-F300, water resistance is W20, water absorption by weight is less than 3%. High working properties of concretes are achieved by means of surfactants, in particular, GP-1 hyperplastifying agent developed by Belarusian Research Institute for Civil Engineering. Production of GP-1 hyperplastifying agents is organized at the «BarChim» chemical plant.

Emulsion technologies for obtaining organic bindings and construction materials on their base are broadly used at road construction in the Republic. Using colloidal chemistry, emulsion-mineral oils with accelerated formation time providing rapid strength gain of roadway covering structure layers due to intensive water drainage and formation of a stable structure have been developed. To increase load-carrying capability of highways, dispersed reinforcement in the form of synthetic fibers, fullerene glass fibers is introduced in composition of road-building materials. The latter is proposed to apply on a surface of fine-dispersed binding cements and fillers, mineral powders, that allows to reinforce a contact zone in a structure of composite materials. Developments are carried out at the Belarusian National Technical University.

Over the 2006-2010 years 103 tasks were fulfilled; 239 new technique objects were created, including equipment-19, materials, substances, tools-74, technological processes - 88. 46 sites and production facilities were created and modernized.

Developments of the Republic of Belarus in the field of materials science

BLR-01

Composite antifriction diamond-containing materials and articles for tribotechnical purposes, sliding units' components for energy equipment with a diamond-containing layer

Technologies for obtaining antifriction composite materials with a surface layer modified by ultradispersed carbon particles for the usage in heavy loaded tribounits have been created. Manufacture of sliding units` components has been organized.

Physical and mechanical properties of macroheterogeneous composites with a matrix based on silicon-manganese bronzes and iron-carbon reinforced granules were investigated. Composites mechanical properties with granules diameter of 1.00-1.50 mm are the following: compression strength is 975-990 MPa, bending strength is 580-660 MPa, impact toughness is 0.18-0.20 MJ/m.

Composite based on the БрК3Мз bronze can be recommended for application with pressures of 5-10 MPa and temperatures up to 1000°C, БрК3Мз 10 bronze for pressures of 10-40 MPa and temperatures up to 150°C, БрК5, 5Мц14 bronze for pressures of 10-20 MPa and temperatures up to 250°C. Introducing ultradispersed diamond-graphite modifying agents in composition of lubricant material decreases friction coefficient, increases wear resistance, broadens loading-speed and temperature working ranges.

In conditions of boundary friction of a «composite - 60Г hardened steel» friction pair, modification with additives of ultradispersed diamond-graphite charge is efficient for pressures of over 20 MPa. The modified lubricant can be used in the stage of run-in providing a relatively low friction coefficient (f=0.04-0.05) practically without any wearing.

Production of composite materials for sliding units, low-speed heavy loaded components working in conditions of elevated temperatures has been organized.

BLR-02

Superhard CM based on micropowders of diamond and cubic boron nitride reinforced by nanophase particles and a tool on their base

The charge composition for obtaining superhard CM based on micro- and nanopowders of cubic boron nitride, diamond, titanium carbide, titanium nitride, additives of nanodispersed aluminum nitride powders and aluminum, nickel, molybdenum and copper powders has been studied. The synthesis of superhard CM based on cubic boron nitride and diamond was developed.

The pilot machine-tool sample for grinding and polishing complex-shaped surfaces of technological tool with increased wear-resistance was developed; its laboratory tests were carried out.

Manufacture of the technological tool is organized.

BLR-03

Friction unit components with a composite chrome-diamond coating

Electrochemical coatings based on chrome modified by ultradispersed diamonds for manufacturing equipment friction unit components.

Technical characteristics:

- hardness increase, times: 1.4-1.5
- coating microhardness, min, unit: 1100
- friction coefficient decrease, %: 30-40
- wear-resistance increase, times: 1.5-1.7
- specific price, min, USD/dm^2: 3.0

BLR-04

Oversize cutting inserts made of superhard CM

Application field

Tool-making facilities for production of edge tool used for semifinishing and finishing of hardened steels, irons and other difficult-to-cut materials. The technology for manufacture of oversize cutting inserts made of superhard CM based on cubic boron nitride micropowders using steel high-pressure equipment.

Technical and economic parameters

- Knoop hardness, GPa: 32-45
- Fracture toughness index, MPa•$m^{1/2}$: 10-13.5
- Ultimate compression strength, GPa: 2.6-3.2
- Thermal conductivity, W/m•K: 100-120
- Heat resistance in air, K: 1570

BLR-05

Process and unit for induction of melting of antifriction materials

Application is manufacture of bimetallic parts of vibration machines and devices various plants. The process and unit are intended for formation of antifriction layers in a centrifugal force field on internal surfaces of parts functioning in conditions of intensive vibration action. Powders, industrial wastes, worn articles are used as raw materials.

Technical characteristics:

- bimetallic parts dimensions, mm: length: 100-550; external diameter: 50-450; wall thickness: 10-60.
- unit productivity, parts/hour: 10-12
- applied layer thickness, mm: 2-50 mm
- rotation velocity, rpm: 50-2500
- isothermal time, min: 5-15
- parts service life increase, times: 2-3
- coating porosity, %: 2-5
- coating hardness, HB units: 160-165

Contact Information
SSI Joint Institute of Mechanical Engineering of the NAS of Belarus, Academic st., 12, 220072, Minsk
Fax: (017) 284-02-41, e-mail: bats@ncpmm.bas-net.by

BLR-06

Composite materials with nanosized components

Novel composite ceramic and ceramic-metal materials have nanosized adhesively active components with enhanced dissipative characteristics. The composite materials (CM) are intended for parts working in thermomechanical fields of different intensity. Compositions for chemical reagents for synthesis of nanosized layers providing the necessary CM structure and composition have been determined. CM models of increased efficiency in conditions of cyclic and impulse thermomechanical loadings were developed. Components` interaction zones were investigated; recommendations on a CM structure design with increased service life were formulated. Manufacturing specifications for applying ceramic nanolayers (thickness <80 nm) on metallic and ceramic powders were elaborated. Technological approaches to control structure and create new CM with nanosized components were worked out; optimal compositions with nanosized components for articles working in conditions of alternative thermomechanical fields were determined; instructions for manufacture of CM-based parts elaborated; experimental samples were fabricated; tests were carried out; efficiency of new materials was determined.

BLR-07

Sliding bearings for car friction units made of powder composite materials

A technology for manufacture of friction units for automotive industry made of powder CM based on iron and copper with increased loading capability has been developed and their production has been organized. A structure, mechanical and tribotechnical properties of powder antifriction materials for function in conditions of increased wearing and mechanical loading were investigated. The powder Cu-Sn-Fe CM with Mo disulfide additives was recommended, which provides hardness of HB 80, breaking strength at radial compression of 3000-5000 N, friction coefficient of 0.021. A typical process was elaborated. «Starter insert» parts for cars are made of self-lubricating powder RV with liquid and solid lubricants are manufactured. The material can replace bronze providing substantial economic effect. Industrial production of «starter insert» parts for cars was mastered.

BLR-08

Powder CM based on polymer binding self-fluxing components with high hardness and manufacture of wear-resistant components of cutting pairs for forage harvester shredders, cultivator tillage tools functioning in conditions of intensive wearing.

Research on increasing reliability and durability of cutting pair components for forage harvester shredders, cultivator tillage tools with a covering obtained by electric contact building-up using metal-polymeric strips made of composite powder mixtures based on wear-resistant self-fluxing alloys has

been carried out. Metal-polymeric strips based on wear-resistant self-fluxing alloys with polymer binding were fabricated.

The technological process for applying coverings by electric contact building-up on a surface of parts working in conditions of intensive wearing and mechanical loading was developed.

The tooling for manufacture of parts with coverings was designed and fabricated. Experimental and pilot batches of powder mixtures and parts with coverings were obtained. Influence of modes for applying coverings using metal-polymeric strips developed on physical and mechanical properties, a material and transition zone structure was studied. The technological tooling for production of bimetallic nuts was designed and fabricated.

Microstructure research was carried out; physical and mechanical characteristics of applied coverings were determined. Processes for preparation and mixing of powder mixtures for obtaining metal-polymeric strips, as well for applying coverings on cutting pairs and agricultural machines tools were developed.

BLR-09

High-porosity cellular material based on nickel and alumina ceramics

Open-cellular inorganic foams are produced by cellular polymers structure coupling and have a developed twisting structure consisting of interconnected cells. They possess extremely high porosity and permeability, the controllable pore size, high stiffness, low density. It is possible to obtain them with high thermal stability, heat and corrosion resistance, catalytic activity. They are used for neutralization of dangerous volatile organic compounds emitted by enterprises in the atmosphere.

Application fields

- filtration of viscous liquids, aggressive or hot ones, including metal melts, and gases; precious metal vapor recovery;
- catalysis, mainly, ecological one;
- heating gas systems of a radiation type;
- flame-arresters, for example, for welding;
- electrodes in batteries; ion recovery systems;
- superlight structure materials.

The materials possess a unique set of working characteristics for a broad spectrum of applications.

BLR-10

Shell pigments-fillers

Pigment-fillers can be used as filling and coloring agents when producing stainers, paintwork water-dispersion materials, dry building mixes, for colouring some plastics, plaster articles, etc.

Technical characteristics:

- fine-dispersed powder of yellow, blue or red color;
- bulk volume: 2.2-3.0 dm^3/kg;
- dispersion, max: 15 μm
- aqueous extract pH: 5-8
- spreading capacity, max: 100 g/m^2
- humidity, max: 5%

BLR-11

Car break assembly parts

Purpose

Car industry plants. Antifriction parts based on powder iron are intended for installation in car break assemblies.

Technical characteristics

- porosity, %: 18-20
- hardness, HB: 700-750
- overall dimensions: external diameter: 15-50 mm, height: 15-60 mm.

Antifriction materials have components, which possess improved lubricating properties. Having got on a surface, the components decreases friction allowing parts to work more effective without extra loading and deformation.

BLR-12

Obtainment of hard alloy complex-shaped tool

Application field is tool production in oil-producing and mineral resource industry, metallurgy, mechanical engineering. The technology for production of hard alloy tool reinforced by superhard materials has been developed.

Technical characteristics

- hard alloy mix grade: BK6
- hardness, min, HRA: 86.7
- compression strength, GPa: 3.8
- density, g/cm3: 14.7
- free carbon content, %: 0.16
- x-phase content, %: 0.02

Contact Information

SSI Powder Metallurgy Institute of the NAS of Belarus, Platonova st., 41, 220005, Minsk
Fax: (017) 210-05-74, e-mail: alexil@mail.belpak.by

BLR-13

Synthesis of dispersed powder Ti(Ti-W)-based compositions for welding materials and applying wear-resistant coatings

A technology for synthesis of dispersed powder compositions based on Ti(Ti-W) for welding materials and applying wear-resistant coatings has been developed. Only a small part (not more than 5%) reacted with formation of $Fe_xCr_{yy}O_z$-type oxides after mixing initial powder (Fe_2O_3, Cr_2O_3) oxides. A small part (not more

than 5%) reacted with formation of complex Fe_xC_y-type carbides after mechanical activation of the initial Fe_2O_3 oxide powder.

Two compositions of dispersed powder material based on Ti(Ti-W) for obtaining welding materials and applying wear-resistant coatings: №1 (wt.%): C - 7.8; W - 16.9; Co - 1.0; Ti - 0.6; Fe - bal.; № 2 (wt.%): C - 3.8; W - 10.3; Co - 1.5; Ti - 0.6; Fe - bal. were developed. The technology for obtaining powder CM was introduced. Production of powder composite materials with capacity of 3 t/a was organized.

BLR-14

Electrodes for building-up of parts working in conditions of abrasive wearing at medium shocks

Consumers are building and repair plants, a mechanical engineering complex.

Electrodes are intended for manual arc building-up of parts by alternative and direct current of direct polarity functioning in conditions of abrasive wearing at medium shocks in a low and slightly inclined position.

For achievement of necessary parameters, complex master alloys for an electrode coating are used to obtain built-up metal with increased wear-resistance.

Main controllable parameters:

- building-up coefficient, g/A•hour: 9.0-9.2
- building-up productivity, kg/hour: 2.0-2.1
- electrode consumption per 1 kg built-up metal, kg: 1.3
- built-up metal hardness, HRC units: 60-64
- through-hardening temperature, °C: 180
- ferroalloys used in the electrode coating,%:
  - ferromanganese: 3.0 - 8.0
  - master alloy: 8.0-10.0.

BLR-15

Formation of protective coatings on a surface of machine and equipment parts, stamps and cutting tool

Formation of protective coatings on a surface of machine and equipment parts, stamps and cutting tool against intensive abrasive and mechanical wear by the method of microplasma action and tribological processing has been developed.

The process allows to increase service life of a wide range of articles taking into account conditions of their operation. Hence, it provides saving of expensive materials and reducing expenditures for repair and electric energy.

Technical characteristics

- increase in wear-resistance in comparison with an unprocessed article, times: 2-5
- adhesion to a substrate, %: 100
- microhardness, GPa: 11.7-16.0
- thickness, μm: for stamps: 1-150; for tool: 1-10
- roughness, Ra: 0.3-0.6

- porosity, %: 7.0-8.5
- 1 cm^2 coating cost with thickness of 10 μm, conventional units/cm^2: 0.05-0,5
- power intensity, kW: 0.2-0.5
- productivity, min/cm^2: 3.0-3.5

Contact Information

Institute of Welding and Protective Coatings
Platonova st., 12-B, 220005, Minsk
Tel.: +375 (17) 292-63-63

BLR-16

Silicoaluminate-based multilayer CM with increased strength

Multilayer CM with increased strength based on a silicoaluminate powder has been developed.

The materials were created using methods of isostatic pressing and high-temperature sintering of charge based on porcelain ware breakage. Particularities of changing a materials structure preconditioned by interaction of oligomeric aluminophosphate modifying solutions with a surface of porous aluminosilicate ceramics were studied.

Regulations on manufacture of filter elements, as well specifications were elaborated. Production of filter elements and devices on their basis was organized.

BLR-17

Synthesis and formation of properties of nanostructured ceramic CM for bone regeneration

The process for obtaining composite ultradispersed powders of nickel-tin, nickel-tin-diamond systems has been studied. Stability of ultradispersed pseudohomogeneous mixtures (conglomerates) besides their structure is determined by the processing sequence for obtaining plasticized salts.

Parameters of main technological operations for obtaining composite ultradispersed powders of nickel-tin, copper-tin, nickel-tin-diamond systems were determined.

The influence of sintering technological parameters on CM physical and mechanical characteristics, and sintering time on hardness and compression strength was established. Using data on influence of fabrication modes on material physical and mechanical characteristics, technological processes were developed.

Contact Information

SSI Institute of General and Inorganic Chemistry of the NAS of Belarus
Surganova st., 9, build. 1, 220072, Minsk
Fax: (017) 284-27-03
E-mail: secretar@igic.bas-net.by

BLR-18

«Altanit» aluminum nitride-based ceramic material with high thermal conductivity

The material can be used as the hybrid IC substrate, microwave transistor holder instead of high-toxicity ceramics based on beryllium oxide for manufacture of resistor bases.

The method is distinguished by high productivity, excludes the use of bindings and additives for sintering activation. It provides high density and heat conductivity of ceramics based on aluminum oxide. As opposed to beryllium oxide it is non-toxic and cheap. The material can be obtained in the form of plates with diameter of 10-26 mm and thickness of 1-5 mm. Inventor's certificates and patents for the method of obtainment are available.

Technical characteristics

- Heat conductivity: 185 W/(m·K);
- Dielectric permeability: 8-12;
- Resistivity: 10^{13} Om·cm;
- Density: 3.25 g/cm^3;
- Microhardness: 16.5-18 GPa;
- Vickers hardness: 14 GPa.

BLR-19

Emerald growing

The effective technology for emerald monocrystals growing from a high-temperature flux allows to obtain crystals with unique optical quality and characteristics close to a precious natural stone.

Emerald characteristics:

- chemical formula: $Be_3Al_2Si_6O_{18}$:Cr;
- color: light green, green, dark green;
- pleochroism: green-yellow-green;
- refractive index: 1.558-1.562;
- density: 2.65 g/cm^2;
- Mohs hardness: 8.

The solution-melting technology allows to optimize color of raw material grown, as well a set of defects similar to natural stones. Emerald grown as a natural one has red color through the Chelsea filter, does not exert luminescence at UV-radiation.

BLR-20

Metallic nanowire and nanostructured materials on its base

Nanowires were successfully used for creation of:

- polymer-based composite materials providing antistatic effect and electric conductivity;
- magnetic lubricants, magnetorheological fluids for precision mechanics;
- anodes with high discharge characteristics for chemical current sources;

- transparent electrodes for charge current collection from a monitor surface, energy photoconverters;

The method is based on salt and metal synchronic co-crystallization on the cathode when electrolysis takes place. It allows to produce metallic fibers in industrial scale, create high-quality novel materials and articles with a new set of properties.

Advantages:

High productivity and yield per reactor volume unit; low prime cost of the product; wire homogeneity by thickness; directivity, corrosion-resistance.

BLR-21

Oxide nanocomposite materials

Nanocomposite based on complex nickel-, manganese- and cobalt-containing oxides for electrode materials for fuel cells, oxygen membranes and catalysts of chemical reactions at waste utilization, magnetoelectric materials for spintronics devices and sensor techniques have been created.

The original method for obtaining nanocomposite ceramics consisting of particles with a little different chemical composition is proposed. The method includes several stages: obtaining standard materials with following reduction and oxidation at low temperatures.

A method for compacting under high pressure and at middle temperatures is used for gasproof materials synthesis.

Simplification of the technology and decrease of synthesis temperature by 300-400°C provide creation of new nanoceramic electronic materials for electrochemistry and gas separation devices with higher characteristics in comparison with traditional ceramic ones.

Contact Information

SO Scientific and Practical Materials Research Center of the NAS of Belarus
220072, Minsk, P. Brovki st., 17
Tel.: (+375 17) 284-15-58

BLR-22

Synthesis of nanosized oxides, semiconductors and noble metals for creation of novel CM

Methods for synthesis of nanosized oxides, semiconductor substances and noble metals for obtaining novel CM have been developed. The process for formation of thin-film CM containing silver or germanium nanoparticles in matrixes of silicon and germanium oxides was elaborated. Perspectiveness of application of SiO_2-Ge, GeO_2-Ag-Eu_{3+} thin-film nanocomposites as luminescent films was established.

The method for formation of chained structures using polymer microspheres doped by luminescent quantum-sized nanocrystals, which are supposed to be used for creation of microlight structures of a new type for optical commutation in microelectronics, was developed. Selective concentration of noble metals using their contact recovery for industrial waste processing containing precious metals was developed.

BLR-23

Textured non-homogeneous nanoscale mixture of metal powders and CM instrumental use

There was investigated as composite systems of ultrafine powders of nickel-tin, nickel, tin and diamonds. The stability of ultrafine pseudo-homogeneous mixtures (conglomerates) in addition to their structures determined by the sequence of operations receiving plasticized salt. The parameters of the basic technological operations of composite systems of ultrafine powders of nickel-tin, copper, tin, nickel, tin and diamonds.

The influence of sintering process parameters on the physico-mechanical characteristics of the CM and the duration of sintering on the hardness and compressive strength. On the basis of the data on the impact of modes of production on the physico-mechanical properties of materials designed processes.

Contact Information

Research Institute of Physics-Chemistry Problems of the BSU
Minsk, Independence avenue, 4
Tel.: +375(17) 209-50-85

BLR-24

Laser strengthening

Laser heat treatment is based on the use of heat generated on a material surface when absorbing a laser beam.

Laser hardening of car rear axle parts allows to increase their durability by 3 times.

For parts like valve spindle, hardness of working necks is 60 HRC units, while general hardness of the part is 40 HRC units.

Laser strengthening is promising in tool-making.

Strengthening of cutting and cold-upsetting tools, press and stamp tooling parts allows to increase their durability by 3-5 and more times.

The 1.6-3.0 times strengthening effect was proved for metal- and wood-working tools, including those equipped by hard-alloy inserts.

Alloying of forging dies made of 5XHM steel, durability of which is increased by 3-4 times, has been developed.

Laser alloying allows to obtain layers on steels and titanium alloys with hardness of 68-70 HRC units, on aluminum alloys with hardness of up to 25-30 HRC units.

BLR-25

Combined plastic formation based on wedge taper rolling and stamping

Production of parts for car, machine-tool, instrument-making, agricultural engineering, tractor construction, aircraft building, motorcycle and bicycle building, mineral resource and nuclear industries.

A number of resource-saving technologies for production of different parts have been developed.

It includes wedge taper rolling of a blank and following flash-free stamping.

The wedge taper rolling is used for manufacture of intermediate profiled blanks for the following precision stamping or other plastic formation processes.

Competitive advantages:

- increase in productivity
- articles high precision and surface finish
- improvement of articles working characteristics by 20-30%
- tool durability before its complete breakage is 1 mil. articles
- excluding or minimizing finishing work.

Contact Information

Physical-Engineering Institute of the NAS of Belarus
Academician Kuprevich st.,10
Tel.: (+375 17) 263-59-09

BLR-26

ITMOL-Su200 - Universal calcium sulfonate-based consistent lubricant

Application fields

Mechanical engineering, metallurgy, agriculture, car industry. The high-viscosity lubricant based on mineral oil is produced using the state-of-the-art technological achievements in the field of calcium sulfonate dispersed phases. It is obtained from a mixture of petroleum oils with kinematic viscosity of 60-110 mm^2/sec at 400°C by densifying with the use of calcium sulfonate complex; a dispersed phase structure provides antiwelding properties:

- extremely high service life;
- working ability up to 150°C;
- excellent mechanical stability;
- excellent lubricating characteristics for heavy duty slow-rotation bearings.

Due to a combination of high mechanical stability, thermal and water resistance, it is indispensable for metallurgy and forging plants. The distinguished feature of the lubricant is high density, which allows it to be used in sea-based objects.

Contact Information

SSI Institute of Heat and Mass Transfer of the NAS of Belarus
220072, Minsk, P. Brovki st., 15
Tel.: (+375 17) 284-23-85

BLR-27

Diamond-like carbon coatings

Technologies for applying diamond-like carbon coatings provide:

- increase of machine and mechanism parts service life;
- improvement of wear-resistance of inspection tool geometrical sizes;
- protection of working surfaces of casting molds and stamps used for formation of plastic articles;
- resizing of working surfaces of worn-out precision friction pairs;
- improvement of implants biocompatibility used in traumatology, orthopedics, cardiosurgery.

The technology uses the method of impulse cathode-ray charge in vacuum and condensation of high-velocity carbon plasma flows. It is based on application of impulse carbon plasma generators with graphite electrodes. High energy and plasma flow ionization degree provide good adhesion of the coating deposited to material of casting molds. Such coatings possess unique mechanical, chemical and thermal characteristics.

Combination of low friction coefficient and high wear-resistance allow to increase manifold service life of precision pairs of machine and mechanism friction units. The use of such coatings enables to improve working characteristics of casting molds and reduce quantity of flawed items, increase endurance of foundry equipment, exclude expensive energy-intensive and environmentally harmful galvanic and chemical processes. Metal implants with the diamond-like coatings are distinguished by high biocompatibility. The coatings do not provoke blood coagulation, are an effective barrier preventing ion metal diffusion. They can be effectively used for implants contacting with organism bone and soft tissues.

BLR-28

Applying protective wear-resistant coatings

Coatings based on diamond-like carbon and a technology for their applying to provide effective protection of a thermal heads` thermistor board surface against abrasion because of movement of a temperature sensitive paper tape in cash registers and other thermal printing register devices.

The technology is based on chemical vapor deposition of diamond-like coatings by decomposition of carbon-containing vapor and gases in low-temperature plasma. It is realized in production conditions using industrial vacuum units.

Main technical and economic parameters:

- average power consumption, kW: 25
- maximal volume of thermistor boards with size of 10x45 mm in a batch, m^2: 0.05
- technological process duration, max, min: 45
- a number of controllable technological parameters: 4
- temperature at the beginning of coating applying process, °C: 20

Coatings` main technical characteristics

- thickness, μm: 2÷4
- hardness, min, GPa: 20
- heat resistance, °C: 400
- wear resistance, m: >50000
- thermal printing operation speed, Hz: >250
- technological lifespan, cycle: 108

Contact Information

SEC «Plasmoteg»
Physical-Engineering Institute of the NAS of Belarus
Academician Kuprevich st.,1, build. 3
Tel.: +375 (17) 211-83-71

BLR-29

Elastomer CM and production of reinforced rubber technical goods

Rubber reinforced cups are used for shaft sealing. They can function in mineral oils at excessive pressure of up to 0.05 MPa (0.5 kgf/cm^2), speed of up to 20 m/sec and in a temperature range: -60°C ÷ 150°C. The material is created on a base of special rubber. A technology for manufacture of reinforced rubber technical goods has been developed.

Technical characteristics:

- nominal tensile strength, MPa: 21.0x23.0
- specific breaking elongation, %: 470-490
- Shore hardness, unit: 68-72
- hardness, IRHH unit: 70-76
- hardness changing after aging in air during 72 hours at (150±3)°C, standard unit: + 4x + 5
- hardness parameters changing after SGR-1 action at 150±3)°C during 72 hours, standard unit: +5
- ozone resistance, hour: >100
- volume changing after SGR-2 action, %: 9.7-10,8
- mixing and homogenization time, min: 40-50

Contact Information

Belarusian State Technological University (BSTU). 220050, Minsk, Sverdlova st., 13a. Tel.: +375(17)226-14-32

BLR-30

Polarizers for optoelectronics and protection technologies

Film polarizers for liquid-crystal information display devices and creation of a dichroism structure based on polyvinyl alcohol and a dichroism agent (molecular iodine or an organic dye). The method is broadly used at production of high-quality polarizers of firms «Nitto Denko», «Polaroid Co.» and «Ace Digitech». The polarizers are axially oriented films containing the polarization agent (iodine or organic dyes) and special additives to give the material necessary optical and mechanical properties. The film polarizers are protected against environmental action by a triacetate film and have an adhesion layer coated by an adhesion polyethylene terephtalate film.

Contact Information

SSI Institute of Chemistry and New Materials of the NAS of Belarus. 220141, Minsk, F. Skoriny st., 36

BLR-31

Impulse-plasma modification of tool working surfaces

Strengthening working surfaces of articles made of medium- and high-carbon tool and structure steels with high accuracy and finishing rating. Equipment for impulse-plasma modification allows to generate impulse plasma flows with diameter of ≈30 mm, temperature of 5000-10000 K and frequency of 10 Hz in air

at standard pressure providing application simplicity, high-productivity and efficiency in treatment of tool working surfaces, whereby a microcrystalline surface layer with a dispersed crystal structure is formed, which possesses high hardness, fatigue strength, wear- and corrosion-resistance.

Due to longer impulse-plasma action, a strengthened layer with a depth of up to 0.5 mm and microhardness of up to 10 GPa is formed on a high-carbon tool steels surface.

Technical characteristics:

- AC power consumption, kW: 15.2
- Supply-line voltage, V: 380/220
- Impulse plasma generation frequency regulation, Hz: 1-10
- Plasma impulse number regulation: 1-999
- Impulse plasma type: air
- Impulse-plasma processing area, mm: 200x200x50
- Steel surface modification speed, max, μm/sec: 100

The technology allows to increase wear-resistance of tool working surfaces, as well its durability and service life.

Contact Information

Belarusian National Technical University
220013, Minsk, Independence avenue, 65
Tel.: (+375 17)296-66-82

BLR-32

Diamond, cubic boron nitride micropowders with yield of up to 60-70%

Cubic boron nitride micropowders are used for manufacture of composite edge and abrasive tool, processing steels, iron and other materials with increased hardness, as well for their superfinishing. Synthetic diamond micropowders are used for obtaining of metal-working composites, grinding and polishing tool for steels, ceramics, alloys, glass.

Technical and economic parameters:

- main fractions grain size, μm: 40
- yield relative to the whole weight,%: 60-70
- abrasive ability, units: 2.5
- increase of abrasive ability in comparison with the best analogues,%: 24
- micropowders correspond to the standard ТУ РБ 03535138ЮО002-98.

BLR-33

Throw-away cutting inserts made of polycrystalline superhard material based on CBN

These throw-away inserts are used for equipping of mills processing iron and hardened steels at semifinishing and finishing with standard and increased speeds at mechanical engineering plants.

The technology for obtaining throw-away cutting inserts made of high-quality fine-grained cubic boron nitride (CBN) powders has been created on base of industrial press aggregates DO 137A and high-pressure hard-alloy chambers. The inserts are intended for edge tool focused on semifinishing and finishing operations.

Technical characteristics

- Knoop hardness, GPa: 32-35
- Fracture toughness index, MPa•m1/2: 9.3-9.5
- Young modulus, GPa: 690-700
- Resistance time over grey iron, min: 60

The use of these inserts allows to exclude import and increase technological independence of mechanical engineering plants.

Contact Information

SSI Joint Institute of Solid State and Semiconductor Physics of the NAS of Belarus
Minsk, P. Brovki st., 17
Tel.: (+375 17) 284-13-13

BLR-34

Structural and high-dispersed silumin modifiers

Application is modification of steels, irons, bronzes, brasses, silumins in foundries and metallurgy.

Structural and high-dispersed silumin modifiers allow effectively to make finer and improve a structure of steels, irons, bronzes, brasses and silumins. All main phase components of the alloy are modified. Modifiers are ecologically safe, completely absorbed by melts and do not form a slag. Modifiers consist of silumin with small additives of Ca, Mg, Sb, Ti, rare earth metals; are relatively low-melt, do not form slag, are absorbed by a melt to a considerable degree, possess refining and degassing ability, has high chemical affinity to oxygen, sulfur, nitrogen and hydrogen.

Modifiers form is ingots, parts of different fractions. The efficiency of modifier action is increase with its high structure dispersion. The modifier is distinguished by low cost, can be easily produced with high productivity using hardening crystallization and casting in a jet mold. Modifier service life is not less than 1.5 hours. The modifier makes finer both initial and eutectic silicon crystals. The novelty is high structure dispersion of modifiers. The sizes of eutectic silicon crystals are 0.2-4 μm. This significantly increases the efficiency and modification operation time.

BLR-35

Aluminum-silicon alloys with nanostructured eutectic silicon

Application is mechanical engineering and instrument-making, aerospace industry. When adhesion friction takes place, workpieces have an inverted structure with anomaly high ductility and wear-resistance. Obtainment of ingots with diameter of 40-150 mm and height of up to 300 mm of silumins with nanostructured eutectic silicon, which based on casting with hardening crystallization. Eutectic silicon in ingots has a globular form and dispersion of up to 200 nm. Ingot mechanical properties increase in 40-70%, service life of experimental pistons is enlarged by 3 times.

Wear-resistance of ingots of AK12 and AK18 silumin with nanostructured eutectic silicon at dry friction over a steel plate exceeds that of antifriction bronze more than 30 times. Adding such ingots in a charge in amount of 20%

allows to retain heredity of a modified structure during more than 2 hours. Service life of experimental worm gears in a redactor of grinding and polishing machine-tools surpasses analogous ones made of БрАЖК9-4 bronze 6 times. Ingots possess anomaly ductility; they can be stamped to produce bushes of different purposes. The technology provides improving mechanical and antifriction properties of silumin ingots, increasing service life of ICE pistons.

Contact Information

SSI Institute of Metal Technology
212030, Mogilev, Byalynitskogo-Biruli st., 11
Tel.: (+375 222) 28-06-50, 28-06-44

BLR-36

Chemical modifiers for reinforced concrete structures using

Possibility to broaden application fields of Portland-slag cement-based concrete by compression strength, frost- and water-resistance grades has been established. The concretes obtained using equal-flowable (P2) concrete mixes with additives (СМ-1 and ГП-1 plastifying agents with Nidoxan-story air-entraining admixture) had frost-resistance by 1 and 2 degrees higher in comparison with no-additive ones. Using the modifiers allows to broaden possible application fields for concrete based on Portland-slag cement up to C 40/50 compression strength grade, F300 frost-resistance grade and W12 water-resistance grade.

BLR-37

Emulsion-mineral mixes with accelerated strength gain

The advantage consists in the accelerated strength gain because of intensive water drainage. The method is intended for construction of local highway pavement layers. Emulsion-mineral mixes with accelerated strength gain are produced using Delta-100 mobile units made in Belarus.

The method has the following advantages in comparison with traditional ones:

- decrease of road works total cost by 20% at the expense of reduction in energy expenditure and construction pavement cost;
- increase of ecology safety in the area of mix obtaining and placing;
- decrease of dependence on whether and climate conditions at road works;
- accelerating coating working characteristics gain.

BLR-38

Modified concretes with high frost and corrosion resistance

The concretes are intended for manufacture of monolithic and reinforced concrete articles and bridgework structures, barriers, pavements, parkings, which are subjected to action of deicing chemical reagents and other aggressive environmental factors. High working characteristics are achieved at the expense of using high-efficiency superplasticizers, air-entraining (gas-producing) additives, delaying placeability loss.

The efficiency of the use of concrete with high frost and corrosion resistance is achieved due to absence of necessity to carry out periodic repairs of structures during their exploitation.

Concrete properties:

- compression strength grade B30-B70
- frost resistance grade (tests according to the second base method): F150-F300
- water resistance grade up to W20
- water absorption by weight, max 3%

Modified concretes with high frost and corrosion resistance have been used at construction of bridgeworks across Western Dvina in the area of Vitebsk and Verhnedvinsk cities, across Sozh river in the area of Krichev city.

BLR-39

Sealing bitumen-elastomer mastics

Sealing cracks, joints; waterproofing at repairing and building of roads, aerodrome surfacing, bridges, overhead crossings, as well foundations and basements at construction. Depending on purpose and softening temperature, there are six bitumen-elastomer mastics produced:

- T-65-filling of pavement cracks;
- Sh-75, Sh-90, Sh-100-filling of joints in a road and aerodrome surfacing;
- Г-90-waterproofing bridges, overhead crossings, buildings` foundations and basements;
- M-85-structure of crushed stone-mastic movement joints in a bridge road bed.

Bitumen-elastomer mastics are produced on the base of oil asphalt, thermoplastic elastomers of domestic or foreign manufacture with additives of plasticizers and fillers. They possess high heat-resistance and deformability at negative temperatures. The mastic is produced in a form of briquettes in 20 kg or bundles in 50 kg packed in a polyethylene film or paper with an adhesion cover. Mastic working temperature is 170-190°C at minimal air temperature +50°C. The mastic is firmly slicked to pre-primed concrete surfaces, forms a solid covering at cooling.

By physical and mechanical properties, it is on a par with mastics of famous world producers «Crafco» (USA) and «Biguma» (Germany).

Contact Information

State Enterprise «BeldorNII»
220073, Minsk, 4th Zagorodny alley, 60
Tel.: (+375 17) 259-82-07
Fax: (+375 17) 204-32-94

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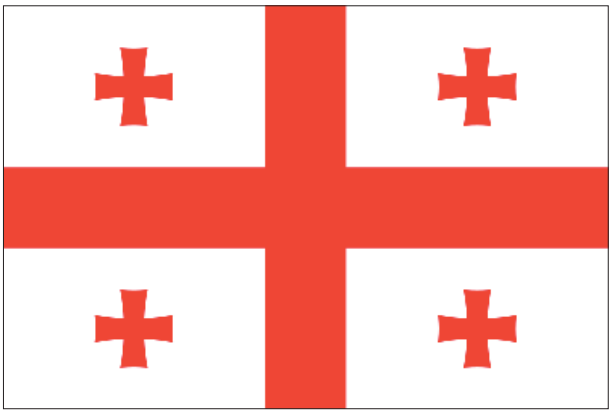


High-effective materials for human hip joint implants. Processing with high accuracy and quality of their spherical surfaces



R. Turmanidze, Professor, D. Sc. **M. Beridze** **T. Aptsiauri**

Georgian Technical University, Tbilisi

One of the widespread diseases of the XXI century is arthrosis. The unhealthy lifestyle of a modern man influences on a bone system that leads to miserable consequences and becomes a reason for increasing needs in artificial implants of practically all types, especially hip joint one.

Heads of such endoprosthesis by a character and size of loading are functioning in extreme conditions. Modern joint endoprosthesis consist of acetabular (cup) and femoral (stem) components, as well a head made of metals or ceramic materials on their basis with an acute problem on creation of wear resistant inert materials for such products.

In each concrete case the selection of the necessary material with proper physical and mechanical characteristics, the increase in processing accuracy and quality of the most significant part of the endoprosthesis, namely spherical surfaces, are a rather actual task, edge of which is constantly growing.

The reason is that if earlier the necessity of such operations has been caused basically by the age factor or traumatologic fractures, over the past twenty years the quantity of ill 30 ÷ 40 year old men and women not having traumas and fractures has sharply increased. In doctors` opinion the fundamental causes of this phenomenon are a sedentary lifestyle of the youth, composition of up-to-date foodstuff, metabolism problems. All above-stated reasons determine the quantity of endoprosthesis used, some dozens millions of pieces per year and, unfortunately, this quantity is annually increasing (fig. 1-2).

Manufacture of implants made of bioceramic materials is rather profitable. The powerful industry of their manufacture and necessary tools and relevant materials has been created. The west market of this production is estimated in 2.5÷3 billion doll. per year.

Medical practice proves that repeated prosthetics of a hip joint

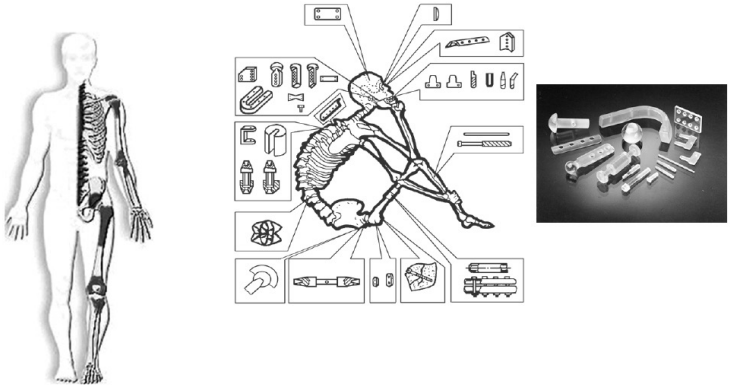


Fig. 1. The influence of the human lifestyle on the skeleton and implants

is connected with big problems. In many cases such operations are practically impossible and, for this reason, service life of a hip joint endoprosthesis up to the end of patient's life has, especially in young age, exclusively great significance.

This circumstance explains the fact that large-scale research works on development of optimum schemes for shape forming, an abrasive tool for finishing operations, technological process, as a whole, to manufacture endoprosthesis spherical heads of different materials with the shape's minimal error and surface's high quality are being conducted in such world's leading countries, as the USA, Germany, GB, Japan, France and other advanced countries (fig. 3).

Endoprosthesis` state-of-the-art designs are invoked to replace hirulen by ceramic material that requires the change of its design, development of new ceramic materials with improved physical and mechanical characteristics, technologies for processing of internal and external spherical surfaces, development of diamond tools providing high quality of the processed surface, determination of optimum wear resistance for a pair of materials for manufacture of these endoprosthesis.

In world practice such heads are manufactured, basically, of different alloys, composite isotropic materials and ceramics. The published data on the above mentioned works do not give the necessary information on processing of anisotropic materials, in particular, a sapphire artificial crystal (fig. 4-6).

Artificial joints with metal, ceramic, metal- and ceramic-polymer friction couples corresponding to natural biomechanical joints «hip joint head – coxal cavity» are widely used at prosthetics.

Alongside with positive qualities, the state-of-the-art designs of the endoprosthesis made of metal, ceramics, polymers, have certain disadvantages. There are insufficient biological inertness and excess wearing of friction couple components among them that leads to impermanence in functioning of the artificial hip joint. Besides, as a result of the material wear process in the endoprosthesis friction couple toxic and cancer danger disintegration products are accumulating in bodies and tissues that leads to complications and requires difficult disabling operative interventions in 30-40% cases.

A spectrum of materials satisfying the criterion of biological compatibility, is limited. As consequence and because of a high resource in conditions of cyclical load action and corrosion-aggressive environment, titanium and its alloys, as material for endoprosthesis, have advantage in comparison with Co-Cr-Mo alloys.

Wearing of heads made of zirconium ceramics makes 7÷9 nm/year, while wearing of titanium heads is 105 nm/year. As a result of this manufacture of implants made of bioceramic materials is a promising direction in development of science-intensive technologies for creation of materials and their treatment.

Fig. 2. Lifestyle of people

Table 1. Biocompatible materials properties

Characteristic	Sapphire	3Y-TZP	(Y, Ce, Hf)-TZP
Bending strength, MPa	> 400	850	> 800
Cracking resistance factor, K_{1C}, MPa·m$^{-1/2}$	3.5	8 ÷ 11	> 7 ÷ 9
Young`s modulus, GPa	400	209	200
Tetragonal phase content, %	-	100	> 98
Density, g/cm^3	3.99	6.03 ÷ 6.05	6.01 ÷ 6.02
General porosity	0	0	0
Open porosity	0	0	0
Microhardness, GPa	19.4 ÷ 22	10 ÷ 12	10 ÷ 12
Y_2O_3 content, %	-	3	3
Autoclave treatment	-	possible	

The most compatible with a human body, wear-resistant and durable material for manufacture of the above mentioned product is the artificial sapphire monocrystal.

Resistance of this material to action of any acids and alkalis incommensurably higher in comparison with metals and polycrystalline aluminium oxide. Apparently, it is the reason why the sapphire does not change the patient's immune status. While different rate of microsites wearing of metals and polycrystalline materials used for bearing surfaces leads to increase in couple's friction factor and abrasion, there us no such effect in case of the sapphire.

Tribological tests of friction couple of biocompatible materials are one of the criteria to select materials for bearing surfaces of human artificial joints. With this purpose similar properties have been investigated for the following friction couples:

- Sapphire with different density of a crystal lattice in a sliding plane: 0001, 1010 and 1018;
- Tetragonal zirconium dioxide with composition: 97%mol. ZrO_2 + 3%mol. Y_2O_3 (3Y-TZP) most widely used for manufacture of hip joint heads;
- Tetragonal zirconium dioxide with 99% nanosized component content of ZrO_2, Y_2O_3, CeO_2 + HfO_2 ((Y, Ce, Hf)-TZP), at Y_2O_3 from 4.5 up to 5.4%, CeO_2 3.0%, HfO_2 no more than 2%.

Some physical and mechanical properties of materials investigated are presented in table 1.

Thus, the aim of the work is creation of a novel bearing hip joint endoprosthesis having improved qualities due to the use of strengthened sapphire and biologically inert technically pure titanium with surface layer modification by SPD and subsequent nitriding.

To investigate sapphire crystal machinability, low-temperature precision grinding (LPG) developed in the «Technology of mechanical engineering» chair of Georgian Technical University has been chosen as a version of methods for diamond grinding of hard and fragile nonmetallic materials.

According to the analysis of complex research carried out, it is possible to make the following conclusion:

At all other conditions equal, the most difficult task is to provide processing on a plane (0001).

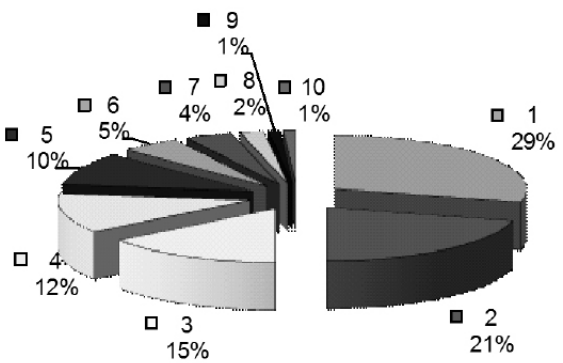


Fig.3. World endoprosthesis producers: 1. USA 2. Japan 3. Germany 4. France 5. Great Britain 6. Russia 7. Italy 8. South Korea 9. Asian region's countries 10. Other countries

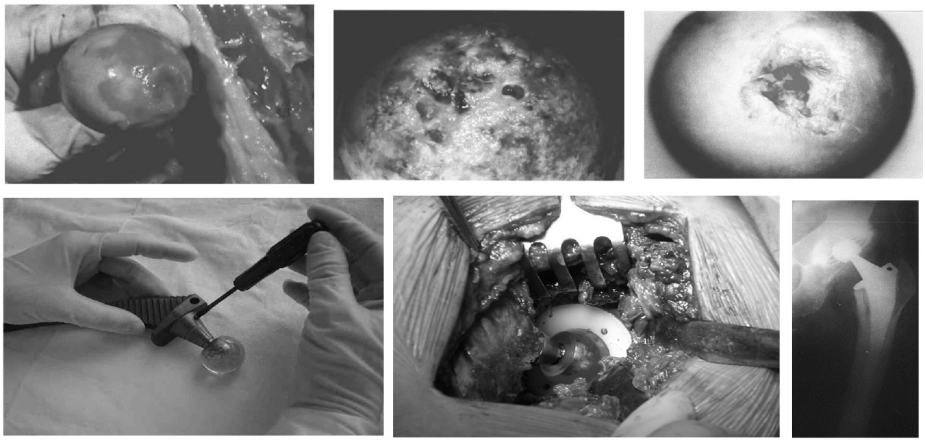


Fig. 4. Pathology of natural human hip joint. Operation on endoprosthesis replacement of human hip joint by the endoprosthesis with a sapphire head

For all diamond wheels the linear material removal value q varies in a range: $q_{0001}/q_{1010} = 0.25 \ldots 0.5$, and $q_{1012}/q_{1010} = 0.75 \ldots 1$.

Processing efficiency grows in a range of cutting speed V=1 … 6 m/sec, whereas it remains constant at its further increasing up to 12 m/sec.

With increasing of pressing force P efficiency grows in the whole range, however, it considerably decreases in an interval of P =1000 … 1500 kPa.

Diamond tool productivity is mostly influenced by its granularity and binding used. The effect from the concentration is insignificant. With increase in the grain size in a range of d_3 = 14/10 … 28/20, efficiency increases 1.5...2.5 times. The maximum processing efficiency is provided by a tool with ceramic binding ({0001} - 130 μm/min; {1010} - 300 μm/min; {1012} - 250 μm /min); then with metal binding ({0001} - 50 μm/min; {1010} - 200 μm/min; {1012} - 170 μm/min); with an organic binding ({0001} - 30 μm/min; {1010} - 120 μm/min; {1012} - 110 μm/min), at the same time the tool with ceramic binding functions in a self-sharpening mode.

Granularity and binding material of the diamond tool, mostly, influence on surface quality. With increase in the grain size in the range, the unevenness height R_z grows in a range of 1÷1.5 classes, and a broken layer depth H increases 1.5÷2 times. At all other processing conditions equal the higher quality of the surface is achieved at orientation (0001) then at other two ones. The difference makes 1÷1.5 roughness classes. Diamond wheels with organic binding show the best results. For example, with bindings BC-11 and organic special binding have been obtained the following results: R_z =0.25 μm; t_{po3} = 35...45%; H=2... 5 μm. In this case the R_z parameter value is by order lower, t_{po3} 1.5 times higher; H is 3...5 times less than relevant parameters for diamond wheels with ceramic and metal bindings.

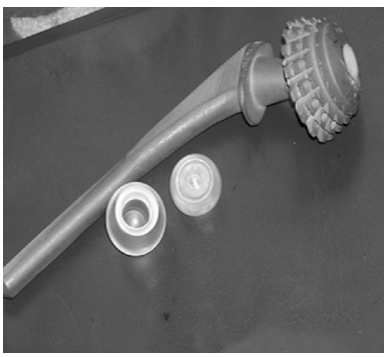


Fig. 5. General view of the endoprosthesis

The character of process influence on target parameters for the chosen orientations of a sapphire crystal ((0001), (1010), (1012)) are constant.

Study of surface morphology has proven the possibility to cut sapphire by plastic deformation of a removed layer at low speeds V=1 … 3 m/sec, with the least depth of a broken underrelief layer.

It is known, that processing of glass-like materials, in particular, a sapphire crystal by plastic deformation of a removed layer, instead of fragile destruction is a guarantee to obtain the processed surface practically not having hereditary defects and a broken underrelief layer. That is why the H value is the least one on these sapphire samples.

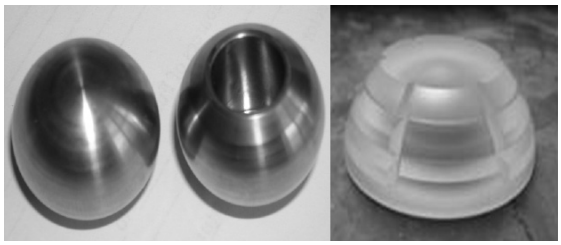
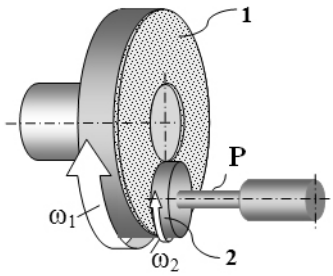


Fig. 6. Samples of the titanium head and sapphire cup for endoprosthesis of hip joint

The result obtained requires extra research, which is planned in future.

Tribological tests of friction couples materials were carried out according to the scheme of rotary friction with contact geometry, such as «ball-on-disc». The flat disk was made of the material to be investigated, the ball was made of the counterface`s material.

Tribological tests were conducted in the T-20 unit with the tribological system, such as «ball-on-disc», which consists of the motionless flat disk made of the material to be tested and the ball made of the counterface`s material rotating with preset speed n. The disk is pressed with the load P. Friction force and disk's linear wearing are measured. The temperature of the process was not registered, but maintained at a constant level.



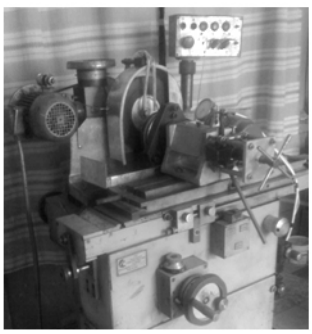


Fig. 7. LPG scheme: 1 – grinding wheel 2 – cassette with parts 3 – laboratory unit for LPG

Dependences of the friction force of sapphire – sapphire, sapphire – ruby couples on time (quantity of cycles) have, mostly, a nonmonotonic spasmodic character. It is possible to distinguish three stages of the wearing process.

Running-in wear is creation of a working roughness and necessary support on rubbing surfaces. In the beginning of work contact between bodies take place in a point; specific load is rather large. It leads to a sharp growth of friction force and, as consequence, to wearing surfaces material.

Normal wear is after achieving of wearing value, when basic surface's optimum characteristics are attained, a stable process of friction between bodies takes place with the gradually decreasing friction force.

Catastrophic wear takes place, when abrasion products during counterfaces friction gradually fill in pockets on the friction surface and owing to weak (drop) feeding of Ringer`s solution into the friction zone they are collected completely occupying free space of pockets, and take part in wearing process of surfaces researched as free abrasive.

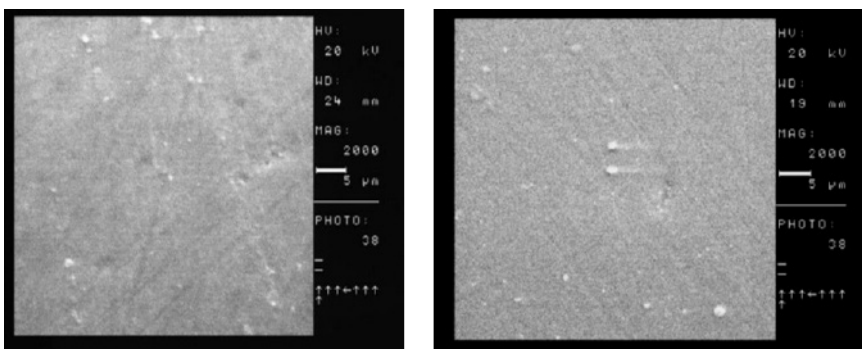


Fig. 8. Photomicrography of sapphire sample surfaces treated by LPG: 1010 orientation and 1012 orientation

It is necessary to take into account that wear resistance and seizure contact pressure of a friction couple significantly depend on thickness of the modified layer and its bearing ability. The increase in thickness of a nitrated layer and its bearing ability is promoted by creation of deformation-originated nanostructures in it. It worth noting that the mechanical characteristics increase of technically pure titanium by cold plastic deformation practically does not change its tribotechnical properties.

To decrease the friction factor and seizure contact pressure and increase wear resistance up to a level shown now by the best metal - metal couple made of Co-Cr-Mo alloy, it is required to solve a task of combination in one friction couple of bearing surfaces with different physical and chemical properties of titanium and nitrogen compound, its crystallographic structure that will be investigated for the first time.

Metal - metal friction couple (wearing of implants is 0.0025-0.005 mm per year) is more wear resistant in comparison with metal - polythene couple (0.5 mm per year). A problem to use Co-Cr-Mo-alloy is connected with building of many nanosized metal particles, which lead to pathological changes in an patient's organism, because of osteofluence (tissue inflammation), metallosis, lysis of bone tissue, and occurrence of abrasive products in internal bodies. Some patients have hypersensitive reaction that can limit applicability of such implants. Besides such friction couples lead to increase of a cobalt and chrome level in blood serum. The question is the influence of ions of these metals on an organism, as a whole. Metal bearing surfaces are contraindicative for patients with renal insufficiency or risk of its development. Implant insertion is contraindicative, first of all, for women of the genital age.

Titanium and its alloys are widely applied in medicine as implants and other articles. From the point of view of biocompatibility for long functioning implants in an alive organism, it is more preferably to use titanium, which, as against alloys, does not contain alloying additives harmful for an organism. However, titanium, as a rule, has low mechanical properties in comparison with its alloys. This problem could be solved by formation in technically pure titanium of a nano-and composite structure.

Application of the sapphire/titanium couples would allow to solve this problem. However, it is considered that it is impossible to make a friction couple made of titanium and its alloys because of their high

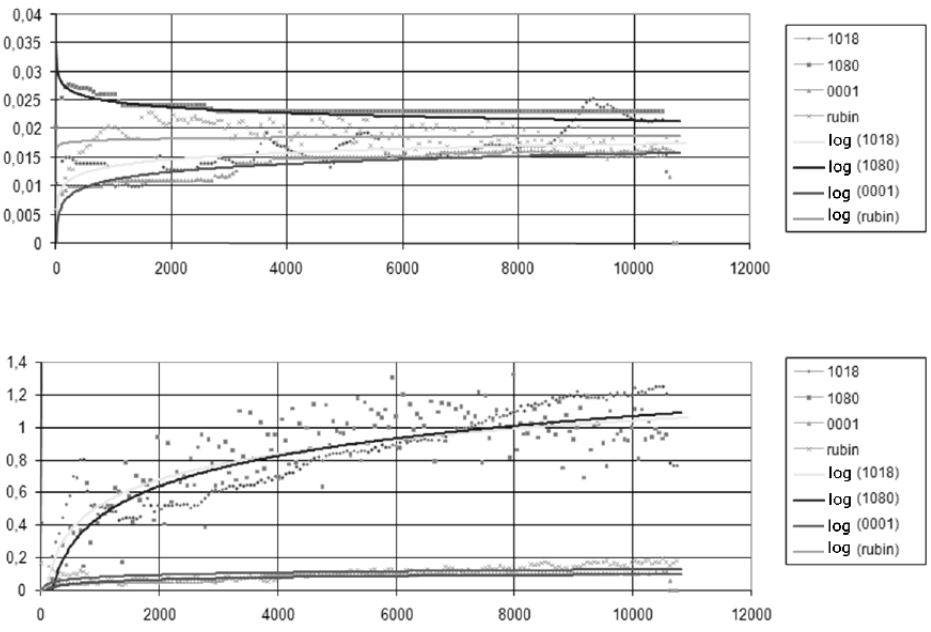


Fig. 9. Scheme of rotating friction – a, example of counterfaces

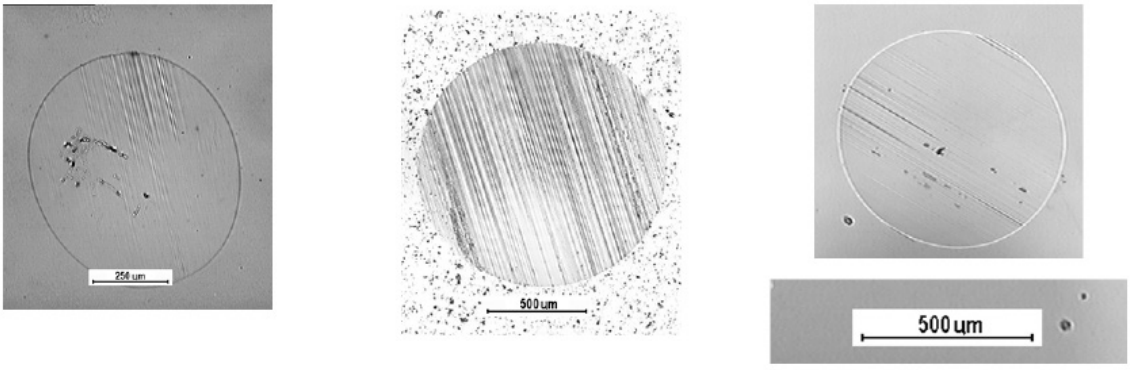


Fig. 10. Photo of wear spots on the surface of a disc made of: 0001 sapphire, 3Y-TZP, (Y, Ce, Hf)-TZP

susceptibility to contact seizure and increased friction wearing. This singularity makes titanium application in rubbing couples rather dangerous.

The best results are shown by the sapphire - sapphire couple with crystal lattice orientation in the 0001 plane regarding friction force - pressing force ratio, sapphire - sapphire couple with crystal lattice orientation in the 0001 plane and sapphire - ruby couple regarding friction force - linear wearing ratio (fig. 10).

Depending on crystal lattice orientation, the best results regarding friction force – pressing force ratio are demonstrated by the sapphire - sapphire couple in the 0001 plane, the best results regarding friction force - linear wearing ratio are demonstrated by the sapphire - sapphire couple in the 0001 plane and the sapphire – ruby couple.

Tribological characteristics of tetragonal zirconium dioxide (Y, Ce, Hf)-TZP in a couple with the sapphire-based control are significantly higher, than the sapphire - sapphire couple (friction force is less 1.3 times; linear wearing is less 1.5 times).

The wearing spot size in friction direction on the 0001 sapphire disk (800 µm) is less in comparison with ZrO_2 tetragonal disks: (Y, Ce, Hf)-TZP – 1.1 times (900 µm), 3Y-TZP – 1.5 times (1200 µm).

Development of novel or improvement of the existing process for machining of a sapphire head sets a task of creation of new, high-effective schemes of forming. Criteria of technological operations optimization

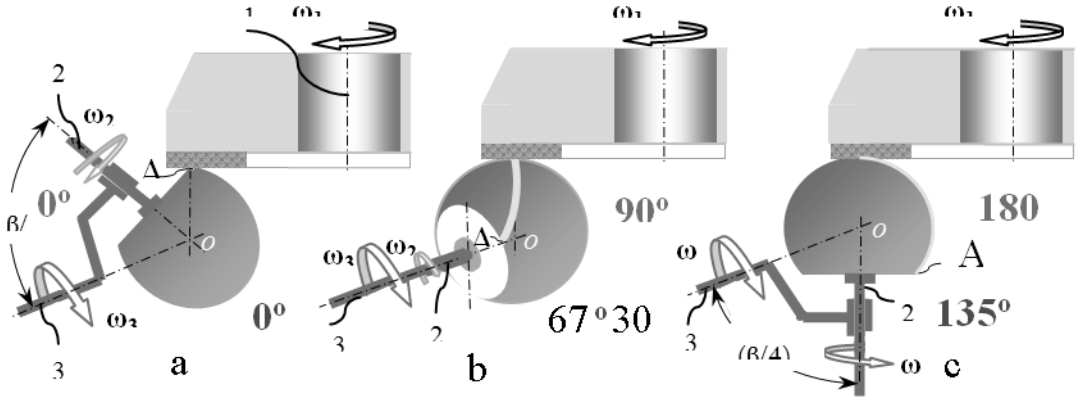


Fig.11. The scheme of forming a partial spherical head of endoprosthesis by face grinding: (a), (b) and (c) are successive relative positions of a ground head while axis 2 turns around the axis 3 within 180°

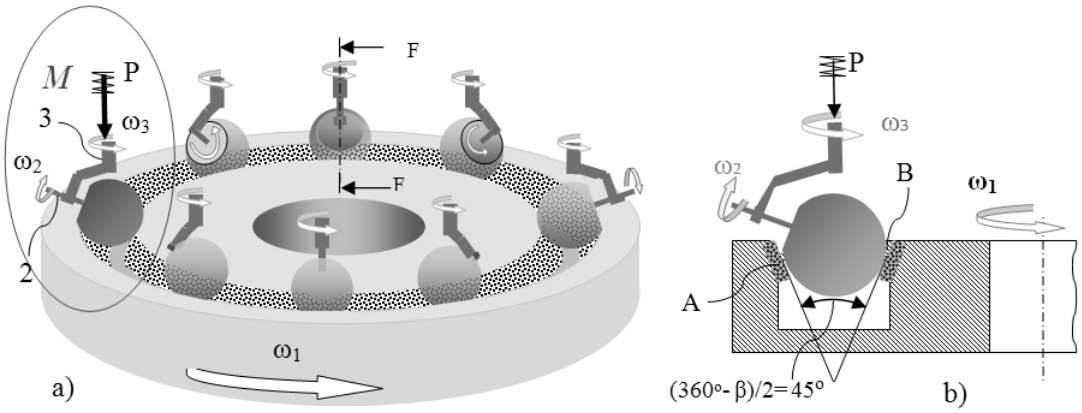


Fig.12. Scheme of forming of a partial spherical head by shaped grinding wheel (on the basis of LPG method).

(productivity, surface quality parameters, processing accuracy), determine a place of novel forming methods in view of their advantages (fig. 7-9).

There are a lot of methods for machining of the spherical head. A number of them has advantages and disadvantages, but the below described method is the most optimal and classical.

The partial sphere is defined by its radius and the angle β of spherical segment. There exist several ways of machining spherical surfaces. The closest to the LPG process by kinematics is a scheme of grinding a partial

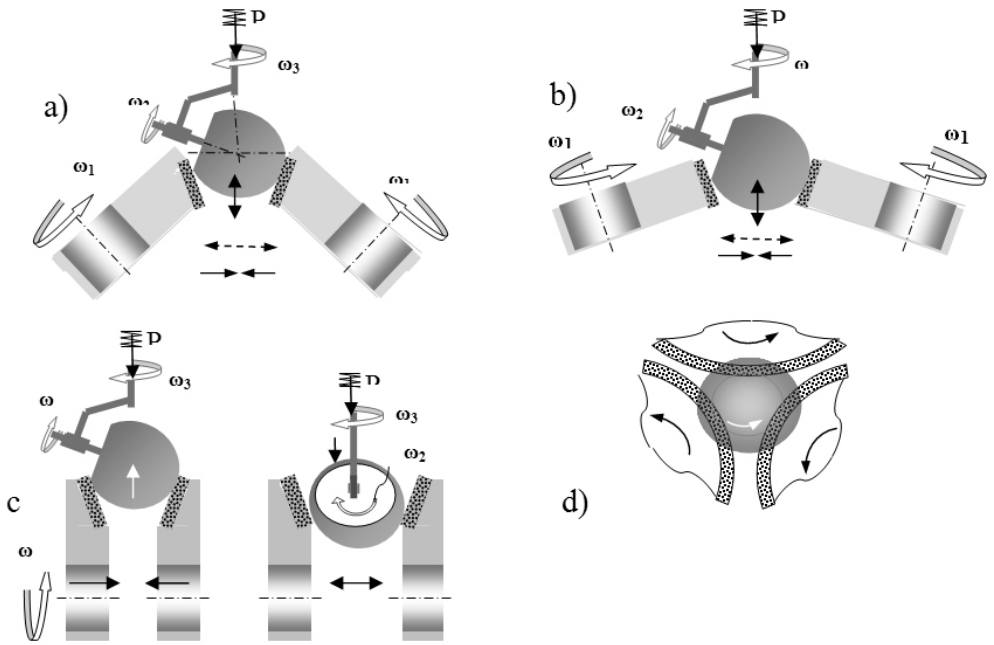


Fig. 13. Possible versions of grinding the heads of endoprosthesis when using commercially available conventional wheel shapes.

sphere by use of a face grinding wheel. Workpiece rotates at angular speeds ω2 and ω3 around the axis 2 and 3 consequently. This kinematic of forming an incomplete surface of sphere is taken as the basis for elaboration and possible realization of more efficient schemes of grinding the spherical heads of endoprosthesis taking into account kinematics and other positive features of the LPG method.

Face grinding wheel rotates at angular velocity ω1 removing the allowance for machining from the sphere at the required cutting speed and feed rate. For total machining the spherical head it must rotate simultaneously around the axis 2 and 3 at the angular speeds ω2 and ω3. The axis 2 and 3 intersects at the centre of sphere in point O. As is seen in Fig.11-13 the angle between axis 3 and 4 must be equal to β/4, but to machine the whole surface of the partial sphere the angular velocities ω2 and ω3 have to be cinematically interrelated as they both specify the values of feed rate components. Linear speed at the wheel/ball interface and the ratio of angular speeds ω2 / ω3 will define the surface texture of semi-finished or finished head of endoprosthesis. Detailed analyses of kinematical links between speeds of rotations and other related parameters of grinding process are out of the scope of this paper and it will be discussed in future publications.

A partial spherical head is rested at formed grinding wheel, consisting of internal and external cones with abrasive layers and rotates around axis 2 and 3 at angular speeds ω2 and ω3 in the same manner as it was described earlier for the scheme. Machinable workpiece by means of spring-loaded force P is pressed to the shaped wheel and is continuously feeding at required depth towards the wheel. Applied pressure is equally redistributed at wheel/work interface i.e. at points A and B. For clearness all positions are equally distributed along the wheel, though such consecutive states takes place at the same area M. This scheme allows also performing machining at few "machining stations" around the wheel. The main shortcoming of this scheme is in complexity of grinding wheel and in difference of speeds at the areas A and B. The latter is possible to compensate in the same way as at LPG process.

Diameters of grinding wheels are not limited when two wheel grinding mode is performed. In case of three-wheel grinding the sphere radius (r) and the maximum radius of wheel (R) are interdependent. Three wheels mode provides higher stability of grinding process. Future study is seen in more detailed elaboration of structural schemes of forming the spherical heads and carry experiments with real spherical heads for endoprosthesis.

Conclusions

The scale of influence the single crystal sapphire crystallographic plane orientation and the grinding conditions on material removal rate, surface finish and the state of sub-surface layer studied at Low-Temperature Precision Grinding (LPG) regimes reveal that:

1. The grindability of single crystal sapphire significantly depends on the crystallographic plain orientation. The relative values of material removal against the specimen having crystallographic plane orientation (1010) are within $q_{0001}/q_{1010} = 0.25 \ldots 0.5$, and $q_{1012}/q_{1010} = 0.75 \ldots 1$. At other equal conditions of LPG process the higher quality of ground surface is achieved for crystal orientation (0001.) The difference with the rest two orientations of crystallographic plane is within 1...1.5 class of roughness.

2. By studying the morphology of ground surface it has been proved the possibility of grinding single crystal sapphire in the ductile mode i.e. to remove deformed layer by shear without cracking fracture at low cutting speeds. At such conditions of machining the least depth of the deteriorated (damaged) sub-surface layer were detected.

3. The structural schemes of forming partial spherical heads of endoprosthesis for human hip joints need further analysis and optimisation with the aim of designing advanced technological process and the prototype of grinding machine

The authors wish to express special gratitude to the Ukrainian Science and Technology Center (USTC) for their financial support of International project, to many colleagues from the Institute of Super Hard Materials of the National Academy of Sciences of Ukraine (Kiev), the Institute of Mono-Crystals of the National Academy of Sciences of Ukraine (Kharkov) and from General Engineering Research Institute (GERI) at Liverpool John Moores University (United Kingdom) for valuable discussions over the years of collaboration.

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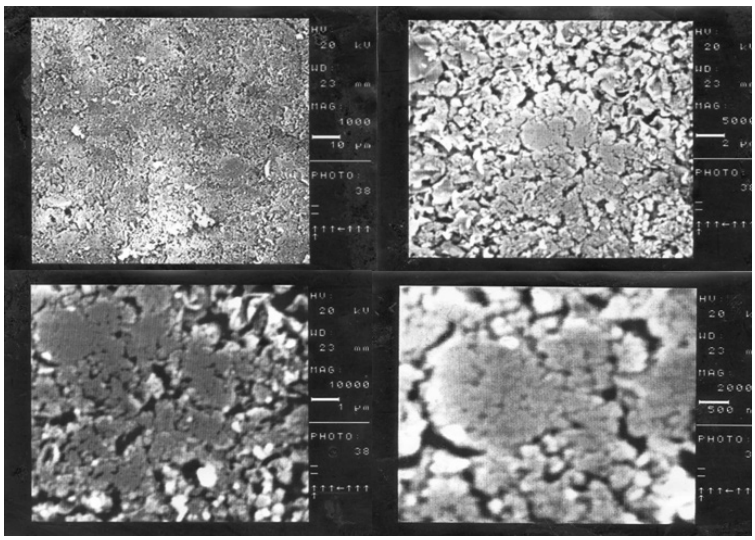
Boron nitride nanopowder

N. Dvali, T. Marsagishvili, G. Tatishvili
I.Dzhavakhishvili Tbilisi State University,
R.Agladze Institute of Inorganic Chemistry and Electrochemistry



In many spheres of high technologies boron nitride (BN) is one of the most important materials, and its application fields are becoming wider (space instrument-making, nuclear engineering, power semiconductor rectifiers, electronics and microelectronics, chemistry and metallurgy, medicine). High-technology development rates precondition the increasing requirements to materials and BN-based articles. The technologies for BN obtaining do not meet the state-of-the-art requirements to such materials. There are some difficulties in obtaining BN powders.

The process is distinguished by multistage chemical transformations, high temperature, significant energy consumption, the use of a multicomponent charge, comprehensive apparatuses that, as a result, brings about high prime cost of the product.

It is to note that, if not taking into account expensive laser and plasma-chemical methods with still limited application for obtaining this compound, the existing technologies do not allow to obtain high-quality BN powders.

The technology for BN powder obtaining requires high temperature synthesis (750-1500oC), which is crucial for formation of a product's hexagonal structure. Not having such structure, it is practically impossible even at implying high temperature and pressure to produce high-density and low-porosity articles. On the basis of abovementioned, the task was set to develop a method for obtaining the boron nitride nanopowder and create an ecology clean and economical technology.

As a result, the technology for obtaining BN nanopowders by a gas-phase method, which is differed from the existing ones by:

- productivity per apparatus` volume unit;
- possibility of continuous production cycle;
- BN synthesis low temperature (≤4000C);
- low price and initial components abundance;
- ecology safety
- uniqueness of powder obtained.

Main properties of powder obtained

- Amorphous powder, average grain size is 2 nm
- Powder color is white.
- Impurities:
  - Oxygen ≤0.5%
  - Borates ≤0.1%
  - Silicon ≤300 ppm
  - Cu, Al, Mg, Fe, K ≤100 ppm for each element
  - Carbon ≤0.05%
  - Calcium ≤0.05%
  - Na ≤10 ppm

Amorphism of materials obtained and nanoparticles size were determined using the X-ray phase analysis and scanning electron microscope. The fig. presents relevant images at different magnifications. High-density, easily machinable, non-stratifiable samples were manufactured by high-temperature pressing in dry atmosphere of NH_3 and N_2.

Main characteristics of the samples

- Crystal structure is hexagonal.
- Color is white.
- Average grain size is 30 nm.
- Density is ≥2.2 g/cm^3
- Specific electric resistance is 10 MOm•cm

If pure isotopes 10B, 11B, 15N are used as initial materials at synthesis of BN nanopowders, there is possibility to obtain boron nitride compounds with hexagonal and cubic structure (Borazon) not having analogues in the nature. It was managed to obtain material, which, on the one hand, retains nanosize of particles, on the other hand, has very high porosity with characteristic size of pores on a nm level. Material's specific density is 0.85-0.9 g/cm^3. The technology for obtaining nanopowders was successfully applied for production of aluminum nitride. Gallium and indium nitrides nanopowders were obtained by the same way.

After small modification the technology allows to obtain nanopowders of different carbides. Isotope-modified powders and boron carbide articles are distinguished by unique physical and mechanical properties: high heat conductivity and microhardness. The powders obtained are also of interest for hydrogen energy, as one of its main tasks is safety storage and transportation of hydrogen [1-5]. Basic principles of hydrogen storage are in a compressed form under pressure, in a liquid form, in a chemically bonded form (metallohydrides) embedded in porous materials.

The latter way is the most promising, as hydrogen is physically adsorbed in some porous materials that allows to accumulate it in large quantities and extract from the material with relatively low expenditures.

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Novel Materials

GRZ-01

Obtainment of boron and aluminum nitrides nanopowders

Application field

Space instrument-making, nuclear engineering, power semiconductor rectifiers, electronics and microelectronics, chemistry and metallurgy, medicine, hydrogen energy.

Description

The gas-phase method is differed from the existing ones:

- productivity per apparatus volume unit
- possibility of a continuous production cycle.

Novelty

Low-temperature BN synthesis (≤400°C). Low price and abundance of initial components. Ecology safety.

Advantages

Relative low cost of the powder obtained.

Development stage

R&D is completed.

Cooperation proposals

Production of small batches of gallium and indium nitrides nanopowders by orders.

Contact information

I.Dzhavakhishvili Tbilisi State University
R. Agladze Institute of Inorganic Chemistry and Electrochemistry
Tbilisi, 0186, Georgia, Tel.: 995322-301830, 995599-190172
e-mail: tamaz.marsagishvili@mail.com

REPUBLIC OF MOLDOVA

Research in the field of applied materials science

D. Ghitu Institute of electronic engineering and nanotechnologies (IEEN) of the AS of Moldova

Research in the field of applied materials science is carried out within the framework of the strategic direction in the field of science and innovation «Nanotechnology, Industrial Engineering, New Products and Materials.» The most promising results are the following:

A new technology for superconducting electronics has been developed within the framework of the institutional project «Engineering of Nanoscale Structure Materials and Development of New Methods for Reconfiguration of Electric, Thermoelectric, and Spintronic Properties and Processes».

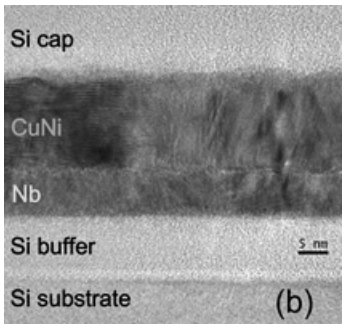
A new process based on the magnetron (cathode) sputtering of niobium and niobium-nickel-copper nanostructures metal films with high superconducting characteristics and parameters long-term stability has been patented.

The thickness of the Nb films and Nb-Cu-Ni nanostructures obtained by vacuum sputtering at 10^{-7} mBar varies in a range of 5-50 nm. The critical superconducting transition temperature is Tc ≥ 5.5 K for 5-nm-thick layers.

To ensure parameters long-term stability, a passivation method by covering of nanostructures with a protective layer of amorphous silicon with thickness of 5-6 nm was used. The technology is the basis for creating a new generation of microelectronic devices, e.g., superconducting valves for microwave devices, telecommunications, and high-speed computers.

MOL-01

Spin valve



Purpose

The basic element in a high-speed switch for microelectronics.

Application fields

Spintronics, superconductivity, nanostructures.

Description

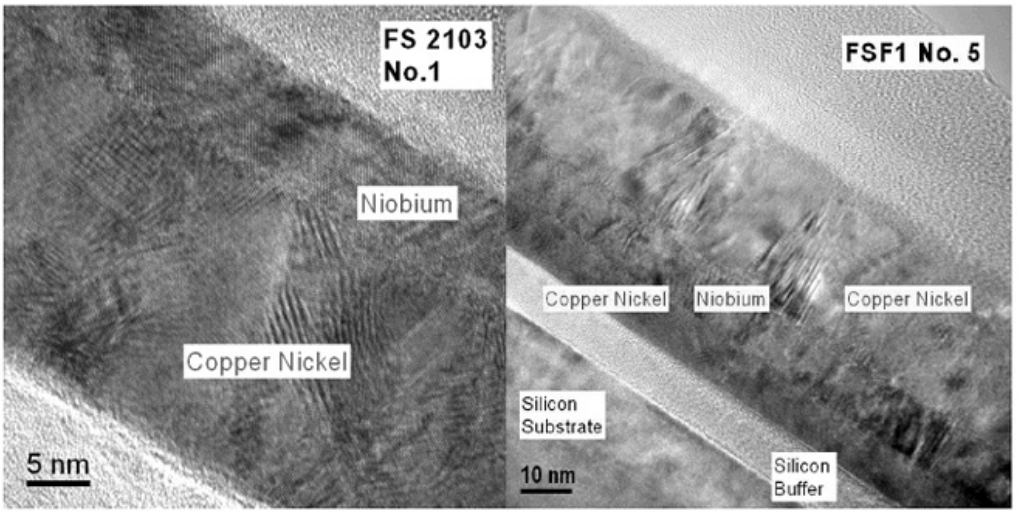
The spin valve element is made on a silicon substrate with layers of a superconductor (Nb) and ferromagnetic (Cu-Ni), which were successively sputtered with the preset thickness and covered with a protective layer against oxidation.

Novelty

The optimum ratio of the thicknesses of the constituent superconductor and ferromagnetic layers leads to decrease in the electrocaloric effect and improvement in the efficiency and sensitivity of the spin valve.

Advantages

Low power consumption required for device operation.



Development stage

Superconductor-ferromagnetic structures for the spin valve's basic element have been obtained.

Cooperation proposals

Partnership with the Institute of Nuclear Physics of the MSU after M.V.Lomonosov, Kazan Federal University.

Contact information

A.Sidorenko, V.Zdravkov, R.Morar
IEEN after D.Ghitu of AS of Moldova, Laboratory of cryogenics
Academy st., 3/3, MD-2028, Kishinev
Tel: 73-70-92, Fax: 72-70-88,
e-mail: anatoli.sidorenko@kit.edu, website: www.iien.asm.md

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A process for manufacture of glass-enveloped single-crystal nano- and microwires based on bismuth and its alloys, where the dimensional quantization effect and topological insulator state is realized for thermoelectric applications and spintronic devices in nanoelectronics, is developed in the Laboratory of Low-Dimensional Structures Electronics of the IEEN within the framework of the institutional project «Engineering of Nanoscale Structure Materials and Development of New Methods for Reconfiguration of Electric, Thermoelectric, and Spintronic Properties and Processes».

The method developed in the Laboratory for manufacture of glass-enveloped single-crystal wires allowed, for the first time, to study glass-insulated perfect discrete single-crystal bismuth wires with diameter of d=40 nm (Applied Physics Letters 86, 102105, 2005) and to observe some new effects in them:

- the energy spectrum dimensional quantization effect and semimetal-semiconductor transition accompanied by increase in thermoelectric efficiency;
- the magnetic flux quantization effect, which generates magnetoresistance oscillations with a period of hc/2e; it is a solid-state analog of the Aharonov-Bohm effect and represents the manifestation of the geometric Berry phase induced by the spin-orbit splitting of surface states (Applied Physics Letters 84, 1326, 2004, arXiv: cond -mat/0702368v2, 2007);
- the presence of negative magnetoresistance in a transverse magnetic field in the nanowires;
- semiconductor-semimetal transitions induced by magnetic field and strain;
- Lifshitz electronic topological phase transitions induced by doping and strain;
- the occurrence of «giant» quantum oscillations in thermoelectric power (Physica B 346-347, 282, 2004);

- the transition to a specific state of the wire surface metal conductivity preconditioned by the inversion symmetry violation on the wire surface (Physica E, 37, 194, 2007).

The obtained glass-enveloped microwires based on BiSb and Bi_2Te_3 of n- and p-type with high thermoelectric parameters can be used for cooling devices in medicine and cytological examinations.

The high thermoelectric power anisotropy established in the BiSn wires allowed to use them as a basis for creating a low-power thermoelectric generator prototype, which can be used in hearing aids.

In general, these effects clearly show that the technique developed in the laboratory to obtain glass-enveloped high-quality single-crystal nanowires of Bi and its alloys becomes promising and decisive for designing nanoobjects, which are of particular interest in both cutting-edge scientific fields of physics of low-dimensional structures and in the applied aspects, such as thermoelectricity, spintronics, and nanoelectronics.

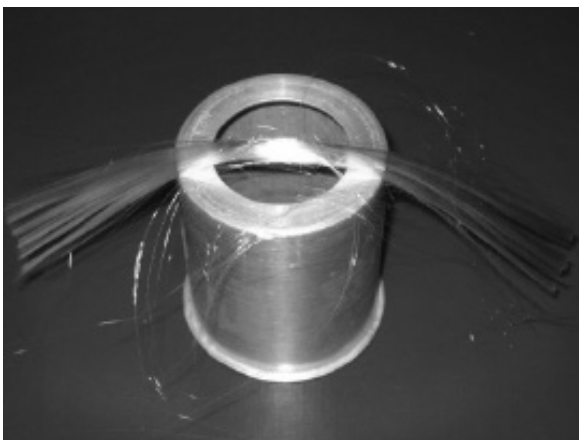
All studies and techniques were protected by patents, published, and broadly discussed in advanced journals of international importance.

MOL-02

Glass-insulated single-crystal nano- and microwires based on semimetal bismuth and its alloys

Purpose

Obtaining nano- and microwires with high thermoelectric efficiency and thermopower anisotropy in different temperature ranges to design miniature thermoelectric energy converters for various purposes, in particular, microthermogenerators with low current consumption (for hearing aids), which use human body heat, as well as highly sensitive submicron-sized thermocouples and cooling devices for medicine, neurosurgery, oncology, and cytological examinations.



Description

The glass-insulated wires with preset diameters and lengths up to a few tens of meters have been manufactured by liquid phase casting using the improved Ulitovsky method. The monocrystallinity and orientation of the samples were determined by X-ray diffraction (Oxford Instruments diffractometer).

Obtaining such high-performance thermoelectric materials is a technologically advanced and almost waste-free production process, which makes it cost-effective in comparison with known method for manufacturing of similar bulk thermoelectric materials.

Application fields

At present, the glass-insulated nanowires are of interest for research. In practical terms, they will be of interest after designing sensors on their basis in the form of sensitive thermocouples or microcoolers for medical purposes, which can be used in neurosurgery and cytological examinations.

Novelty

For the first time, single glass-enveloped single-crystal bismuth nanowires with diameter of up to 40 nm, in which the energy spectrum dimensional quantization effect and semimetal-semiconductor transition

is realized being accompanied by increase in thermoelectric efficiency, have been obtained. The glass-enveloped microwires based on BiSb and Bi_2Te_3 of n- and p-type with high thermoelectric parameters can be used for cooling devices in medicine and cytological examinations. The high anisotropy of the thermoelectric power observed in the BiSn wires has made it possible to use them as a basis for creation of a low-power thermoelectric generator prototype.

For the first time, direct-field equidistant oscillations with a flux period of hs/2e have been revealed in 50-nm Bi wires that was connected with the electron spin from the surface states. This opens up the way to use them in spintronics and nanoelectronics.

Advantages

Such glass-enveloped single-crystal wires have reproducible parameters and are stable over time. The advantage is that the wires are safely protected from environmental effects. Wire-based sensors are resistant to mechanical effects and corrosive media. In addition, manufacturability and waste-free production put them beyond competition.

There are exclusive features of thermoelectric cooling (based on glass-enveloped wires) in medicine as compared to cryoliquid systems, notably:

- almost instantaneous switch of the cooling and heating modes;
- very simple control of cooling/heating modes through supply current change;
- design of thermoelectric coolers in the form microthermocouples in a glass envelope gives the possibility to reach almost any interior regions of a human body.

Development stage

The thermoelectric parameters of the microwires obtained are being optimized to design highly sensitive thermocouples, anisotropic thermogenerators, and thermoelectric elements on their basis. A prototype of an anisotropic microgenerator based on glass-enveloped wires has been created and its parameters are being optimized.

Cooperation proposals

Contract and joint research projects.

Contact information

A.Nikolaeva, P.Bodiul, Konopko L., D.Meglei, O.Botnar,
G.Para, A.Turcan, I.Popov, E.Moloshnik
IEEN after Ghitu of the AS of Moldova,
Laboratory of electronics of low-dimensional structures, Academy st., 3/3, Kishinev, MD-2028,. Tel. / Fax: +373 22 738116, e-mail: A.Nikolaeva@nano.asm.md, website: www.iien.asm.md

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Research in the field of new functional nanostructured materials based on complex transition-metal oxides is carried out. A setup was constructed to obtain thin and nanocomposite films, superlattices using the method of epitaxial growth from aerosols of organometallic compounds (aerosol-assisted metal organic chemical vapor deposition (AAMOCVD)). This work is executed on two research projects:

STCU project #5390 «Metalorganic Aerosol Deposition of Complex Oxides with Enhanced Functionalities: Atomic-Scale Compositional Tailoring»; its goal is the development and growth of new ferromagnetic materials with high Curie temperature in the form of artificial superlattices (SLs) of complex oxides.

The approach of the researchers to optimize the magnetic exchange interaction is based on stress engineering in the functional layers of the SLs, which will be grown in the form of fully strained structures with functional layers of manganite with a perovskite structure and the intermediate layers coherent with the substrate.

The accuracy of deposition at the monatomic layer level is a key factor in growing of materials with desired properties. The choice of $La_{1-x}(Ca, Sr, Ba)_xMnO_3$ manganites with colossal magnetoresistance as a material for functional layers is preconditioned by their unique magnetotransport properties and high resistance to environmental influences.

The institutional project «Engineering of Nanoscale Structure Materials and Development of New Methods for Reconfiguration of Electric, Thermoelectric, and Spintronic Properties»; in the framework of this project, technologies for obtaining high-quality films of $La_x(Ca, Sr)_{1-x}MnO_3$ manganites applicable for creating thermal radiation sensors (bolometers) are being developed. The advantage of manganites in designing bolometers is their high temperature coefficient of resistance (TCR) ≥ 10%. In early works (1995-2002), a high level of noise, which made this material non-competitive at TCR ≈ 10% was mentioned. However, an improvement in the technologies for producing films has made it possible to obtain LCMO films with TCR ≥ 30%.

In particular, the group obtained LCMO/MgO films with TCR ≈ 35%. It is shown that these films can be used to design bolometers with a figure of merit of at least an order of magnitude greater than that of VO_x.

MOL-03

Technology of epitaxy from aerosols of organometallic compounds

Purpose

The technology is intended for obtaining epitaxial films, superlattices, and nanocomposites based on transition metal oxides, such as manganites ($La_{0.67}Ca_{0.33}MnO_3$) and titanates ($BaTiO_3$), as well as simple oxides, such as MgO and ZnO. Design on a monatomic level makes it possible to create materials with improved parameters (Curie point above room temperature) as well as materials with new artificial functionality (multiferroics).

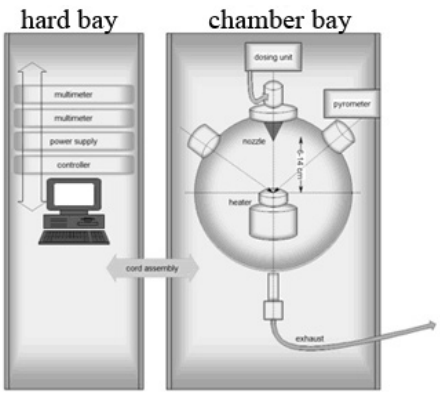
Application

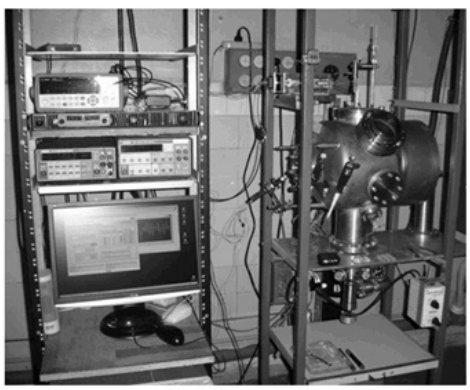
Magnetic sensors, memory elements and infrared sensors based on uncooled bolometers.

Description

Deposition of organometallic compounds aerosols is a vacuum-free chemical technology originally developed for obtaining thin oxide films (PRL 97, 107205 (2006)) and improved for deposition of nanocomposites (Nature Mat. 2, 247 (2003) and superlattices (PRB 79, 134413 (2009).

Aerosols of organic solutions containing β-diketonates of metals (such as La, Ca-, Mn-acetylacetonates), are sprayed onto a heated substrate.





The film grows on the substrate through a heterogeneous pyrolysis reaction of organometallic components. The authors have already demonstrated the epitaxial layer-by-layer (2D) growth of manganites with ferromagnetic properties and titanates with ferroelectric properties as well as superlattices and nanocomposites.

Novelty

At present, the installation for epitaxy by the AAMOCVD method is unique in Moldova and has several advantages in comparison with the only analogues located in Germany (University of Gottingen). The AAMOCVD technology is being developed in close cooperation with the University of Gottingen, and the result of this cooperation is joint publications and patents.

Advantages

- ease to change films composition by varying the precursors composition;
- high partial pressure of the oxidant (up to 1 atm);
- possibility to use large-area substrates required for production.

Development stage

The AAMOCVD installation is put into operation.

A technique for obtaining materials structured at a monoatomic layers level is being developed.

Cooperation proposals

Development of new materials based on various metals oxides ($LaSrCoO_3$, $SrRuO_3$), superconductors (YBCO), ferromagnetics (La(Ca, Sr, Ba)MnO_3), semiconductors (PBCO, LCO, LVO, ZnO), ferroelectrics ($PbZrTiO_3$, $BaTiO_3$), and their combinations in the form of nanocomposites and superlattices. Opportunity to work on the technological installation for designers of oxide-based materials, including doctoral students and graduates, is offered. In addition, construction of an AAMOCVD installation and development of a technique for obtaining an oxide material is possible. There is interest in cooperation with laboratories that can provide structural analysis, such as X-ray diffraction/reflection and microscopy.

Contact information

A.V.Belenchuk and O.M.Shapoval
IEEN after Ghitu of the AS of Moldova, Laboratory of sold-state structures, Academy st., 3/3, Kishinev, MD-2028
Tel. +373 22 72 31 36, fax: +373 22 72-70-88
E-mail: belenchuk@nano.asm.md, shapoval@nano.asm.md, website: www.iien.asm.md

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Development of new nanostructuring processes and methods for nanoscale reconfiguration of the A4B6 materials properties is carried out within the framework of the institutional project «Engineering of Nanoscale Structure Materials and Development of New Methods for Reconfiguration of Electric, Thermoelectric, and Spintronic Properties and Processes».

MOL-04

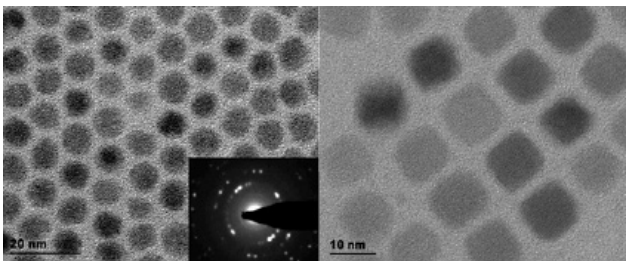
Nanostructuring technological process

Purpose

Nanotechnology and nanoelectronics.

Application

Materials for far-infrared technology.



Description

Methods for obtaining doped nanomaterials based on PbSnTe with unique properties, such as high photosensitivity in far infrared and long-term photoconductivity, have been developed.

Advantages

Unique properties, such as high photosensitivity in far infrared and long-term photoconductivity

Development stage

A technique for obtaining PbTe nanoparticles with sizes of 3-10 nm has been mastered.

Contact information

A.V.Nikorich, T.D.Gutsul, A.Todosichuk
IEEN after Ghitu of the AS of Moldova, Laboratory of Sold-State Structures, Academy st., 3/3, Kishinev, MD-2028
Tel. +373 22 73 70 72, fax: +373 22 72-70-88
E-mail: nicorici@nano.asm.md, website: www.iien.asm.md

Developments of the Republic of Moldova

Collection of information was organized by Institute of Economics, finances and statistics of AS the Republic of Moldova

Material science

MOL-05

Brevicarine: new use

Purpose

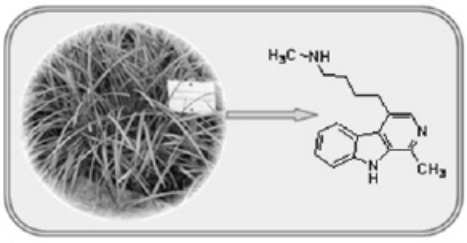
Natural anti-TB drugs.

Description

Natural alkaloid brevicarine derived from a widely spread in Moldova plant Carex brevicollis DC.

Known drugs Rifampicin was used as the control standard in the assays for in vitro inhibition of M. tuberculosis H37Rv.

Brevicarine proved to be a more active anti-tuberculosis compound (table below) with low toxicity (LD50 375 mg/kg).



Bacterium Strain	Brevicarine		Rifampicin	
Mycobacterium tuberculosis $H_{37}R_v$	MIC, mg/mL	Inhib. %	MIC, mg/mL	Inhib. %
	6.25	100	6.25	98

Novelty
New application of the known substance.

Advantages
Brevicarine is a relatively cheap natural compound derived from a widely spread in Moldova plant and can be used in medicine.

Development stage
A laboratory regulation for brevicarine isolation from residues generated at alkaloid brevicarine production from (Carex brevicollis DC) has been developed.

Patent MD № 4009 is available.

Cooperation proposals
- Development of pharmaceutical dosage form, its production
- Carrying out the preclinical and clinical trials.
- Development of process regulation for active ingredient production.

Materials for biological and medical purposes

MOL-06

Plant growth stimulant CU–1 ("VIRINIL")

Purpouse
Increasing the grafted plants yield by improving the circular callus formation.

Application
Nursery in viticulture, horticulture, floriculture.

Description
Treatment of vaccinations with copper (II) glycinate-L–serinate water solution («VIRINIL») provides the most positive effect; it stimulates callus formation and imparted components fusion at concentrations in a range of 0.0005 - 0.0020%.

The drug is used at vaccination of grapesand fruit trees (apricot, cherry, cherry), and rooting of roses and strawberries. By its effectiveness it is superior to the well known method using 0.2% heteroauxin solution.

The preparation allows to increase the grafted cuttings yield, raising circular callus formation up to 96% in comparison with initial cuttings.

Advantages

Epy copper complex used for cuttings treatment can be stored unchanged for several years in a solid state; it is stable, while broadly used heteroauxin is unstable and decomposes in the light, lose their useful properties.

Copper (II) glycinate-L-serinate is readily soluble in water, has anti-microbial properties that is for plant diseases control of great importance.

The waxing operation of vaccinations before laying for stratification is excluded.

Development stage

The preparation is sold in the local market.

As very dilute solutions are used, the necessary amount of active substances is synthesized in the Laboratory of Bioinorganic Chemistry and Nanocomposites, of the Institute of Chemistry of the Academy of Sciences of Moldova.

Cooperation proposal

Advertising campaign.

Organization of small enterprises for its production.

Contact Information

The Institute of chemistry of the AS of Moldova
Director: T.Lupascu, D. Sc. in Chemistry, professor
Academiei str., 3; MD-2028 Chisinau,
Phone: (373.22) 72 54 90; fax:факс (373 22) 73 99 54;
E-mail:lupascut@gmail.com; ichem@asm.md; http:www.chem.asm.md

Materials for biological and medical purposes

MOL-07

Astaxanthin – Plus is a new preparation from green algae haematococcus pluvialis

Purpose

Preparation has a therapeutic perspective in treatment of cardio-vascular diseases, cancer, neurological and immunological disorders, diabetes, ischemia, Alzheimer and Parkinson diseases, anti-ageing effect.

Description

A complex biologic preparation with astaxanthine obtained from green alga Haematococcus pluvialis biomass using the original technology for extraction, incorporation and stabilization in different vegetal oils: sunflower, corn, wallnut, olive, grapes seeds.

The technology for astaxanthine preparation obtaining in vegetable oils (sunflower, corn, rice, olive, nuts and grapes seeds) includes a mixing biomass with oil during 3 hours.

Prior to mixing with the oil, biomass is subjected to acid hydrolysis to destroy the cell wall. Astaxanthine is fully transferred from biomass, and extraction time is reduced by 16 times.

The technology provides the rapid transition of astaxanthine possessing strong lipophylic properties in the oils.

Advantages

The ecology-friendly preparation is obtained from a primary vegetal raw material. It has a number of economical advantages. The process is non-toxic, provides diversification of the spectrum of remedies and nutraceuticals for the pharmaceutics and medicine.

Development stage

Patents MD 132, MD 146, MD 4104 are available.

Installation pilot has been created.

Cooperation proposal

Comercialization of final product.

Commercialization of technology.

Contact information

V.Rudic, V.Miscu, L.Rudi, L.Cepo, T.Chiriac, I.Iatco, D.Sadovnic
Institute of microbiology and biotechnology of AS of Moldova, Phycobiotechnology laboratory
1, Academiei, str., MD 2028, Chisinau
Tel. +373(22) 72 53 06; +373(22) 72 57 54;
E-mail: microbioteh@yahoo.com

Materials for biological and medical purposes

MOL-08

Improved technologies for obtaining microbial enzyme preparation with lipolytic action

Propose

Obtaining of enzyme preparations with lipolytic action with degree of purity G10x and high technological properties for application in food, leather and silk industry, medicine, production of detergents, household for elaboration of new, high effective, modern biotechnology.

Description

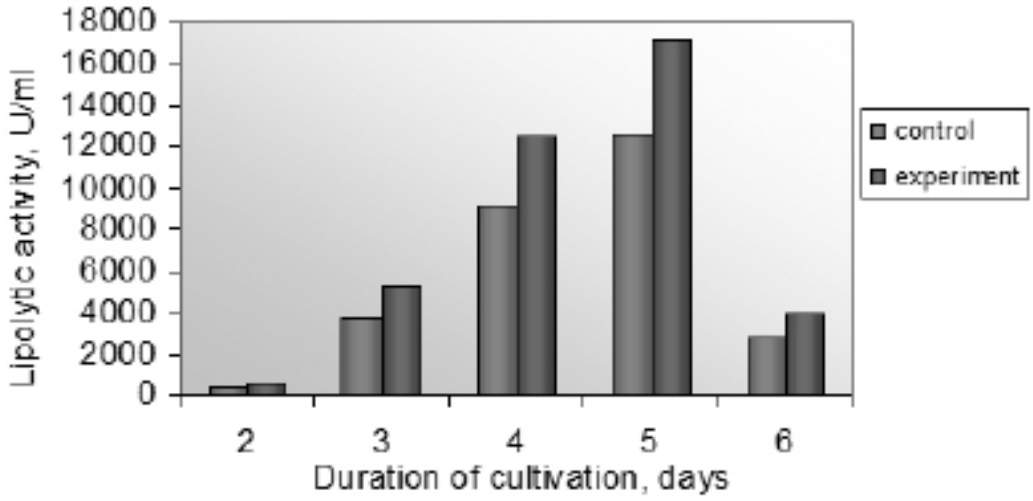
Technologies consist in obtaining of lipolytic enzyme preparations by their sedimentation with the use of ethylic alcohol from cultural liquid of micromycetes.

Producer strains are characterized by a short life cycle, high ability to synthesize lipase in submerged cultivation on cheap and available nutrient media in condition of state-of-the-art microbial directed synthesis of enzymes.

The developed technologies enable to obtain enzyme preparations with high lipolytic activity.

Novelty

The originality and novelty of technologies is the use as producers of new strains from mycelial fungi genus Rhizopus and Aspergillus with high and stable lipases synthesis ability and a short life cycle (24-72 hours); application of methods of directed microbial enzymes synthesis using as bioregulators and stimulators of



coordination compounds of Cu(II) and Co(III); obtaining of new high technological enzyme preparations, competitive with commercial appropriate preparations.

The effect of coordination compounds of [Co(MgH)2•Py2]•BF4•H_2O on lipases biosynthesis by Aspergillus niger CNMN 01L strain

Advantages

Advantages of developed technologies are increase in producer lipolytic activity from 31.2 to 49.9%; lipases stabilization under stress conditions; a short cycle of producer cultivation; cheap and available nutrient media; possibility to use state-of-the-art methods for enzymes directed synthesis; high activity of enzyme preparations.

Development stage

Scientific-technical documentation for technologies to obtain enzyme preparations with amylolytic action by directed synthesis of enzymes has been developed:

- Laboratory process regulation;
- Technological process scheme;
- Enzyme preparation specification.

Patents MD 2362, MD 2458, MD 2709 are available.

Cooperation proposal

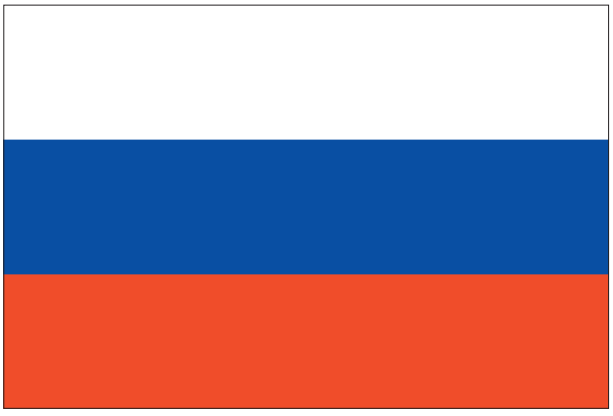
Joint testing.

Technology implementation.

Contact information

A.Deseatnic-Ciloci., J.Tiurin, S.Labliuc, S.Clapco, V.Rudic, N.Garbalau
M.Stratan, O.Bologa, E.Coropceanu, T.Curta, C.Liapurin, T.Sirbu
Institute of microbiology and biotechnology of ASM, MD 2028
Academy Street, 1, Kisinau, tel 73 98 24
E-mail: alexandra.ciloci@gmail.com

RUSSIAN FEDERATION



State and prospects of Russia in the field of creation of new materials

V. Fokin, Ph.D., Deputy Head of Department, ICSTI

The obtainment and elaboration of materials determine in many respects the level of development of the scientific-technical and economic potential of leading world countries.

According to evaluations of some experts in the coming 20 years 90% of materials will be replaced by essentially new ones. This will result in revolution in different fields of engineering. The availability of work on new materials is also confirmed by the fact that almost 22% of world patents on inventions are granted in this field. Quite recently Russia has occupied a leading place by many indices characterizing the level of national scientific and technical potential. The Soviet science was most effective in the world by the economic index: volume of scientific production per 1 dollar of expenses. By this index it surpassed practically 10 times the USA, Japan, Germany, France.

The 90s were rather difficult for the Russian science. These were years when it was necessary to preserve in a conservation mode the scientific personnel which had been created for many tens of years. Since 2002 when bases of the policy of Russia in the field of science and high technologies approved by the President of the Russian Federation for the period till 2010 and further prospects were adopted, the science, actually, began to pass from the conservation mode to a creation mode.

Unfortunately, country's orientation to development of a raw component has impeded that process seriously, however, the stirred up crisis, as expected, has forced developers to become more active practically in all branches of science and technology, including material science.

Considerable scientific groundwork of Russian scientists as a whole enables Russia to preserve rather high scientific and technical potential in the field of new materials up to the present. Evaluations of independent experts show that in this area Russia has a high common level and priority achievements in a number of areas. The highest level of development concerns composite and super hard materials, a slightly lower position on ceramic materials. However, Russia is keeping up with the world level in any area and in each area has products comparing well with world analogues.

According to evaluations of American experts possibilities of Russia in the field of technologies of materials in a number of areas are equal to possibilities of leading industrial countries.

The base for developing of new materials has been preserved in Russia. About 200 research teams are working successfully in 33 regions. These teams are capable to develop new materials and technologies of their manufacturing at a level meeting up-to-date requirements.

Analytical materials are prepared on the basis of mass-media interviews, reports and speeches of public officers responsible for corresponding areas of work in sessions of the Government of the Russian Federation and in the State Duma, as well as on the basis of articles, speeches and interviews of leading scientists and experts of the country.

The raw materials sector dependence decrease strategy is being implemented purposefully in Russia. The economy is gradually changing its image, becoming a diversified system with a developing hi-tech sector.

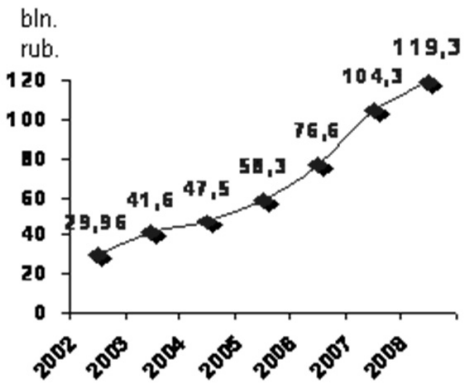
The areas connected with the use and introduction of high technologies are receiving state support. Through federal goal-oriented programs investigations in priority areas of science, engineering and technology development are financed on a competitive basis.

The financing principle has changed: the state supports not institutes, but projects with an end-product at the output. This makes it possible to implement the whole innovation chain: from generation of ideas to commercialization of results.

In the major sectors of the economy: aircraft building and shipbuilding, defense industry, atomic power engineering, nanotechnologies specialized state-owned corporations are functioning. However, an active discussion that legal forms of their existence contradict the Russian legislation has begun recently. Thus, probably, the status of such state-owned corporations will be modified as it was done for Rosnano.

Formation of an interconnected and multilevel innovation system is taking place. State financing of R&D is carried out in Russia within the framework of 9 basic federal goal-oriented and branch programs. In 2008 (the last year before crises) 119.3 billion rubles were allocated from the federal budget for civil R&D.

In 2009 financing of scientific investigations from the budget was planned to increase by 26%, however crisis effects have forced to correct somewhat the budget allocated for these purposes.



At present time the main programs are as follows:

- Federal goal-oriented program "R&D in priority areas of development of the Russia's scientific and technological complex for the period of 2007-2012"
- Federal space program of Russia for the period of 2006-2015
- Government armament program for the period of 2007-2015
- Programs of state academies of sciences and high school science programs
- Projects of the Russian basic research fund.

The basic program is "R&D in priority areas of development of the Russia's scientific and technological complex for the period of 2007-2012."

From 2007 to 2012 the size of its financing should be about 195 billion rubles. Approximately 134 billion rubles are federal budget funds, the rest of 61 billion rubles should come from off-budget sources. The share of this program is about 70% of general financing. The best forces of the country are involved in the implementation of the program.

The program has five basic areas: living systems, information-telecommunication systems, industry of nano systems and materials, rational nature management, power engineering and energy saving.

Areas	Cost of work (million rubles)	Financing from federal budget
Technologies of metals and alloys	3564	1282
Technologies of amorphous, quasi-crystalline materials, intermetallides and functionally gradient coatings and materials	4808	1804
Technologies of polymer-, ceramic- and metal-matrix composites	1526	763
Catalytic processes and nanomodified catalyst production methods	963	481.5
Technologies of polymer composite materials	1030	315
Membrane-catalytic materials	1333	666.5
Technologies of sorbents, absorbents, catalysts for life support and treatment systems	1198	489
Electronic materials and structures	3357	2238
Total	***17779***	***8039***

60% of general financing are directed towards creation of new materials: about 40% - to the section "Industry of nano systems and materials", the rest – to projects within the framework of other areas connected with creation of new materials.

Within the program up to 140 competitive technologies of commercial use should be developed, ten high technologies should be introduced, some technologies of Russia's world priority should be also introduced, new organizations possessing a world-class instrument base should be created.

According to tentative estimations implementation of specified activities should lead to the growth of the innovation sector, improvement of the export structure due to increase of the hi-tech production share up to 10.2% and increase of the hi-tech production portion at the world market by 2012. As predicted, the share of innovatively active companies in the industry should increase up to 18% by the end of 2012.

A logic continuation of the program "R&D in priority areas of science and technology development" is the federal goal-oriented program "Scientific and technological base of Russia for the period of 2007-2012".

Its overall size of financing – 99.4 billion rubles, including:

- a). at the expense of federal budget funds – 49.5 billion rubles,
- b). of them to R&D – 35.9 billion rubles;
- c). at the expense of off-budget source funds – 49.9 billion rubles.

In the field of new materials the program provides financing of the following areas.

The result of implementation of the program in the field of new materials should become as follows:

- newly developed technologies corresponding to the world level: 113-119;
- patents or other documents certifying novelty of technological solutions: 107-112;
- technologies transferred to production: 118-124.

Nanotechnologies have become a priority in the field of new materials in Russia.

In order to implement the state policy regarding development of innovation activity and commercialization of products in the sphere of nanotechnologies the Russian corporation of nanotechnologies Rosnanotech has been created in accordance with the President's decision. The authorized capital of the Corporation is 130 billion rubles. Considerable funds are spent for providing collective use centers (CUC) with unique equipment. Of more than 70 CUCs founded over on the basis of leading scientific organizations and institutions of higher

education, more than is working in the priority area "Industry of nanosystems and materials". Today, at least in the central part of Russia, practically in any region a scientist can find a world-class research installation.

The priority R&D in the sphere of nanotechnologies in Russia is defined as follows:

- civil and twofold purpose constructional nanomaterials with specific operational properties (first of all strength and temperature properties);
- materials and technologies for nanoelectronics and nanophotonics;
- carbon-based composite nanomaterials (carbon nanotubes, fullerenes);
- medicines and biomaterials;
- creation of scientific, analytical and manufacturing equipment for nanoindustry.

Expected results of the Program implementation by 2015:

- size of financing for formation of nanoindustry's manufacturing infrastructure - 180 billion rubles;
- sales volume of Russian nanoindustrial products - about 900 billion rubles;
- share of Russian nanoindustrial products at the high-tech world market – 3.0%.

1-4 years	5-8 years	9-14 years	More than 15 years
Cosmetics	Chemical catalysts	Solar cells	Microprocessors
Textile	Paints	Compact power systems	Quantum computers
Lubricant	Medicines	Biomaterials	Molecular processor
Displays	Diagnostics	Implants	Nano-bio
Sensors	Nanomatrixes		Nanoelectromechanics
Composites	Food packing		Regeneration of tissues, organs
	Energy/fuel		
	Illumination		

Time of entrance of nanomaterials to the market (forecast).

Within recent years innovation infrastructure basic elements have been created. They are: more 50 industrial parks, more than 70 innovation-technological centers, about 100 technology transfer centers. Work to interconnect all infrastructure links - scientific, technological, financial, industrial – is being conducted. Due to state financing alone about 300 facilities have been set up in regions.

During last five years it was rather successful development of the innovation system major elements. These elements are: project-oriented funding; full innovation chain - from oriented applied research - through technology development - to commercialization of results; formation of necessary innovation infrastructure centers. System approach has provided a rather successful combination of scientific research with formation of innovation system elements, science and business interaction. It has made it possible to reveal barriers and problems which are necessary to be overcome.

Integration of Russia into outer scientific and technical space is going on.

The basic areas of activity of the country in the field of international cooperation are, first of all, as follows: representation of interests of Russia in international organizations, scientific communities and programs (UNESCO, UNIDO, Asia-Pacific economic cooperation (APEC), CERN, 7th EU frame programs, international program "Eureka", projects ITER, XFEL), as well as fulfillment by Russia of obligations within the framework of Intergovernmental agreements on scientific and technical interaction on a bilateral basis.

Russia is maintaining bilateral scientific and technical cooperation practically with 100 countries, of which there are intergovernmental agreements, protocols and memorandums with 60 countries.

In the interests of formation of the national innovation system with the use of international experience. About 20 international scientific and technical centers and laboratories (with EU, CIS, APEC, China, USA, Germany, Finland, Holland, France, Israel, countries of Latin America) have been created.

The federal goal-oriented program "R&D in priority areas of development of Russia's scientific and technological complex for the period of 2007-2012" has become one of the basic tools to implement bilateral cooperation. Within Program's set of issues "Knowledge generation" alone more than 130 projects with 40 leading countries of Europe, Asia and America are being carried out in five priority areas (living systems, industry of nanosystems and materials, information-telecommunication systems, rational nature management, power engineering and energy saving).

The most active cooperation is being implemented with Germany (more 30 joint projects), and China (about 20 projects).

As a whole Russia is going progressively the innovation development way. However, all problems are not solved.

By now the main problems are as follows:

- ruptures in the innovation cycle and in the transition from basic research to commercial technologies. The low level of applied products and underdevelopment of the innovation infrastructure regarding commercialization of high technologies lead to that knowledge is delivered abroad when export of technologies is at extremely insufficient level;
- enterprise sector resources are focused to a large measure on purchase of import equipment: offered knowledge to a greater extent is in demand abroad. Capitalization of the high intellectual resource occurs mainly outside Russia's borders and considerable funds of the enterprise sector are excluded from reproduction processes of the domestic research and development sector;
- lack of qualified personnel. A significant amount of representatives of the Russian science are working abroad. They are also engaged in breakthrough technologies and providing innovation development of economies of other states.

Estimating the state and prospects of Russia in the field of new materials, it is possible to ascertain that despite considerably less experience in conducting innovation activity in comparison with leading industrial powers an effective national innovation system is available in Russia. Commercialization of scientific and technical results is being carried out and growth of new hi-tech production is provided. The present level of domestic products corresponds to the world level in the majority of materials science areas.

Nanotechnologies to improve medical equipment quality

B. Krit, D. Sc., Prof., MATI

N. Morozova, Ph. D., Senior lecturer, RMAPGE

D. Tsyganov, Ph. D., Head of Chair, RMAPGE

Quality improvement of medical equipment and tool is of current interest. For example, the wheelchair weight determines in many respects possibilities of people with reduced movement capabilities, and the level of requirements to safety and comforts forms rather rigid frameworks for medical tool manufacturers.

Orthopedic implants alongside with biological compatibility have to be strong and light. Tests of surgical scissors or needleholders must prove their high cutting ability and absence of minimal traces of corrosion after 50 cycles of sterilization.

Efforts of developers and manufacturers with the aim to increase medical equipment operational characteristics are undertaken in two directions:

- creating new materials and alloys with preset properties;
- modifying products` properties already created using different treatments.

The quantity of works related to the first direction was sharply reduced, that is caused, mainly, by a practically full «using up» of abilities of existing materials, alloys and their components. For this reason the most effective solution of the problem will be creation of new methods to treat medical technical products, improve parameters of existing products.

To improve characteristics of such products experience of use of ionic - beam and electrolytic-plasma methods is described in the article, which allow significantly to change a surface state; the possibility emerges to substitute traditional materials by less expensive and available ones.

An algorithm for complex improvement of medical technical products characteristics is proposed depending on their specificity. The most widespread material for the tool used in medicine is chromic stainless steel of 20X13 ÷ 40X13 grades. The level of functional medical tool properties is determined, mainly, by hardness, wear- and corrosion-resistance [1]. In this case the best method of surface treatment is ion - beam modifying (IBM) [2].

Fig. 1. Medical tools after IBM

Characteristic	Before treatment	After treatment	Note
Hardness, HRC	51 ÷ 53	<59	
Microhardness HV, GPa	9.0 ± 0.4	<13.5	
Corrosion resistance, %	<25	<10	Standard 64-1-3028, GOST 19126-2007
Surface roughness R_a, μm	≤ 0.16	≤ 0.1	
Cutting properties after resterilization	50 cycles	≥ 200 cycles	GOST 3479-85
Bactericidal properties	No	Ys	

Table 1. Medical tool characteristics

The following tools have been chosen for experiments: microtools, neurosurgery - needleholder, scissors, neurosurgical probe fork; surgical - tweezer, scalpel; stomatologic - spatula, plugger, dental elevator (fig. 1). Working surfaces of products made of 20X13 alloyed steel were subjected to W, Mo and Cr ion bombardment with 35 keV energy and fluence in a range of 1016 ÷ 1018 cm^{-2} (table 1).

The base aspects of IBM process procedure for medical tools made of 20X13 steel: surface treatment by Mo ions with 35 keV energy and 10^{18} cm^{-2} fluence is an optimum in relation to complex increase of basic characteristics.

To create the light-weight wheelchair it is expedient to use of magnesium alloys, whose density by 1.5 times less in comparison with Al, while having practically identical strength. However, low corrosion resistance of magnesium alloys does not allow them to find own level among constructional materials. A significant contribution herein can be made by creation of nanoceramic superhard corrosion-resistant composite layers on a parts` surface using the microarc oxidizing method (MOM) [3]. In this respect results of climatic tests of frame fragments made of MA2-1 magnesium alloy in a salt fog chamber (fig. 2) carried out in the specialized research laboratory «AGMI Material Testing and Quality Control Co.» (Hungary) are the clear proof.

Tubular samples subjected to MOM treatment in a silicate-alkaline electrolyte in an anode - cathode mode within 1.5 hours (anode current density is 7.5 A/dm^2, cathode current density is 4.5 A/dm^2, modified layer thickness is about 70 μm) and initial alloy samples have been tested. Tests corresponded to the international standard [4].

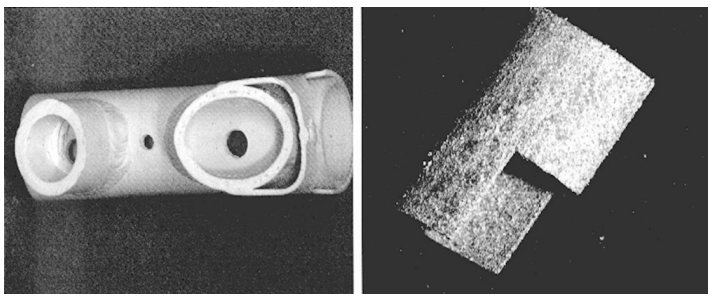


Fig. 2. Mg alloy corrosion tests (modified sample – raw sample).

After 72 hours testing, there practically were no visible traces of corrosion destructions on samples, while the raw sample was affected by 100% corrosion. Thus, MOM modifying action reduces the intensity of Mg-based alloys corrosion practically by the order. MOM treatment of a hip joint implant surface (fig. 3) is also promising.

The nanoceramic oxide layer with preset porosity created on the titanic alloy surface and consisting of a spinel-like nanostructured mix of Al_2O_3 •TiO•TiO_2 is capable of knitting organically with the bone fabric not resulting in host reactions. Besides titanium alloys traditionally used as a basis of implants, it is important to study the possibility to apply lighter metals for these purposes, for example, aluminium or magnesium, as their surface modified by the MOM method, must preserve endoprosthesis biocompatibility at a high level of gravimetric parameters.

The research carried out evidently shows the possibility of influence on a metal alloys surface by high-energy methods and testifies the necessity of their detailed studying with the aim to expand application fields, in particular, at manufacture of medical equipment.

Fig. 3. Hip joint implant after MOM treatment

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The developments of Russian organizations, presented by F&F Consulting Co.

RUS-01

Protein-vitamin fodder from low-value vegetable raw materials for animal husbandry and poultry

An accelerated solid-phase microbiological fermentation process and equipment for production of fodder for agricultural and fur animals, poultry and fish, saturated by proteins, vitamins and other useful substances with the use of special enzyme (Lesnov`s ferment) has been developed.

The fodder is produced from low-value vegetable raw materials and waste products (bran, brewing waste, shredded straw, chaff, beet-chips, sunflower shell, grain waste products, including rice husk).

In contrast to fodder yeasts and traditional enzymes, which decompose fibre and polysaccharides in monosaccharides, increasing, mainly, an fodder's energy component, Lesnov`s ferment (5 g per a raw material ton) promotes formation of high-assimilable microbic protein and irreplaceable amino acids, as well synthesis of vitamins groups D, B, E, K, P, PP.

Products	%	Rape oil cake	Distillery stillage	Brewing waste	Wheat bran	Wheat straw	Beet-chips
Natural	fibre	35.5	20.1	18.5	13.5	45.0	23.6
Natural	protein	34.7	21.1	23.1	15.0	3.6	8.9
Fermented	fibre	10.1	10.1	6.5	7.6	39.0	16.0
Fermented	protein	46.2	37.4	42.3	21.0	7.8	17.3

The fermented product provides:

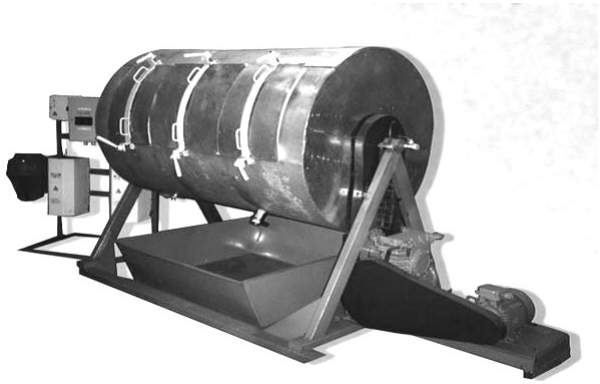
- Cattle, a daily average liveweight gain is more than 1000 g, milk yield growth is 20-30% with fat and protein content increase in it;
- Pigs, a daily average liveweight gain is 700 g, reduction of breeding terms up to 100 kg from 190 to 160 days, fodder absorbency increase by 40%;
- Poultry, egg production increase by 20%, chicken survival rate is not less than 95%.

Besides, increase of immunity to various diseases takes place at all animals and birds.

The use of fermented fodder allows to reduce the cost price of end products by more than 20%.

The product obtained does not contain toxic substances, the nitrates and nitrites content is reduced at fermentation, mycotoxins are destroyed.

Non-polluting solid-state fermentations process excludes a stage of preliminary

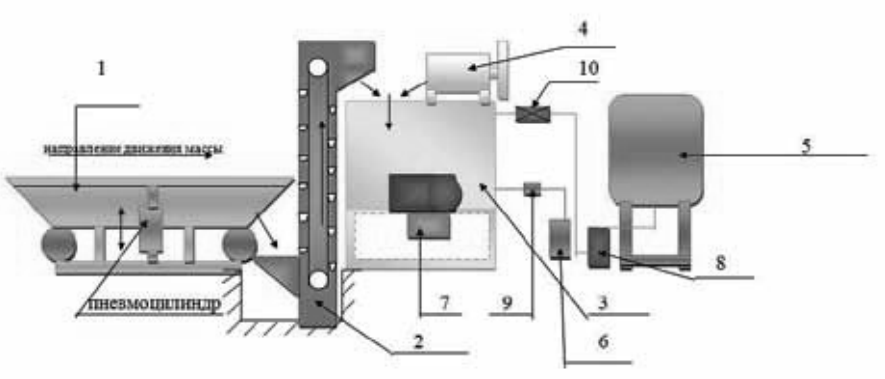


UBK-2 fermentation unit

hydrolysis of polysaccharides. There is no sterilization of the finished product. It does not require significant capital expenses. Industrial line payback is 1-1.5 years.

The industrial line arrangement scheme: 1 – receiving hopper 2 - lifting loading conveyor 3 - mixer-fermenter 4 – UBK-2 fermentation unit (fermenting module) 5 - water heater 6 - compressor 7 – delivery screw conveyer 8 - pump 9 – air-feeding system's valve 10 water delivery system's valve

The fermentation is carried out in an automatic mode with maintenance of parameters necessary for successful process behavior. Ferment re-activation and increase of the microbic biomass up to the necessary



Parameter	Value
Productivity on wet fodder at two-shift work, kg/day, min	1,500
Installed capacity, kW Power Thermal	 3.0 15
Specific power consumption, kW·hour/t	8.5
Fermentation reservoir working volume, m^3	1.0
Service staff	1
Weight, kg	820
Dimensions, cm	170x120x185
Operating mode	Periodic

level take place in the fermentation unit. After that it goes to the mixer-fermenter, where the basic fermentation process is realized.

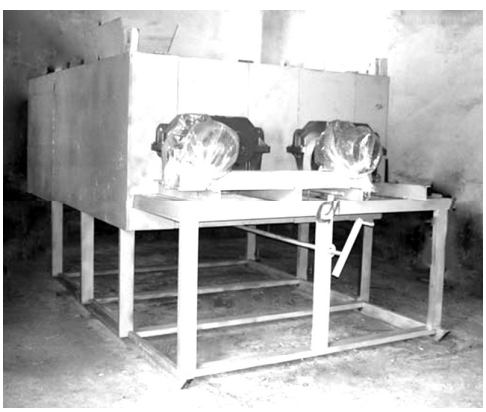
Technological process stages

I. Raw material delivery. It is carried out using transport of any kind.

II. Raw material crushing. Initial fodder (straw, chaff, sunflower shell, corncobs) has to be crushed.

III. Raw material loading. The crushed raw material is loaded into the mixer-fermenter and fermenting module.

IV. Working ferment preparation. It is carried out in UBK-2 fermentation unit. The ferment dry powder is used at the



SM-6 mixer-fermenter

Parameter	Value
Productivity on wet fodder at two-shift work, kg/day, min	8,000
Installed capacity, kW Power Thermal	 2.0 7.5
Specific power consumption, kW·hour/t	4.5
Fermentation reservoir working volume, m^3	4.0
Service staff	2
Weight, kg	2,850
Dimensions, cm	419x202x220
Operating mode	Periodic

1 - Fermented distillery stillage, 2 - Fermented crushed linen straw (as against traditional technology fibre separation takes place within 20-24 hours), 3 - Fermented beet-chips, 4 - Fermented wheat straw, 5 - Fermented dried up rape oil cake, 6 - Fermented granulated straw, 7 - Fermented bran, 8 - Fermented sunflower shell

rate of 1 g per 200 kg dry fodder. Biomass increase time is 3-7 hours at 40-60°C.

V. Fodder heating - humidifying in the mixer-fermenter. It is necessary for partial destruction of pathogenic microflora contained in it, pasteurization, dissolution of mineral salts and other additives.

VI. Working ferment feeding. It is carried out during mixing at humidity of 50-55% and at 50-55°C.

VII. Fodder preparation. It is carried out in the mixer-fermenter. Fermentation duration depending on the fibre content in raw material to be treated varies from 3-4 to 10-12 hours at temperature of not less than +10°C.

VIII. Finished product unloading. After the fermentation the finished product is dispensed to animals or dried and granulated.

Cooperation proposals

- Development and turn-key-based manufacture of shops on fodder production from low-valuable vegetable raw materials with the use of Lesnov`s ferment for all kinds of animals and poultry.
- Manufacture and complete set of equipment, including process control and regulation devices.
- Author's support at installation, carrying out of starting-up and adjustment works, personnel training.

ROMANIA

Sintered sheets with high porosity: structure, properties, processing

I. Vida–Simiti,
prof., D. Sc., Dean of faculty,
Technical University
of Cluj-Napoca

The paper represents a review of the research of the author related to sintered porous materials. It presents in a synthetic way the classification, the main properties and the functional characteristics of the porous sintered sheets: behaviour to mechanical stress, permeability and technological possibilities of processing.

The sintered materials with high porosity can be mainly obtained from metallic and ceramic powders by free spreading methods followed by sintering. These types of materials have a structure characterized by porosity and a largely specific surface. The porous sintered structure consists of the framework of the basic metals (metallic matrix) and the spatial network of the pores.

The metallic matrix made up of the sintered powder particle assures the resistance structure to the outside mechanical stress. The network of intercommunicating pores assures special properties and function to these types of materials, owing to porosity and highly specific surface.

We can mention some of them: the filtering or cleaning of the fluids (gases and liquids) from impurities, the flame traps, sound absorbents, the fluidizing and uniform distribution of fluid on a surface or into a given volume, the separation of liquids or gases, the homogenizing (mixing) of a liquid with gas, catalytic and electrochemical properties, biotechnological properties.

Introduction

The porous materials obtained in layers by spreading or low compaction pressure by sintering metallic and ceramic powders represent porous materials with high porosity. They are used as a semi product to obtain some filtering elements of different geometric forms through procedures of plastic deformation, welding and machining.

A classification of the porous materials with porosity and high specific surface according to the porosity and size pore is presented in fig. 1 [1]. In fig. 2 is shown a diagram of the technological itinerary for the manufacturing process sintered sheets with high porosity.

The specific structure of these materials consists of a metallic frame formed of the grains of sintered powder and a spatial lattice of pores, most of them opened and intercommunicating with one another (fig. 3).

Intercommunicating pores ensure a good permeability of these materials [2, 3]. Sintered sheets of a very high porosity seem to be a new type of material with specific characteristics.

The sintered porous stainless sheets are subjected, among others, to tensile and compressive stresses during some executing technological operations and exploitation. These stresses have as an effect, modifications of the porous structure parameters followed by modifications of the main characteristics (filtering, technological and mechanical properties). Consequently, the study of sintered porous stainless sheets at compression and tensile stresses is necessary for an optimum dimensioning of filters and for determining the technological parameters to obtain different constructive forms [1, 3]. The powder used to obtain the studied porous sheets by sintering is of the type 316 L (Höganäs). Its chemical composition consists of 0.3% C, 16…18% Cr, 10…12% Ni and Mo, 1% Si, 0.03% S, 0.03% P, the remainder being Fe.

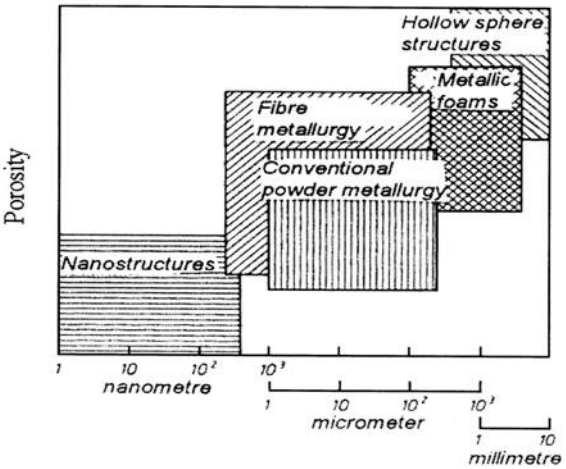


Fig. 1. The classification of porous materials

Mechanical Stress Behaviour

The homogenized powder is strewn with a strewing device on a steel sheet-metal used as a support. In view of the strewing operation, the support plates are isolated on both sides by covering them with a fine-grained slurry layer of Al2O3. The powder layer is then dressed at the desired thickness (1…2 mm). The tests presented in the paper have been performed on sintered porous sheets of 1.5 mm thickness.

Sintering has been performed in a protective atmosphere of hydrogen. The influence of sintering parameters on the optimum porous structure of desired porosities has been studied. For the particle size range used in the work (-40 μm; (+40-80) μm; (+80-125) μm), the temperature range within (1290…1310)°C (at sintering time 120 min) has permitted to obtain certain sintered sheet-metals having an optimum porous structure and the porosities given in the paper [4, 5].

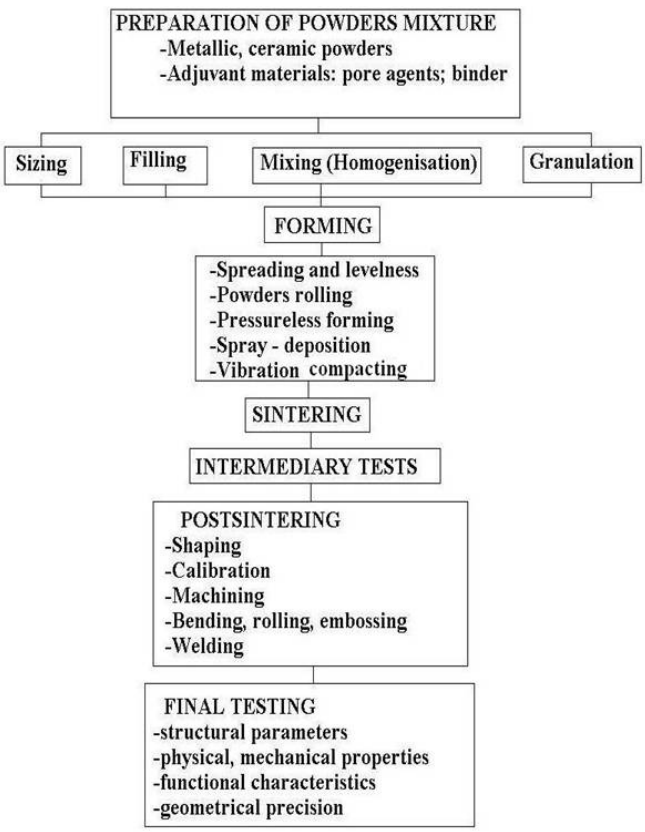


Fig. 2. The diagram of technological itinerary for manufacturing the sintered sheets with high porosity

Tensile Test

To determine the mechanical characteristics (the tensile strength, the conventional yield limit, the elongation on fracture), tensile tests on a large number of samples cut from porous sheets of different porosities and of different initial-particle

size range have been made on a universal testing machine of the "Instron" type.

For the tensile testing of porous sheets, a new type of sample with the shape and dimensions presented in Fig.4, being manufactured by applying highly accurate cutting in order to raise the dimensional accuracy and to diminish the failings from the cutting zone, has been used. The shape of the circular arc (R 50), adopted for the gauged zone of the sample, imposes the fracture of each sample in the central part, namely at the minimum width of 25 mm [4].

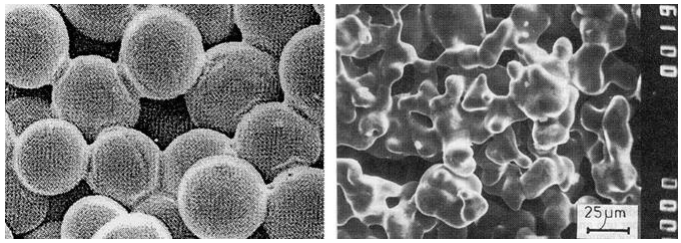


Fig. 3. Porous sintered structures. a – spherical particles, b – irregular particles

In the case of tensile strength as a function of porosity, considering (for this study) each particle size fraction separately, the dependence relations with the least values of the residuum of the mean residuum and of Gaussian concordance test, are those of the experimental type. Thus, the variation law of tensile strength as a function of porosity is the relation [4, 5, 6]: $R_p=R_m \cdot \exp(-V_1 P)$ (1) [4-6], where R_m – the tensile strength of the matrix of material compact powder, P – porosity, V_1 – 5.13 for the particle size of 40 µm; V_1 – 5.86 for the particle size of (+40-80) µm; V_1 – 6.63 for the particle size of (+80-125) µm.

The parameter V_1 represents the decreasing rate of the tensile strength with increasing porosity. From the data given above, one can see that V_1 increases linearly with the increasing size range of the powder used. Therefore the tensile strength of the sheet decreases.

With regard to the tensile strength, it is not unimportant whether the material porosity consists of many and small pores (the case of small size particles) or of few and big pores (the case of big size particles). In the latter case, the tensile strength will be less at the same porosity than it is in the first case.

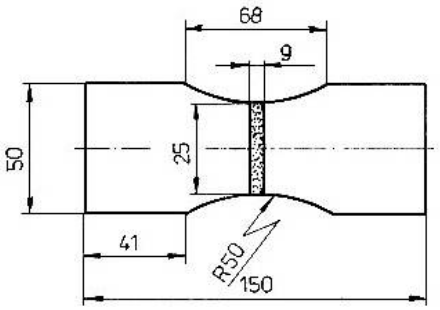


Fig. 4. Specimen used for tensile test

If the size powder range used is left aside and all the experimental results are taken into account for the whole porosity range, the dependence of the tensile strength on the porosity is more complicated, being described as a relation of type: $R_p=R_m(1-P^2)^2 \cdot (-V_2 P)$ (2), where V_2=4.49.

In case of yield limit variation of the sintered porous stainless sheets as a function of porosity, the variation law that may be used in all cases, regardless of powder size range, is a law of type (2) with V_2=2...5, depending on the powder size range [4, 5, 6]: V_2=2.27 for the particle size –40 µm; V_2=3.48 for the particle size (+40-80) µm; V_2=4.39 for the particle size (+80-125) µm; V_2=3.12 regardless of the particle size.

The curves 4 in figs. (5, 6) show the same dependencies when the powder size used is left aside. These curves have only been included for comparison with curves 1, 2, 3, which were experimentally determined and plotted by the computer for each powder size range used to obtain the porous sheets under consideration.

The curves obtained in this way may be used to determine the tensile strength and yield limit of a sintered porous stainless sheet of high porosity.

The analysis by scanning electron microscopy of the fracture surfaces of the porous sheet samples subjected to traction underline the fact that the fracture zone is localized in the sintering necks generated through sintering (fig. 7) [4]. These necks represent some nick zones that are real concentration zones of the tensions that govern the way of fracture as well as the propagation mechanism of the cracks.

With the experiments performed on porous materials of austenitic stainless steel powders, the majority of the fractures have taken place after well-marked plastic deformations of the sintering neck with a large radius of curvature.

This fact denotes the reduced or inexistent effect of the tensional concentration in the zone of most of these necks. In fig. 7c, even the presence of the sliding planes was noticed on some fractured necks. This

justifies the moderately ductile character of the necks fracture, due to the austenitic structure of the metallic matrix. But, on the porous material assembly, the fracture of the porous metals may be considered as having a brittle character.

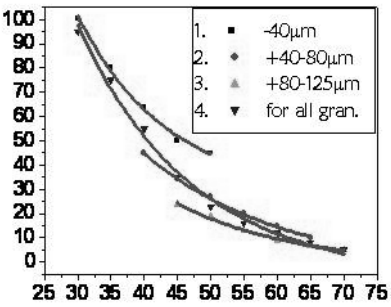


Fig. 5. Dependence of tensile strength on porosity and particle size range

Compression Test

The hydrostatic pressure of the fluids that are filtered as well as the mechanical action of some metallic parts that are in contact with the porous body, cause its deformations, a fact that justifies the necessity of the compression test of thin porous sheets.

Compression testes on samples of sintered porous stainless sheets of different initial thicknesses and porosities with a punch of 11.3 mm in diameter were carried out on a machine of the Instron type. During each loading step, the load (as well as the respective pressure) has been calculated with the equation: $\varepsilon=\ln\bullet(h_0/h)$ (3).

The porosity obtained after each deformation step been determined. The experimental results suggest the following relations for characterizing the dependence: $p=A\bullet\exp(B\bullet\varepsilon)$ (4), $P=P_0\bullet\exp(G\bullet p)$ (5), $P=1-(1-P_0)\bullet\exp(M\bullet\varepsilon)$ (6), where p is the deformation pressure; ε the monoaxial plastic deformation; P the current porosity; P_0 the initial porosity; A, B, C, M are parameters.

In figs. (8-10), the form the characteristics $p=f(\varepsilon)$, $P=f(p)$, and $P=f(\varepsilon)$ is presented in case of compression, described by relations – with the A, B, C and M parameters determined on the computer.

As can be seen from these figures, the values of these parameters are in close agreement with the theoretical considerations concerning the initial porosity dependence P_0 of the compression behaviour of sintered stainless sheets of high porosity.

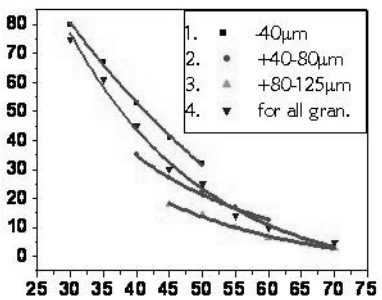


Fig. 6. Dependence of yield point on porosity and particle size range

The compression deformation characteristics of the sintered porous sheets of high porosity (Curve A) are different from those of the compact materials and of the sintered materials of a low initial porosity (Curve B in fig. 11). This shape variation of the curves may be explained by the decrease of the material porosity at compression.

When the complete compaction is achieved by compression, theoretically the material tends to behave like compact materials (Curve C). But a well-marked increase of the pressure is noticed, together with small deformation increases (Curve D) till the complete crushing of the material under the punch takes place. The disagreement in shape between the curves C and D may by explained by a well-marked strain hardness of the metallic matrix material, at the same time with the deformation and compaction in the zone of Curve A.

Influence of the Technological Parameters on the Structure and Permeability

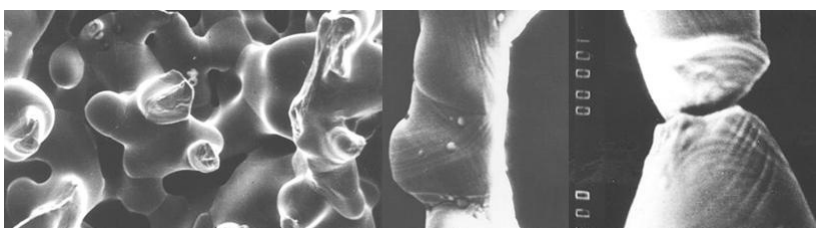


Fig. 7. SEM images of the fracture: general view (x1000), elongated sintering neck (x10000), fractured neck (x10000)

From the powders classified into four powder size range, porous samples were realized by spreading, pressing and sintering in the shape of disk tablets with 60 mm diameter and about 3 mm thickness. The powder size range, the formation procedure, compacting pressure and sintering regime influences

the porous structure's porosity and pores sizes. For the current studies five powder size range of stainless steel powder (316L) was used.

In order to determine the maximal size of pores, the bubble test was used according to the methodology provided by the international standard EN 24003.

Fig. 12a presents the influence of the compacting pressure on the porosity for all the size range of the stainless steel powders used. As expected, a marked decrease of porosity was found, following the compacting pressure and the reduction of the size of the particles.

The porosity as a structural parameter may be considered as a guiding influence factor on some filtrating functional characteristics of permeable porous structures: the permeability and filtering fineness.

Fig. 12b presents the influence exerted by the compacting pressure as a technological factor on the pore size and on the maximal size respectively for each particle size range of the stainless steel powder used.

The maximal size of the pores increases from one size range to the other in parallel with the increase of the powder particles. This tendency is explained by the different size of the empty spaces left in the arrangement of the compacted particles. Therefore the particle size range fraction represents a determinant factor of the permeable porous structure and its parameters.

Fig. 13 presents the influence of the porosity on the viscous permeability coefficient (a) and the maximal pore size (b) in the case of air flow through the pores. The change of porosity resulted in the increase of the compacting pressure and powder size range.

"Surface Effect" in the Porous Sintered Sheets

In the case of thin sintered sheets obtained from powders, there are variations in same structural and functional parameters depending on thickness. From a certain thickness, depending on the powder size, there is a uniformity of the porous structure which ensures the reproducibility of the parameters and functional characteristics [6, 7].

The papers presents the results of experimental researches concerning the influence of the thickness of permeable sintered layers from stainless steel powders with different particle size on some structural and functional characteristics: porosity, pore size.

For each powder size range used for the experiments, the porosities and the maximal pore dimension of the obtained sheets are higher at the minimal thickness, decreasing up to certain values which subsequently remain constant (Fig. 14).

As the superficial layers of the sheets have reduced densities, and consequently higher porosities compared to the rest of the porous body, the "surface effect" manifests its influence in the case of thin sheets. Thus, the lower porosity of the superficial layers influences the porosity value of the porous body as a whole, reducing its effect or disappearing completely at higher

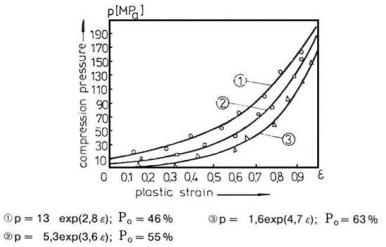


Fig. 8. Compression strain curves

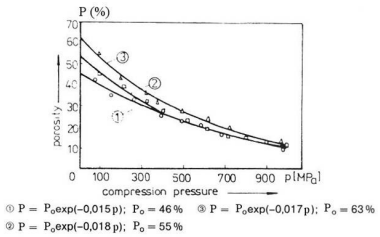


Fig. 9. Porosity variation depending on pressure

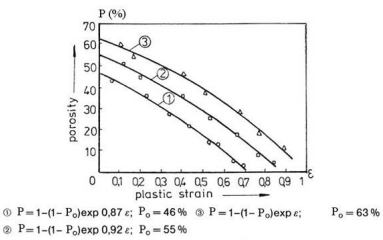


Fig. 10. Porosity variation depending on strain

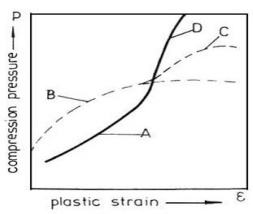


Fig. 11. Characteristic shapes of strain curves: A+D - porous sintered sheet; B - compact material; C - sintered material with reduced porosity

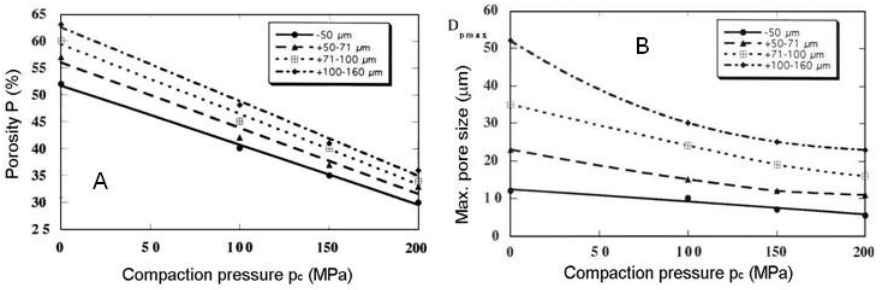


Fig. 12. Influence of compacting pressure on porosity (a) and pore size (b)

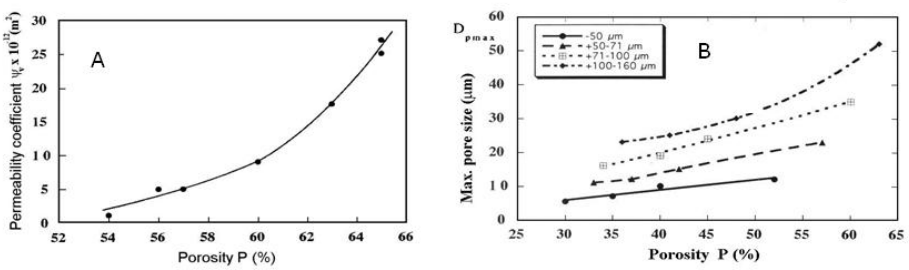


Fig. 13. Variation of the permeability coefficient (a) and maximal pore size (b) according to porosity

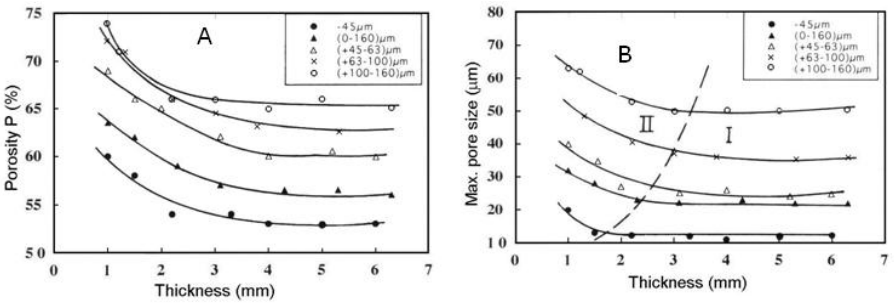


Fig. 14. Variation of porosity (a) and maximal pore size (b) with the thickness of the porous sheet

thickness. The effect is more marked in the case of sheets obtained from greater and larger powder particle sizes. From a certain thickness the surface effect loses its influence.

The critical thickness and the maximal equilibrium size (equalling dimension) of the pores $D_{p\,max\,e}$ for each powder size range are shown in table 1.

The higher values of the maximal pore dimension for thickness less than the critical ones are also due to the "surface effect", which also manifests in this case due to the imperfect arrangement of the powder particles that diminish the ordering degree of the structure. At greater thickness there are more powder layers by which the particle arrangement is stabilized, the porous structure tending to become regular.

Zone I (Fig. 14) determined by the higher values of the critical thickness, corresponds to the ordered, regular porous structures, and zone II to the irregular structures, with reproducible structural parameters and functional characteristics.

Size range	-45 [μm]	0+160 [μm]	+45-63 [μm]	+63-100 [μm]	+100-160 [μm]
g [mm]	1.5	2	2.5	2.8	3.0
$D_{p\ max.e}$ [μm]	12.3	22	25	36	50

Table 1. Values of critical thickness and equalling dimension

Technological Processing Possibilities of Sintered Sheets

Bending

One of the procedures of plastic deformation by which tubular parts can be made of sintered porous sheets is rolling. The principle of rolling is the wrapping of the porous sheet over a central cylindrical roller having a diameter equal to that of the tube to be executed by using another roller with smaller diameter (fig. 15).

The presence of compression forces determines an increase of the deformation capacity of the materials, namely smaller values of the minimal rolling radius as compared to the bending ones.

Another method providing a high curving capacity for sintered porous sheets is bending (rolling) with elastic cylinder [8, 9, 10].

This procedure also has the advantage of protecting the porous structure by reducing or excluding the crushing effect at the contact under pressure of the sheet with the active elements of the bending device.

Bending with elastic cylinder (fig. 16) is a forming and modelling process, by rotation, of rolling type, where one of the cylinders is rigid, the other one being covered by a layer of elastic material (polyurethane). The two cylinders, as rolling active elements, have unequal diameters. On the contact surface, along the angle of contact ρc, between the porous sheet (3) and the elastic layer (2) there appears a uniformly distributed load, due to the pressing force action of the rigid cylinder. The rotating movement provides a successive forming and modelling, the sheet coming out of the contact zone with a curvature depending on the pressing force, respectively on the depth of penetration in the elastic layer [8].

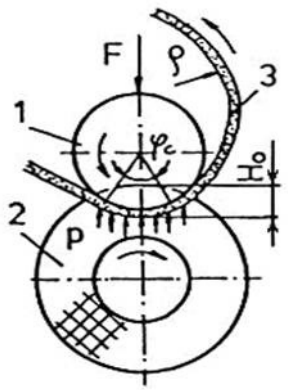


Fig. 15. The diagram of the rolling with elastic cylinder of sintered porous sheets

The tested sheet was obtained by sintering the layers made of austenitic stainless powder (316L), freely spread and smoothed at the above thicknesses, having a particle size range of (0...160) μm and a porosity after sintering of approximately 45%.

Fig. 16 presents the influence of pressing force (a) and penetration (b) on the curvature relative radius. When increasing the pressing force, a growth of the curvature, respectively a diminution of the bending relative radius is noted. This variation is explained by the greater contact angle between the roller 1 and the porous sheet when increasing the pressing force, so the forming and modelling effect becomes stronger. The data in the diagram represent the arithmetic mean of the experimental results.

The dependence laws of the curvature relative radius versus the pressing force and the depth of penetration, which best describe the experimental results, are exponential type relations: $P_{rel}=A_1 \cdot \exp(-B_1 F)$ (7), $P_{rel}=A_2 \cdot \exp(-B_2 H)$ (8), where: A_i, B_i are parameters determined by computer.

The hyperbolic shape of the dependence law for compact sheets does not correspond in all respects in the case of sintered porous sheets.

As a result of crushing tests (pressure with a hob) of sintered porous sheets, with or without and intermediary elastic layer (polyurethane), the structural aspect is completely different. In the case of direct crushing (without intermediary elastic layer), the intense densification and pore bridging may be noticed,

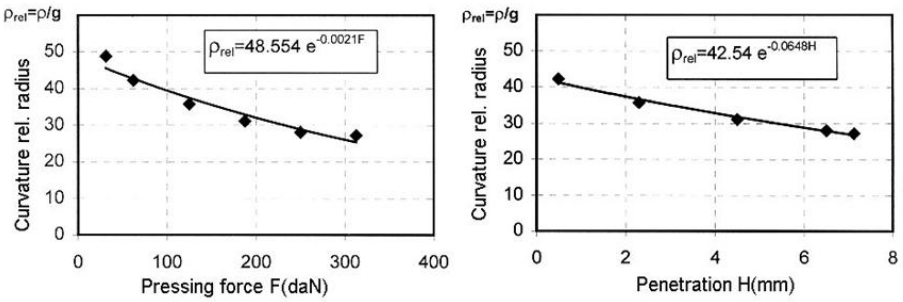


Fig. 16. Influence of the pressing force (a) and penetration (b) upon on the curvature relative radius

while with interposition of an elastic layer between the hob and the material, this effect is reduced or inexistent at relatively low pressing forces.

Electrical Discharge Cutting using Wire Electrode

The specific porous structure of sintered sheets influences the process of cutting by electrical erosion using wire electrode [11]. The properties of sintered porous material and the specific conditions in which the erosion process by electrical electrode takes place develop the process of local melting and flow in the thermally influenced zone with the reduction of the initial porosity and also the size of pores.

The productivity of wire electrical erosion cutting of porous sintered materials is expressed by the cutting speed increase with the porosity and the work intensity. The defects discovered in the thermally influenced zone are by far more reduced as compared to other methods of cutting-out (shearing, flame cutting, plasma cutting). The method of electrical discharge with wire electrode is recommended for the processing of porous sintered sheets in order to obtain parts of complex shapes with geometrical precision, high quality cutting surface and without substantial marginal defects (fig. 17).

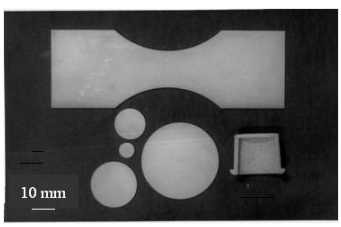


Fig. 17. Samples cut out by electrical erosion using wire electrode

Experimental tests were performed using sintered porous sheets obtained by free spreading of austenitic stainless steel powder type 316L, (1.75...2.00) mm thickness and porosity ranging between 15 and 40%. The sintering conditions are: temperature 1300 °C and sintering time, 120 minutes. A type AGIECUT 250 devices for wire electrical discharge cutting with digital command was used in the following conditions of cutting-out technology: the dielectric - de-ionized water, wire copper electrode of 0.2 mm diameter; wire travelling speed 20 mm/s; discharge tension 150 V. After preliminary trials the optimal value of the condenser capacity in the discharge circuit was established at 150 nF, corresponding to a finishing regime [12]. At higher values the almost complete closure of pores on the cut surface was found, therefore the influence was so strong that the affected zone was no longer porous.

Analyzing the area thermally influenced following the cutting process a number of effects on the porous structure were found.

The thermal effect was located in the cutting area, namely around the discharge craters, and its influence on the structure and depth of the superficial layer was correlated with the discharge energy.

Analysis of the SEM images of the thermally influenced layer in comparison with the initial porous structure evidenced distinct areas of lower porosity and with much smaller pores (fig. 18). The high temperature due to the electrical discharge as well as the lower thermal conductivity of the porous material caused additional sintering by increasing the size of the interparticles necks, reduction of the size of pores and porosity. Both on the cut surface and the thermally influenced area partially melted and resolidified particles may be noted (fig. 19). These processes developed in the areas of electrical

discharge of micro channels of ionization of high temperature, whose sizes may be considered to be of the same order as the ones of the interparticles necks.

In conditions of local melting inherent to the process, other physical and chemical phenomena may occur that influence the micro- and macrostructure of the material. Thus, it is possible that a part of the melt material will evaporate, then condense and deposit, while another melt part will flow and by the capillarity effect penetrate into the pores of the cut surface or the neighbouring pores. It may be stated that the above-mentioned cumulative effects lead to the decrease of porosity and size of pores in the thermally influenced area. The process of electric erosion is also accompanied by the superficial oxidation of the material exposed to erosion. The atomic oxygen resulted from the decomposition of ionized water will oxidize the component elements of the alloy (e.g., Fe, Si, Cr). The oxides formed appear in the form of fine pellets on the cut-out surface

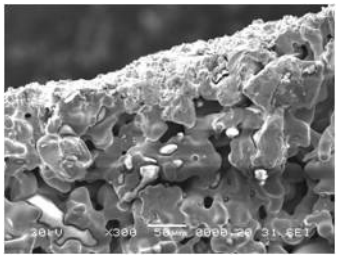


Fig. 18. The thermally influenced area at electrical discharge cutting with wire electrode of the sintered porous sheet (SEM - 300X)

It may be stated that the area thermally influenced following the process of wire electrical cutting of sintered porous materials is relatively small, while the extent of the margin defects evidenced (reduced porosity, pore closure, superficial oxidation) is not too great. The consequences of the presence of these defects are much more reduced as compared to the ones induced by the mechanical cutting procedures such as plastic deformation or shearing. In some cases it may be considered that the reduction of porosity is beneficial, the cut-out area representing the very joining area between the porous part and other mounting elements in the subunit of which it is a component.

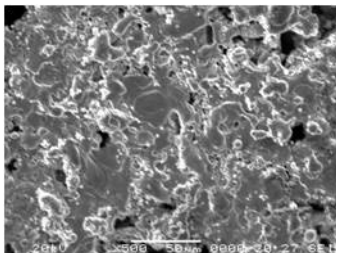


Fig. 19. The aspect of the surface resulting by electrical discharge cutting with wire electrode (SEM - 500X)

Fig. 20 presents the influence of porosity on the cut speed for different values of the current intensity. The cut speed is defined by the value of the cut section per time unit. A slight increase of the cut speed (assessed by the times to cut constant lengths of material) was found when porosity increased. This may be explained by the decrease of the actual section of the material of the cut metallic matrix at the same discharge capacity, namely the implicit increase of the travelling speed. Based on these results the dependence correlation between the cut speed and the current intensity may be calculated for each value of porosity (fig. 21). Increase of the current intensity will decrease the cut time, i.e. increase of the cut speed, following increased discharge energy and more intense erosion process.

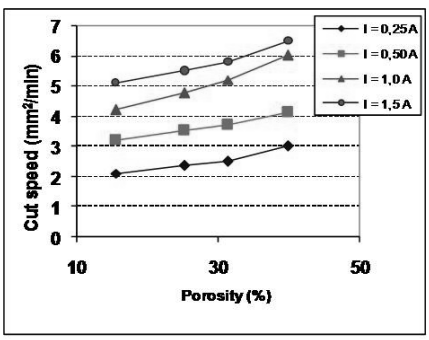


Fig. 20. The influence of porosity on the productivity in the electrical discharge cutting

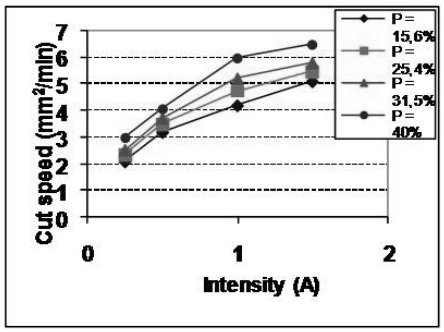


Fig. 21. The dependence of the productivity on the current intensity in the electrical discharge cutting

However, both graphs evidence a more reduced influence of the porosity on the cut speed. Practically the curve slope is relatively small. The effect of re-sintering and re-penetration of the eroded material into the pores reduces the more marked influence of the initial porosity.

Conclusions

The dependence laws of the mechanical characteristics as a function of the sheet porosity of stainless metallic powder of high porosity are of an exponential form according to relations (1), (4-6). At the analysis of the mechanical characteristics as function of porosity, the particle size of the powder used must be considered. At the level of the sintering necks, the fracture of the sintered porous stainless materials has a ductile character.

The compression deformation characteristics of the sintered porous sheets of high porosity have a different form from those of compact and sintered materials with reduced porosity.

The process of bending by rolling of porous sintered sheets will observe the minimal bending radius in order to avoid fissuring of the exterior layer. The minimal rolling radius (deformability indices) depends on the thickness and porosity of the porous structure and represent and indicator of the deforming capacity.

The current researches led to patenting the manufacturing of porous tubes by rolling the porous sintered sheets using cylindrical elastic tubes. For each particle size range fraction used there are porosity variations at reduced thickness of the porous samples, due to the "surface effect".

A critical thickness of the porous permeable layers is found, from which the maximal pore dimension remains constant, the uniformity coefficient has the value one, and so the porous structure becomes ordered, tending to regularity and reproductibility.

The porous structure of sintered sheets influences the process of wire electrical discharge cutting. The properties of the sintered porous material (especially decreased thermal conductivity) and the conditions induced by the electrical discharge erosion (high temperatures) develop the re-sintering process in the thermally influenced area, with decrease of porosity, reduction of pores and their clogging by the eroded material.

The cutting productivity of the wire electrical discharge procedure for sintered porous materials, expressed by the cut speed, increases with porosity and the intensity of the electrical current applied.

Certain defects evidenced in the thermally influenced area (more dense porous structure, oxidation of chemical components) generate considerably more reduced adverse effects than in case of other methods of cutting metallic sheets. In most cases these defects have a positive influence on the assembling capacity of the sintered porous parts. The wire electrode electrical cutting of sintered porous sheets is recommended in order to obtain parts with complex shapes and high geometrical precision, high quality cut surface and tolerable marginal defects.

The results obtained in the present study are necessary both for determining some functional parameters and for establishing the manufacturing technology of the permeable porous pieces.

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The static behavior of layers from structure of roving and mat composites

I. Curtu, M. Stanciu, A.Stanciu
University of Transylvania, Brasov, Romania, B-29 DUL EROILOR

Composite materials are used in a variety of applications being appreciated for their superior properties. However, their use in aggressive environmental conditions, lead to damage and breakage of fibers, matrix fissure, damage of the bond between fiber and matrix. In this respect, the paper presents research on the values of the deformations and stresses of roving and mat composite layers, carried out by numerical methods (FEM) and experimental (TER).

Between layers of composite samples were mounted resistive strain transducers (TER) since the fabrication of composites. The samples were subjected to bending, as measured the specific strains and determination of tension for each layer. Theoretical and experimental investigations revealed the static behavior of ROVING and MAT composite microstructure.

Introduction

Composite materials have a wide use in various applications: in the aviation industry, marine structures, transport, etc. One of the areas composite materials can be used, is represented by panels structures with some soundproofing characteristics, like acoustic barriers (Stanciu, 2010). Given the variety of static, dynamic, variable requests, aggressive environment factors that the panels structures are subjected to. It is necessary to know the stress and strains, especially their size for each lamina (layer) of the composite structure (Cerbu, 2010, Motoc 2010). Thus, the paper aims to present theoretical and experimental results on strains from the composite layers of Mat and Roving type composite, in case of static bending in four bearing points. Although the materials comprising the composite material can be isotropic, due to their layout, material can be, on average anisotropic. Materials that are operating in practice may be homogeneous or inhomogeneous. Internal stress and strain field, at the microscopic level, is locally influenced by the relative difference between the local properties of structural elements (matrix and reinforcement elements), their size, shape and relative orientation, and the geometry of the reinforcing elements (Curtu 2009).

Materials and method of investigation

During the research, the composite materials performed by MAT and Roving materials, both in layered structures of each type of material and in laminated composite structures of both materials were analyzed. In this way, MAT type is the most commonly used form of reinforcement material, consisting of a layer of fibers with lengths ranging between 3.2 and 50 mm randomly oriented. The fibers are bound together by an epoxy resin binder type (fig. 1). The ROVING type consists of a collection of parallel fibers or filaments, bundled without an intentional twisting fabric type (Fig. 1). It is used to reinforce those structures where high strength is desired in the direction of fibers.

- RT 800 in the warp-glass fiber composite material in epoxy resin matrix 4x with specific mass of 4x 800 g/m^2, 3.2 to 3.6 mm thickness.

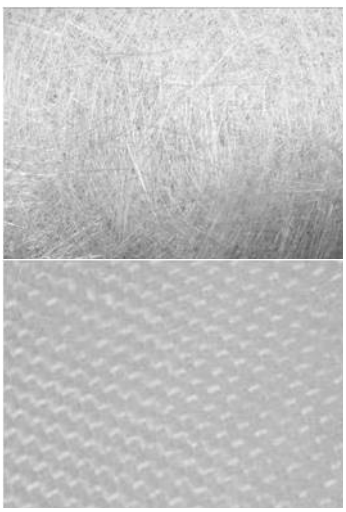

Fig. 1. The structure of studied composites: fiberglass - short fibres (MAT), roving fabric

- RT 800 woof-fiberglass composite material (fabric) in epoxy resin matrix, with 4x specific mass of 800 g/m^2, 3.2 to 3.6 mm thickness.
- MAT 450 - fiberglass composite material (short FIBERS) in epoxy resin matrix, having a specific mass of 4x450 g/m^2, 1,6 to 2 mm thickness.

Type of samples, material	*Code*	*Width [mm]*	*Thickness [mm]*	*Area [mm^2]*
RT samples 800 in the warp, 4 layers	E U1	9,8	4,3	42,14
	E U2	9	4,3	38,7
	E U3	9	4,4	39,6
	E U4	10	4,4	44
	E U5	9,3	4,3	39,99
RT samples 800 in the woof, 4 layers	E B1	9,8	4,5	44,1
	E B2	9	4,4	40,92
	E B3	9	4,5	45
	E B4	10	4,3	42,57
	E B5	9,3	4,3	43
MAT450-RT800 samples in the warp - MAT600, 8 layers	E 1	10	7	70
	E 2	9,5	7,2	68,4
	E 3	9,3	7,6	70,68
	E 4	9	7,1	63,9
	E 5	9,5	7,2	68,4
MAT samples 450, 4 layers	E M1	9	4	43,1
	E M2	9,4	4,1	44,92
	E M3	9	3,9	41
	E M4	9,2	4,1	42,57
	E M 5	9.6	4.2	43

Table 1. Characteristics of the samples

The investigation was based on two methods the theoretical one using the finite element method (FEM) by applying the program MSC Nastran, and the experimental one, with the help of the Spider 8 device, which determine the specific strains of the layers of material through resistive electric transducer (TER), the samples being subjected to four point bending. Applied load was 600 N for specimens made of four layers, while for MAT-Roving composite material of eight layers, the sample was tested at a force of 1000 N. To determine the strains with the help of tensometry method, among the layers samples it were pasted TER from the manufacture, as shown in fig. 2.

To capture the measured signal, in order to achieve half of the bridge it was necessary to apply the connection scheme. The samples were subjected to four points bending. The signal was captured from electrotensometric resistive transducers with electronic measuring system Spider 8, set for half-bridge connection and device HBM Kompensator MK Hottinger Baldwin Messtehnic. In fig. 3 there are presented stages of testing, measurement and data processing.

Results and discussions

After tests, it determined the variation of specific strains of the layers of the samples. In table 2 there are summarized the average values of maximum specific strains for the samples tested obtained experimentally.

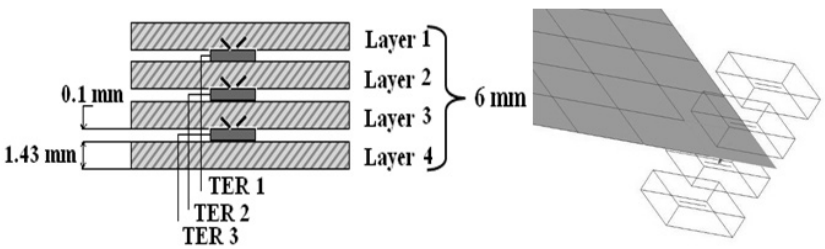

Fig. 2. Representing a sample with TER among layers

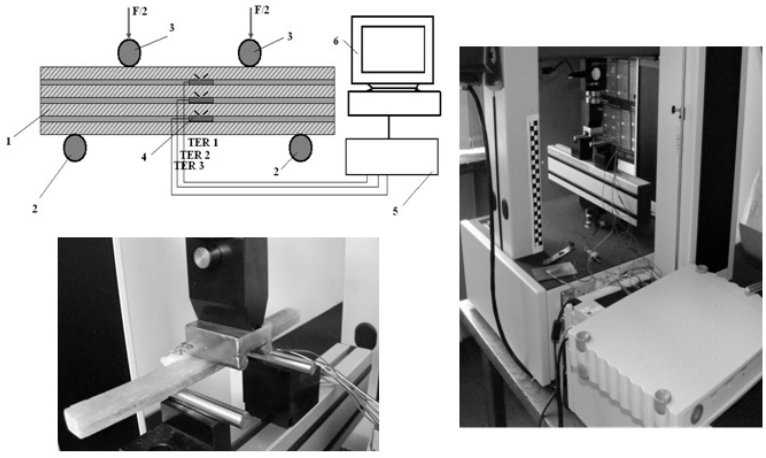

Fig. 3. Test and measurement equipment (1 - sample, 2 - bearing, 3 - point of force application, 4 - electrotensometrice resistive transducers, 5 - signal acquisition device, 6 - data processing unit)

	Deformații specifice ε				
	RT 800 U	***RT 800 B***	***Mat 450***	***Mat-Rov U 8 layers***	***Mat-Rov B 8 layers***
TER 1	0.02565	0.01744	0.03355	0.01719	0.01953
TER 2	0.00235	0.00255	-0.00058	0.00902	0.01220
TER 3	-0.02336	-0.01616	-0.03318	0.00394	0.00615
TER 4				-0.00117	-0.00186
TER 5				-0.00470	-0.01107
TER 6				-0.00922	-0.01372
TER 7				-0.01512	-0.01816

Table 2: The strains values through experimental method

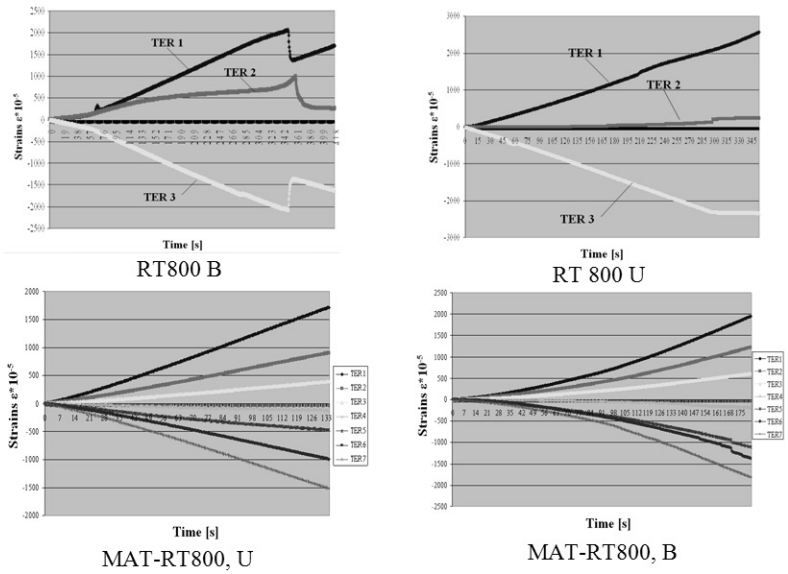

Fig. 4. Variation of strains for each type of material tested

The data acquired in the form of graphs of variation of strains of each layer, with respect to time of application, are presented in Fig. 4. Analyzing the behavior of the layer from the sample structure, it was found that the values of the strains are approximately symmetrical to the neutral axis, the layers being stressed to tension and compression.

Comparing the values of the strains of the outer layers (face contact with layer 2, fig. 2) of the most requested samples with different composite structures (fig. 5), it's revealed that the highest strains are obtained in the case of MAT 450 material, with four layers, and the lowest strains are obtained in the case of eight layers composites, obtained by combining the MAT 450a with ROV 800.

In the final phase of the composite bearing capacity loss, destruction of the composite is achieved through: large delamination among layers, destroying large areas of the matrix, flaming fiber local in comprised areas, phenomena that may occur simultaneously or sequentially (fig. 6).

Since experimental measurements involve consumption of materials, TER, workmanship, in the study it was followed the possibility of using finite element method in determining the stresses and strains at the

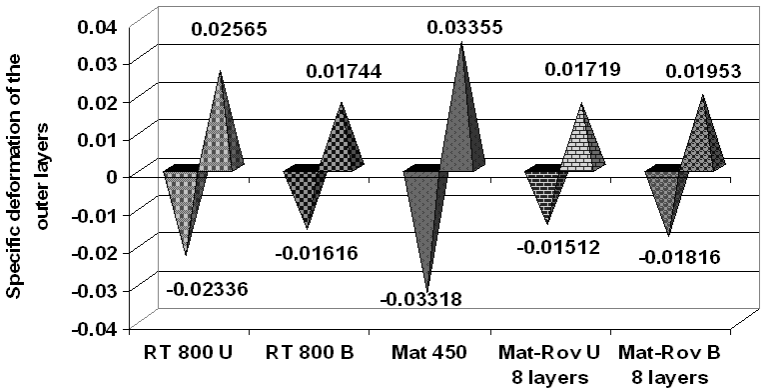

Fig. 5. The strains determined in the outer layers

microstructure level, so that future studies should focus on several simulations.

Thus, shaped layers of material and strain gauge, each layer being characterized by specific properties of constituent materials, there were established the shape and type of stress (fig. 7). Material

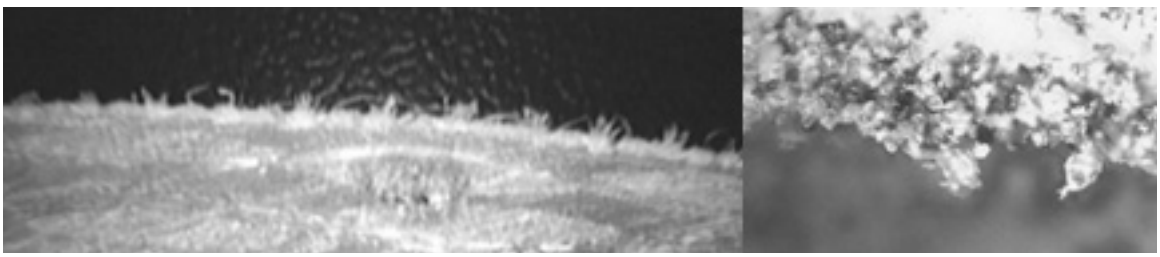

Fig. 6. Images captured with a 2D camera and microscope during the failure of samples

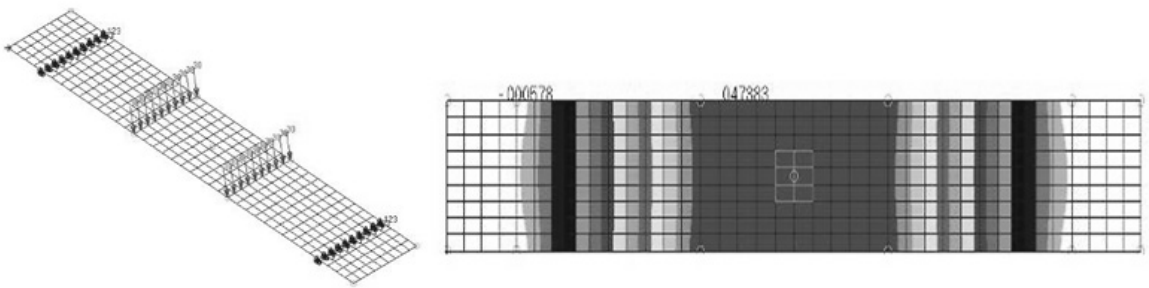

Fig. 7. Stages of the FEM modeling of composite samples

properties (elasticity, Poisson's coefficient, density) were determined experimentally according to European standards.

After running the program NASTRAN, FEM results were compared with experimental ones. It was found that the experimentally determined specific strains have higher values than those calculated by FEM (fig. 8). To obtain experimental data with calculations based on FEM, these are amplified by a factor of 1.21 .... 1.45. Minimum values of the coefficient refers to composites with several layers: 6, 8, 10, and maximum values in composites with fewer layers: 3.4, 5.

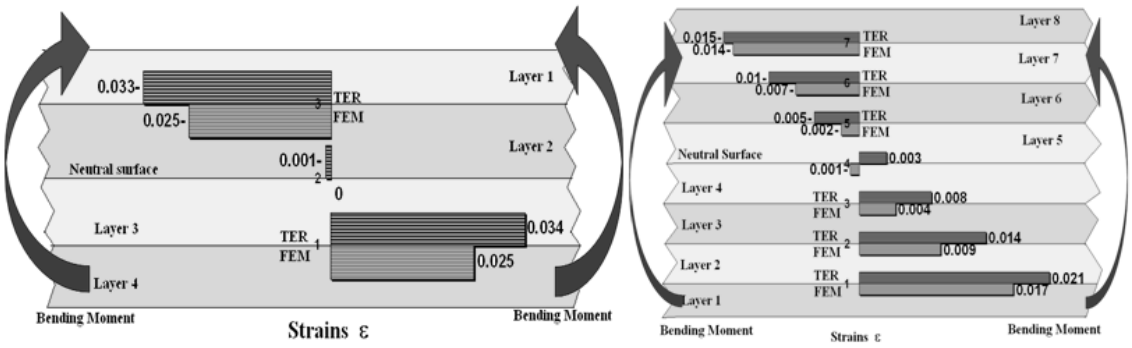

Fig. 8. Specific deformation diagram obtained by FEM and TER

Conclusions

The study presented in this paper contributes to knowledge of the properties of composite MAT 450 type, 800 Roving and combinations of these materials and to characterize the macroscopic behavior of composites, mechanical phenomena developed among the layers of materials. Analysis of strain gauge results makes a contribution in addition to experimental tests and finite element contributing to the validation of experimental research. So numerical calculations performed with FEM, amplified by a factor equal to 1.21 to 1.45, lead to values comparable with real ones. The originality of the research consisted in measuring the specific strains among the layers.

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the contract number POSDRU POSTDOC-DD, ID59323. Some of the studies presented in the paper were the research subject of the PhD thesis: Contribution to the Mechanical Properties Determinations for the MAT - Roving Composite Materials used at Cylindrical containers, made by Anca Stanciu Eng.

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UKRAINE

Priority directions of research in Ukraine: by results of marketing analysis

T. Kvasha, Chief of Division, UkrISTEI

E. Kochetkova, Chief of Dept., UkrISTEI

G. Zadorozhnaja, Lead scientist, UkrISTEI

E. Paladchenko, Senior scientist, UkrISTEI

Selection of priority directions of research and development plays an important role in the state scientific-technological policy. Such directions are implemented in the form of large interbranch projects on creation, mastering and distribution of technologies, promoting cardinal changes of a technological basis of economy, on development of fundamental research, scientific-engineering support of social programs, international cooperation.

Definition of scientific-engineering and innovative priorities is important for the most developed countries of the world (the USA, Japan, Germany, the Great Britain, China, Russia) and for countries, which because of restricted resources took advanced positions only in separate directions of technological progress.

The basic instrument of definition of priority directions and the list of critically important technologies in many countries is Forsyte - forecast of vision of the future of science, economy and a society for the purpose of identification of zones of strategic research and technologies, which can bring the greatest profits to a particular country [1].

During the last decade all over the world specialists use the following three main methodologies of Forsyte [2]: Delphi, critical technologies and panels (target groups of experts).

Selection of priority directions of research and developments in different countries is carried out differently. In the USA selection of priorities in science and technologies implies: provision of leadership in all directions of human knowledge; strengthening of unity between fundamental science and national priorities; development of partnership of the state, industry and academic circles in the area of expansion of capital investments into fundamental and engineering sciences and for effective use of material, human and financial resources, raising of a level of engineering knowledge of citizens.

In the RF selection of landmarks of scientific-technological development is carried out on a regular basis by formation of the list of priorities and critical (important) technologies. Priority directions of development of science and critical technologies are analyzed and corrected, taking into account global tendencies and intermediate term priorities of social and economic development of the country.

In Ukraine Forsyte-research is conducted since 2008. Its purpose - definition of priority topical directions of research and development, strategic priorities of innovative activity, revealing of critical technologies in the above-mentioned directions.

This research is implemented within the frameworks of the State Program of prognostication of scientific-technological development for 2008-2012, approved by the Cabinet of Ministers of Ukraine on September 11, 2007 (#1118) [3]. According to the order of the Ministry of Education and Science of Ukraine, the base

organization, providing implementation of this program, is the Ukrainian Institute of Scientific, Technical and Economic Information (UkrISTEI).

During 2008-2010 specialists have developed and specified methodology of strategic marketing analysis of scientific-technological progress, perfected techniques of definition and specification of critical technologies in priority directions of scientific-engineering development. Fundamentals of research - polls of target groups of experts.

In 2008-2009 strategic marketing analysis was conducted in the following directions: «power efficiency and energy-saving», «new substances and materials», «new techniques of prophylaxis and treatment of the most widespread diseases».

In 2011 the similar research took place in the direction «informational-communication technologies».

Analysis is carried out according to the following scheme:

- global tendencies of the world science and technologies;
- current state and perspectives of development of scientific-engineering potential of Ukraine on the basis of analysis of publications (papers, monographs, defended dissertations, research reports);
- normative-legal and legislative bases of Ukraine in the area of scientific-technological policy in separate spheres;
- strategic marketing research on revealing of perspective newest technologies;
- list of enterprises, at which introduction of critical technologies and production of an innovative product is possible;
- informing of the government and a society about selected critical technologies and perspectives of their introduction.

Each of these stages can, in its turn, include certain additional stages and corresponding procedures.

Strategic marketing analysis for revealing of perspective topical directions and the list of the newest technologies on the basis of expert estimates includes the following:

1. Formation of a database (DB) of experts or expert panels in three directions: scientists – staff of scientific research institutes (SRI), most actively working in corresponding priority directions; administrative personnel - representatives of administration, industrial associations, business-communities; businessmen - representatives of companies, where introduction of critical technologies is reasonable.

2. Polls of selected experts. Each group receives a questionnaire, containing certain questions, taking into account their competence and allowing to structure contents of the passport of technology, having selected in it separate semantic blocks. Questions of different questionnaires correlate among themselves. In case of discrepancy of opinions of respondents additional polls through the Internet are conducted. It allows: to save expenses for mailing and processing of questionnaires, gives operative information; automatically to analyze answers, receiving generalizing factological material.

3. On the basis of answers of experts preliminary lists of the newest technologies and their passports are created. In parallel experts inspect the last.

4. Estimation of technologies by market experts according to a developed system of criteria and selection of the most perspective. Criteria of selection are the following:

- total period of research and introduction of the newest technologies;
- total volume of financing of research and introduction of technologies;
- number of items of high-tech production, which are supposed to produce on the basis of the given technology;
- annual sales volumes of new production;
- its functional and price characteristics.

Initial orientation to social demand is of great importance, it is also necessary to take into account variants of use of the list of critical technologies and a sufficient degree of detailing of these technologies regarding necessary financial resources and manpower for conducting of research and introduction of technologies.

Proceeding from analysis of global tendencies of science and technologies, the priority is given to those from them, the level of which is higher or corresponds to the world.

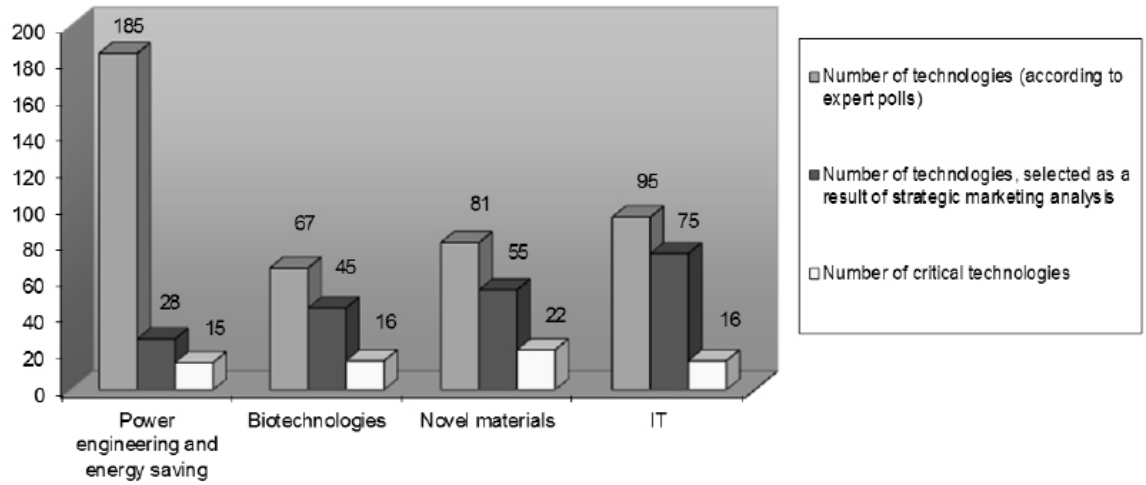

Fig. 1. Results of marketing analysis, revealing perspective technologies in priority spheres of scientific-engineering development of Ukraine

5. The second stage - polling of experts from real sectors of economy regarding expediency of use of technologies and presence of corresponding resources in Ukraine for introduction of the selected technologies.

6. Formation of lists of critical technologies and topical directions, taking into account results of the second poll.

7. Expertise of the selected technologies by members of expert councils in each separate sphere.

8. Formation of final lists of directions and critical technologies, taking into account expertise, performed by members of expert councils; approval of these lists.

9. Creation and actualization on the web-page of UkrISTEI special information under the title «Forsyte - strategic marketing analysis of scientific-technological development in Ukraine»

10. Preparation of generalized materials and suggestions for the Cabinet of Ministers of Ukraine under lists of priority scientific research and critical technologies.

In the sphere «Power engineering and power efficiency» the following 15 technologies are recognized critical according to corresponding directions: effective power supply of structures and buildings, electric power engineering, new kinds of fuel and power resources, power machine building and heat pump technologies.

In the sphere «New substances and materials» - 22 technologies in the following directions: production and application of composite, constructional, functional and nano- materials; in the sphere «New technologies of prophylaxis and treatment of the most widespread diseases» - 16 technologies in the following directions: production of new enzymatic agents, creation of diagnostic agents and methods on the basis of molecular biology, medical products (including biologically active substances and nanoparticles), varieties of agricultural crops with use of gene engineering [1].

Informational-communication technologies - comprise 16 technologies.

As a result of strategic marketing analysis the following things have been created:

- data base of passports of the newest technologies;
- database “Experts of Ukraine“;
- list of research and development universities and high schools, conducting research in the above mentioned spheres;
- list of industrial companies, where introduction of critical technologies is possible;
- page «Forsyte - strategic marketing analysis of scientific-technological development of Ukraine» at the web-site of UkrISTEI (http://www.uintei.kiev.ua/foresight/index.php).

Passports of critical technologies contain the following important marketing signs:

- period of implementation and introduction of results of research;
- total amount of finances and expenditures for implementation and introduction of scientific research;
- annual sales of new high-tech production/service (in value terms);
- functional and price characteristics of new production.

Results of marketing analysis are represented in a Fig. 1.

These analysis formed the basis of the Law of Ukraine from September 8, 2011 (#3715) «About priority directions of innovative activity in Ukraine», in which strategic priority directions of innovative activity for 2011-2021 are determined, and also the basis of a decision of the Cabinet of Ministers of Ukraine from 07.09.2011 (# 942) «About approval of the list of priority topical directions of scientific research and scientific-engineering development for the period till 2015».

Ukraine has powerful scientific potential, allowing to conduct fundamental and applied research, and a diversified industrial complex, 30% of this complex is oriented to hi-tech manufacturing (mechanical engineering and instrument engineering, power engineering, aircraft and spacecraft building technologies, material science, etc.). Science has saved its ability to conduct research and to receive results of the world level in the following directions: nanostructures and nanotechnologies; immunologic technology, biosensors and molecular diagnostics; biotechnologies of plants and biophysics; computer science; micro- and optoelectronics; aerospace technologies, a series of other directions of physics, chemistry and biology.

Significant success is reached in the sphere of creation of new substances and materials, nanocomposites, semi-conductor scintillators, nanotechnologies for production of powder metals. The other important direction - cellular biotechnology. Ukraine specialists have developed special medical products and biologically active substances, have solved a series of actual problems of space and gravitational biology, have received new high-quality varieties of grain, fodder, vegetable and flower cultures [4,5].

Further we represent the series of technologies, revealed as important (as a result of strategic marketing analysis in the direction «New substances and materials») and included into the list of critical technologies:

Mechanical Engineering

UKR-01

Improvement of working characteristics of products from constructional materials at creation (by cold plastic deformation) gradient fine-dispersed and nano- structures

Assignment

Increase of lifetime and liability of products from constructional materials.

Area of application

Mechanical engineering, aerospace industry.

Description

Formation of gradient structure of a surface of alloys of metals allows to create structures with specific functional characteristics, inaccessible to materials with usual equilibrium structure. The basic method of gradient nanostructuring of surfaces - addition of energy by means of intensive plastic deformation.

Physical mechanisms of mass transfer, generation and mobility of defects, refinement of grains and formation of new grain boundaries in such conditions are practically not studied. There is no information

about relaxation processes in structures, generated in conditions of extreme plastic deformation. Thermal stability of gradient structures in constructional alloys and evolution of internal stresses in them in time is not studied. At the same time, controlled processes of formation of gradient nanostructured layers will allow to receive limiting strengthening of a structural state.

Novelty

Novelty of this technology - presence of a component of displacement at deformation of external and internal surfaces of details from constructional materials. Due to this the following phenomena take place:

- gradient surface hardening, as alternative to chemical-thermal treatment for improvement of physical-mechanical and working properties of splines of various profiles;
- substitution of operations of cutting drawing by cold plastic deformation, perspective for profiling of surfaces and gradient surface hardening;
- increase of lifetime of spline couplings for railway, air transport and agricultural machinery.

Advantages

- Cost of cardan shafts will drop down approximately 1.5 times in comparison with cost of such items (approximately USD6,000) of the company Gantz MAVAG-Budapest (Hungary);
- Lifetime will increase (according to forecasts, in 1.2 times) in comparison with lifetime of import shafts (10 years);
- Mastering of an experimental-industrial technology will allow to keep workplaces at factories, producing or repairing rolling stock of railway and motor transport, will improve a technical state of transport and its safety.

Development stage

The technology is at the stage of creation.

The planned year of ending of the process of creation - 2013.

Power Engineering

UKR-02

Ceramic fuel elements for generators of electric power with different power from biofuel and domestic waste, mine methane, natural gas, gas-hydrates and hydrogen sulfide of the Black Sea and hydrogen

Assignment

Production of electric and thermal energy.

Area of application

Power engineering, mechanical engineering, agriculture, mining and metallurgy.

Description

Ceramic fuel cells (FCs) - the first by efficiency and ecological safety technology of production of electricity from hydrogen, various hydrocarbons and hydrogen sulfide, air oxygen. FCs produce the volume of electric energy, which is three times more then the volume, produced by the best thermal stations or internal combustion engines. Working mediums in them - water and carbon dioxide. FCs are very flexible by their power. If energy is not consumed, FCs practically do not consume fuel. FC is the device, which outputs electric energy of chemical reactions between hydrogen, carbon and oxygen outside. FC itself is a ceramic device

and a layered composite, its heart - electrolyte from zirconium dioxide, Ukraine is rich with this material. The other layers - anode and cathode, which output electricity for its consumption.

Creation of industrial technologies of production of fuel elements and batteries on their basis for manufacture of generators of electric and thermal energy with total power of 5kW for the purpose of provision of householders and social facilities with them is to be the first stage of the process of development of the FC-direction in Ukraine. Gained experience will allow to develop operatively manufacture of powerful (more then 1 MW) generators for power engineering, transport and industry.

Novelty

Powder of zirconium dioxide 10Sc - 1Ce - ZrO from Ukrainian deposits and electron-beam deposition of films of the electrolyte on a porous anode - carrier of a FC allows to improve significantly general conductivity up to ~ 0.2 ohm/cm^2 at 600^{o}C.

Advantages

Introduction of FC-technologies will allow to reduce consumption of natural gas in two-three times and to decrease emission of harmful substances into environment. FCs is really high-tech technology, capable to advance the country to new stages of development.

Development stage

Scientific research is conducted.

The technology is at the stage of creation.

The planned year of creation of the technology - 2015.

Coatings

UKR-03

Deposition of multilayer and composite functional coatings with use of units of a new generation «Bulat»

Assignment

Improvement of working characteristics of cutting instruments, tool sets and details of machines.

Area of application

Mechanical engineering.

Description

The vacuum-arc unit «Bulat» of a new generation will have the upgrade system of electrical supply, will use small-size efficient power supply devices of arc evaporators and substrates, including high-voltage parts, managed by a computer. The unit will have a series of systems, previously absent:

- provision of the process of nitriding of steels in vacuum-arc two-stage gas discharge with subsequent deposition of wear-resistant coatings;
- automatic control of deposition of multilayer coatings, including nanolayers of different structure with regulation of their thickness (from 10 nm);
- mixing of 2-3 gases (nitrogen, argon, methane) within accuracy up to 1% before their release into a vacuum chamber, provision of automatic maintenance of pressure of mixed gases at the set level;
- generator of high-voltage impulses with amplitude of 2000 V and frequency up to 15 kHz;

- infrared pyrometer with the range of measurement of temperature of a substrate in the process of coating deposition 100... 600°C.

Work of devices, power supply units, creation of high vacuum in the chamber is managed by a computer with the corresponding program.

Offered technologies:

- deposition of super-hard nanostructural one- and multilayer coatings on products from constructional and lean alloy steels, which do not allow their heating above 150 °C. At deposition of coatings on products high-voltage impulses of negative potential with frequency of 1 ... 15 kHz are used. The technology provides increase of wear resistance of products from steels ШХ15, Х12М, ХВГ, etc. up to 5...10 times (stamps, punches, rolling rollers). Till now deposition of vacuum-arc coatings on such products was impossible, since corresponding deposition temperature reached 500°C. Thus, the new class of instruments and tool sets with vacuum-arc coating appears. It is very important, since the majority of sets (for example, stamps) are very expensive;
- Complex vacuum-arc treatment of products from fast-cutting steels, including nitriding in vacuum-arc two-stage gas discharge with subsequent deposition of super-hard coatings from nitrides of metals of the 4-6th groups in the uniform technological process. Such treatment significantly increases lifetime of products, even in comparison with products with the same coating, but without nitriding. Since the nitriding process takes place at temperatures about 500°C, the technology can be used only for treatment of fast-cutting steels.
- Deposition of vacuum-arc coatings on tools for hard-to-cut materials (chrome-nickel steels and alloys, stainless steels, titanic alloys). These are multilayer coatings TiN-MoN, TiN-CrN, NbN-ZrN on tools from hard alloys, fast-cutting and lean alloy steels. Regulation of thickness of nanolayers of coating allows to optimize its properties, and that provides maximum useful result for each kind of tools, work material and a process rate.

Novelty

Super-hard coatings from TiN and also complex treatment have no analogues in the world, some multilayer coatings are used in industrially developed countries.

Advantages

Research on creation of super-hard one- and multilayer and complex coatings at deposition temperature of 100-500°C has demonstrated increase of wear resistance of products from constructional, lean alloy and fast-cutting steels up to 5-10 times. Economic benefit is provided due to increase of efficiency of the corresponding equipment (reduction of time for readjustment, increase of feed rate and processing speed). Reduction in several times of the necessary number of tools and operations due to better finishing, saving of energy at the expense of decrease of cutting forces are also important factors. The annual effect from introduction of this technology only at one engineering plant can make not less then UAH 1-1.5 million. It is planned to supply not less then 10-12 engineering plants of Ukraine with tools with super-hard nanostructural coatings.

Development stage

The technology is at the stage of creation and introduction. The planned year of creation of the technology - 2013.

Water Treatment

UKR-04

Nanostructural ceramic and polymeric materials for hybrid membranes for purification of drinking and technological water

Assignment

Treatment of water (including sea water) for different applications.

Area of application
Stations of water treatment («Vodokanal») of almost all cities of the country. Purification of technological waters of industrial companies, stations of desalination of sea water in the south of Ukraine.

Description
This technology integrates production of polymeric films, their functionalization by catalytic components, creation of ceramic membranes-supports from nano-disperse powders of oxides, their further functionalization and assemblage into a stack with polymeric films-membranes.

Novelty
In the market of membranes of the second generation there are players from 17 countries (the USA, Great Britain, Japan, South Korea, Germany, etc.). Overall output is close to USD1 bln. In 2012 the market of nanofiltration is estimated as USD350 mln., and by 2015 it will make USD1.07 bln. It is expected that in 2015 the market of technologies of sea water desalination will make USD5.5 bln.

Advantages
Hybrid membranes for purification of potable water, which will be produced as a result of introduction of this technology, correspond to their world analogues, but have lower cost.

Development stage
R&D.
The planned year of creation of the technology - 2015.

Mechanical Engineering

UKR-05

Wear-resistant nanostructural ceramic materials for high-temperature and high erosion-resistant friction units

Assignment
Production of nanostructural friction units.

Area of application
Mechanical engineering

Description
The newest technologies of production of nanopowders and their sintering allow to create nanoceramic materials, wear resistance of which significantly is outstanding (exceeding analogues).

Novelty
In 2010 the segment of the market of wear-resistant ceramics has made USD0.63 bln. According to forecasts of analysts, this market soon will make USD0.98-1.02 bln. Approximately 35% of wear-resistant ceramics will be represented by nanostructural ceramics. Production of wear-resistant and nanostructural ceramics is high-profitable - 100-150 %.

Advantages

Analysis has displayed 5-6-fold growth of wear resistance of nanoceramics in comparison with traditional one. Creation of technology of production of ceramic nanostructural bushes and bearings from nanocrystalline powders of SIC, Si3N4, TiB2, etc. is considered.

Development stage

R&D. The planned year of creation of the technology - 2014.

Medicine

UKR-06

Technologies of use of nanomarkers for analysis of a current state of biological objects

Assignment

Synthesis of nanoparticles, nano-phosphors with controllable luminescence. Functionalization of nanoparticles by molecules (mobilization and immobilization). Production of nanostructural functional nanomarkers for biomedicine, for example for monitoring of a current state of cellular metabolism.

Area of application

Pharmaceutical companies.

Description

Creation of nanocrystalline particles with the set structure, containing luminescent additives with different organic components in combination with drugs.

Novelty

In 2011 production of nanomarkers has come to the level of USD12 bln. In 2012 expenditures on discovery of new nanomarkers will make USD5.2 bln., on clinical research - USD1.7 bln., on molecular diagnostics - up to USD5 bln. Functional nanoparticles have a segment of the market, estimated as USD1.5 bln.

Advantages

Functionalized biomarkers of a medical-biological type outstrip their world analogues by characteristics.

Development stage

R&D. The planned year of creation of the technology - 2015.

Chemistry

UKR-07

Nanostructural photocatalysts on inorganic and polymeric carriers for new chemical technologies and efficient coatings

Assignment

Corrosion resistance in medical institutions.

Area of application
Building companies, medicine.

Description
Production integrates creation of nanocrystalline particles of photocatalysts with the set structure at a level of 30 t/year, polymeric or hybrid carriers, combining of these components and their deposition on a substrate.

Novelty
Photocatalyst production in 2010 has reached a level of USD1.02 bln. In 2014 production of such coatings in building industry will make USD1.5 bln. Economic benefit from introduction corresponds to high profitability - 170-200%.

Advantages
Photocatalytic coatings by their functional and price characteristics are at the level of world analogues.

Development stage
R&D.
The planned year of creation of the technology - 2015.

Mechanical Engineering

UKR-08

Extra-high-modulus composites at joint use of carbon filaments from polyacrylonitrile (PAN), nanostructural carbon fillers and epoxy binding

Assignment
Research in the area of production of nanostructural and carbide particles and filaments, mainly from vegetable raw materials, sizes and properties of which allow to modify successfully an epoxy matrix even in inter-element space of carbon high-modulus bunches. Strengthening of adhesion links between filaments and a matrix. Growth of electroconductivity of composites, a cumulative effect of reinforcement with filaments and filling with electroconductive components significantly expands the sphere of their use in engineering at application of expensive reinforcing carbon filaments. Improvement of working characteristics of products from composite materials in 1.5-2 times.

Area of application
Aerospace engineering, mechanical engineering.

Description
With well developed aerospace industry, in which extra-light constructional composite materials are widely used currently, Ukraine has faced a problem - to create own production of carbon filaments or to purchase import products. Import limitations, specific enough values of the index «price-quality» of carbon-fiber products force manufacturers of composite materials and products from them to use carbon filaments with insufficiently high characteristics (Japanese products - T300, Russian filaments - УКН-5000). Before the Ukrainian scientists at the first stage (even before establishment of own production of filaments) there was a problem of searching of ways of sharp improvement of properties of carbon plastics, a coefficient of elasticity and strength due to use of domestic engineering solutions.

Offered technologies

Use of developed in the Institute of Problems of Material Science (IPMS) of the National Academy of Science (NAS) of Ukraine carbon and carbide nanostructural phytogenic particles. Their sizes, structure and properties allow to modify carbon filaments and to perform structuring of an epoxy binding component, providing penetration of particles – nanomodifiers into inter-element (inter-fiber) space of carbon-bunches. It promotes significant growth of adhesive forces between filaments and a matrix and also improves interlaminar rigidity and strength of composites. Principal problems of joint application of carbon filaments or fabrics and particles of nanomodifiers, requiring scientific research, are the following:

- precision automated transportation of carbon-bunches through special tanks with binding components, where there are particles of nanomodifiers;
- impregnation of carbon filaments by dressing with binding components at use of ultrasonic, thermal and mechanical influence for safe fixation of nanoparticles on modified filaments-prepregs;
- production of composites (carbon-plastics) with use of controlled winding and hardening.

Novelty

Novelty is in rational application of the above mentioned physical methods for one cycle of creation of fiber prepregs, that will allow to implement pumping of carbon filaments into structure of composites and to reach a level of materials with extra-high-modulus properties. Electroconductive nature of nanomodifiers will allow to use carbon-composites in new areas (shielding and radar-absorbent coatings), that is very important for aerospace vehicles.

Economic benefit of introduction will be provided due to:

- significant reduction in price of carbon-fiber products,
- commercialization of composite materials with the improved complex of working properties in corresponding markets.

Advantages

Analogues of this production do not exist in the CIS countries.

Development stage

Creation and introduction.

The planned year of creation of the technology - 2013.

Novel Materials

UKR-09

Ultra-high-temperature and corrosion resistant ceramics for units of aggregates for aggressive chemical environments at temperature more then 1600°C

Assignment

Wide range of products for power engineering and other industries. Increase of working temperatures up to 1600-2200°C and life time of high-temperature machines and aggregates, working in conditions of aggressive chemical environments.

Area of application

Power engineering, mechanical engineering, processing of mineral raw materials (fro example, basalt).

Description

Development of such ceramics is initiated by special requirements to materials of nose cones and sharp edges of space shuttles, new gas-turbine engines with working temperatures of 1600-1700°C, and also power engineering materials.

Developed in the IPMS of the NAS of Ukraine ultra-high-temperature ceramic materials with high chemical resistance (to oxidation) and corrosion resistance are composites with a ceramic matrix on the basis of oxygen-free refractory compounds (zirconium and hafnium borides - zirconium and molybdenum silicides - silicon carbide). For sintering activation some borides and carbides are added. Methods of consolidation of ceramics with use of hot and reaction hot pressing, and also sintering without additional pressure (free sintering) are developed.

Offered technologies

- production of ceramics from composite powders of general synthesis in systems boride-silicide-carbide. Use of this technology allows to create high-quality highly active at sintering charge mixture with components, common synthesis of which is hard enough (molybdenum and zirconium silicides). Charge mixture has high indices of homogeneity and regulated dispersion;
- activity of charge mixture at sintering (hot pressing) is provided by introduction of small additives-catalysts (tungsten and chrome borides, tungsten, boron or carbon carbides). Addition of carbides and carbon promotes removal of impurities - oxides of corresponding metals (zirconium, hafnium, silicon) in reactions of reduction and refining of materials;
- sintering activation is provided by transition to reaction hot pressing, when final components are synthesized at sintering (the basic boride is created as a part of ceramics after reduction of the corresponding oxide by boron carbide);
- conditions of free vacuum sintering of ceramics imply use eutectic character of the selected systems with addition of some metals (chrome) and sintering in the presence of a disappearing liquid phase with formation of secondary borides;
- development of hetero-phase composites with a ceramic matrix of a grain type (with protective layered structures on a surface), providing high strength in a wide interval of temperatures, high thermo-strength, lowering of risk of brittle fracture, low creep rates, resistance to high-temperature oxidation and corrosion, is planned;
- new oven equipment and apparatuses for synthesis of raw materials at experimental-industrial sites will be developed. New equipment and inductive heaters of cost-efficient plants for hot pressing with low metal consumption for production of large-sized products from ultra-high-temperature ceramics (diameter - up to 350 mm and height – up to 150 mm) is created. This equipment will be used for production of materials and products on the pilot production site of the IPMS. This equipment will become the basis for commercial manufacturing of products from ultra-high-temperature ceramics.

Novelty

Ultra-high-temperature ceramics and technology of its creation have no analogues. Experimental parts from zirconium diboride - silicon carbide are tested in the European Space Agency and in the USA.

Advantages

Economic benefit will be received due to increase of working temperature of corresponding aggregates of gas-turbine engines (GTE), and, hence, due to increase of their efficiency, life time and also reliability of high-temperature machines and aggregates, working in conditions of aggressive environments, due to substitution of platinum in nozzles at production of basalt filaments.

Use of special flue tubes in new burners (aerodynamic plasma reactors), developed by the Institute of Geotechnical Mechanics (Dnepropetrovsk) for burning of low-grade high-ash coal in boilers of thermal power plants (TPP), according to calculations of the scientific-engineering center «Ecology-Geos» (Dnepropetrovsk), will improve conditions of burning and ensure fuller coal burning; it will allow to decrease use of fuel oil and to lower by 8-12% consumption of natural gas, to decrease down to 4-6% mechanical underburning of coal,

to increase by 0.3-0.5% efficiency of a boiler, to lower electric power cost price by 0.5-0.8%. Expected annual economic benefit from introduction of new burners on one TPP boiler of Pridneprovskaya TPP, according to calculations, will make about USD2 mln., and that includes the following savings:

- black oil ~ USD500,000;
- gas ~ USD700,000;
- coal underburning ~ USD700,000;
- reduction of harmful emissions ~ USD100,000.

Large-scale introduction of this technology within the frameworks of a fuel-energy complex of Ukraine will allow to solve actual problems of power engineering, to improve ecological and social conditions of industrial regions, to receive economic benefit in this branch of economy equal to USD350-400 mln./year.

Analogues of this technology do not exist in the CIS countries.

Development stage

The technology is at the stage of creation and introduction.

The planned year of creation - 2013.

Instrument-Making

UKR-10

Capillary hydrogen-metal-hydride structures and linear pneumatic fire (and overheat) alarms for AN-series airplanes

Assignment

The purpose of the project - establishment of production of domestic linear pneumatic fire (and overheat) alarms (LPFA) for systems of fire alarm and safety of AN-series planes, electric locomotives, etc. Production of LPFA requires creation of thin (1.6 mm) capillaries, filled with metal hydride, isolated from walls, hydrogenation (saturation by hydrogen) of hydride-forming metal, containing in a thin metal capillary of considerable length (1.5-6 m), creation of special membrane transmitters of pressure, implementation of a computer system of saturation with hydrogen and activation of a capillary hydrogen-metal-hydride system, testing of characteristics and cycle stability of LPFAs.

Area of application

Instrument engineering, aerospace industry.

Description

In fire alarm systems of airplanes of Ukraine there are out-of-date models of thermocouple transmitters, made in Russia. Point thermocouple blocks are executed on the basis of three sequentially joint thermocouples. Each block provides local control of inflammation or overheat. Abroad such models are not used any more. American and West European airplanes are equipped with linear pneumatic fire alarms (LPFA) with advantages over out-of-date thermocouple transmitters. They provide spatial control of places of possible inflammation. LPFA also have significantly larger output signal, and that provides their high reliability (protection from electromagnetic pickup, inducing malfunction) and allows to reduce significantly volume of fire safety equipment, receiving information about current state of engines and testing all transmitters. More over, LPFA, made from stainless steel, have significant resistance to mechanical damages and long life time in comparison with traditional thermocouple transmitters. It is necessary to mark out that the offered development (new linear fire alarm) will promote solution of actual for Ukraine problems of safety on transport.

Novelty

The IPMS of the NAS of Ukraine and Joint-Stock Company «Ukranalit» have great experience of developments in the area of study of physical-chemical processes of interaction of hydrogen with metals, and also in creation of new highly efficient alloys - accumulators of hydrogen, which can be applied in different equipment at using their reverse interaction with hydrogen. Significant experience there is also in the area of development of gas-analysis equipment for different applications, automated units for measurement of hydrogen-sorption, electrochemical and thermodynamic properties of metal-hydrides, in the sphere of development of software for the specified equipment. Research, including those under the innovative project «Development of hydrogen-metal-hydride technologies and their application in medical instrument engineering and in alarm systems on transport» (State registration # 0106U006700) have displayed, that potential of these organizations allow to create LPFA, competitive in the market, in particular, in comparison with products of «Meggitt».

Advantages

Establishment of production of LPFA, used in systems of fire alarm and safety of airplanes (including AN-series), electric locomotives, will allow to stop import of such systems.

Development stage

The technology is at the stage of creation.

The planned year of ending of works - 2013.

Medicine

UKR-11

The newest nanobiomaterials and implants on their basis

Assignment

Ceramic and metal nanobiomaterials and implants on their basis for rapid progress of surgery and other areas of medicine. Results have displayed significant reduction (twice) of a period of postoperative stay of patients in hospitals, possibility of treatment of traumas and diseases, which previously were considered as inoperable, and also significant improvement of quality of endoprosthesises of a coxofemoral joint, creation of new medical products and methods of treatment.

Area of application

Surgical clinics and other medical organizations.

Description

Nanoceramic materials, close by properties to bone tissues (bioactive ceramics - the unique kind of materials, completely integrated with organism tissues, involves into metabolism and can correct bone restoration and also homeostasis of elements and other physiological processes in a human organism). Bioinert ceramics is a unique kind of materials, neutral to human organism environment. Technologies of their synthesis are based on successive approximation of properties of implants and coatings for restoration of a certain type of bones, cartilaginous tissue, functions of local delivery and removal of drugs, treatment of genetic defects, integration of metal implants with bones. New metal bioinert alloys with the coefficient of elasticity, coordinated with the same of bone tissues – materials, guaranteeing unlimited work life of metal implants (in the presence of bioceramic coatings). Possibility of development of such alloys follows from the last research of titanic alloys.

Novelty
Novelty is in creation of new medical products, significant improvement of efficiency of surgical operations with bone and cartilaginous tissue, including implanting, creation of new types of treatment with local delivery of drugs, gene therapy.

Advantages
Cost of surgical operations quickly grows all over the world due to application of new materials and technologies, confirming the thesis that health is invaluable. The effect will be received due to substitution of import products (cost of which is about USD2 bln.), restoration of working capacity of patients, and also as a result of rational use of domestic raw materials (titan, zirconium), export of developed materials and technologies.

Development stage
R&D.
The planned year of creation of the technology - 2013-2015.

Mechanical Engineering

UKR-12

Nanostructural super-capacitors and autonomous systems on their basis

Assignment
Technologies of nanostructural super-capacitors for environmentally friendly power-intensive transport, autonomous systems of power supply, used in hybrid systems with FCs and solid-state lithium current sources with high specific capacity.

The following steps - creation of a technology of super-capacitors with high specific capacity on the basis of Ukrainian raw materials and domestic patentable developments.

Area of application
Automobile industry, manufacturers of autonomous welding units.

Description
Capacitors are made from Ukrainian raw materials. Electrodes and electrolyte are in tight aluminum cells. Cells are united into sections for increase of capacity and current.

Novelty
In the market of the USA, Japan and South Korea this production only appears. In 2015 the market segment will reach USD1.1 bln. This is highly profitable production, since incomes on introduction 5-7 times higher then investments.

Advantages
Due to uniqueness of developments Ukraine can take up 10% of the market.

Development stage
R&D.
The planned year of creation of the technology - 2014.

Medicine

UKR-13

Composite bone implants from nanostructural ceramic and metal materials with a bioactive surface and mechanical properties, close to properties of a bone tissue

Assignment

Manufacture of nanostructural biocompatible materials on the basis of alloys of the system Ti-Si-x with optimum biomechanical properties and osteoconductive and osteoinductive properties of a surface.

Area of application

Locomotor apparatus treatment departments of different clinics of Ukraine, dentistry.

Description

Production implies creation of alloys of titanium of the system Ti-Si-x with properties, close to mechanical properties of bone tissues, production of bone implants, deposition of nanostructured coatings from bioactive materials from calcium phosphate and a transitive nanostructural intermediate layer. As a result, gradient distribution of silicon with it increased content on a surface, and that provides synergetic effect with elements of bioactive ceramics. This process gives specific osteoinductive properties to the surface.

Novelty

The basic difference of these products - they will be made of titanium alloys with improved biocompatibility in comparison with standard titanium alloys, where there are vanadium and aluminum, and with optimum biomechanical properties. The other advantage of such materials – their nanostructural surfaces in the place of their installation into bone tissues. Introduction into medical practice of such products with bioactive nanostructural coating will allow to lower traumatic effect of operations and completely to restore extremity functions. Due to high biological compatibility with an organism and absence of harmful chemicals in their content products practically have no limitations regarding life time. It excludes necessity of their replacement and is of great importance for health of a human and lowering of corresponding expenditures. In the market there are about 20 countries, developing bone implants of a new generation. The volume of production is already close to USD1 bln. In 2012 the market of bone implants will make USD400 mln., and by 2015 the market segment will reach USD1.5 bln.

Development stage

R&D. The planned year of creation of the technology - 2015.

Mechanical Engineering

UKR-14

New constructional and tribotechnical economically-alloyed sintered steels and irons with improved physical-mechanical properties on the basis of domestic raw materials

Assignment

Improvement of physical-mechanical, functional and tribotechnical properties of sintered constructional and wear-resistant iron-carbon materials due to combined alloying with simultaneous use of highly efficient

methods of mechanochemical treatment, sintering and hot forging and saving of initial raw materials at production of products and at use of scarce alloying elements (Mn, Si, etc.) on the basis of Ukrainian raw materials.

Area of application

Mechanical engineering.

Description

The technology is based on creation of new grades of sintered economically-alloyed iron-carbon alloys on the basis of systems Fe-Si-C (B), Fe-Mn-Si-C (B), Fe-Mn-Ti-C (B) and Fe-Mn - Cu-C (B) with improved physical-mechanical and working properties due to their combined alloying with use of optimized content of low-melting alloys and simultaneous use of highly efficient methods of mechanochemical treatment, activated reaction sintering and hot forging.

Development of new materials will be based, primarily, on domestic raw-material base instead of widely used powder alloying elements of the group: Ni, Mo, V, W, Co, extraction and production of which is not carried out in Ukraine.

Novelty

Difference of the offered approach to production of sintered constructional and wear-resistant materials on the basis of iron-carbon alloys from traditional methods is in wide application of optimized content of low-melted eutectic alloys, synthesized with use of Ukrainian raw materials. Materials with improved strength and corresponding plasticity will be created. Application of optimized alloys alongside with increase of a degree of homogeneity provides significantly lower content of oxygen in sintered materials. This is especially important for systems with elements with high affinity to oxygen. Use of such alloys allows to create powder materials of various functionality with a wide range of properties, reached due to variation of content of alloys and their mixtures with the main material. The effect from this technology introduction is provided due to significant (in 5-10 times) reduction of consumption of expensive alloying elements, which are not extracted and are not produced in Ukraine.

Advantages

By physical-mechanical and working parameters this technology is at the level of the best analogues.

Development stage

The technology is at the stage of creation.

The planned year of ending of creation of the technology - 2013.

Mechanical Engineering

UKR-15

Wear resistant dispersion-substituted composite electrocontact materials on the basis of copper with use of internal oxidizing and hot forging of porous preforms

Assignment

Wear resistant electrodes for resistance welding, contact elements of current collectors, contacts of high-speed cutout switches for switching of high currents at minimization of spark erosion wear of contact surfaces.

Area of application

Mechanical engineering, electrotechnical industry, instrument engineering.

Description

The technology is based on reaction mechanochemical synthesis of powder mixtures and special methods of hot treatment by pressure of porous powder preforms with implementation of schemes of sliding deformations, creating nanostructural dispersed-strengthened structure of a material. Hardening of the copper matrix is provided by uniformly distributed in it mechanochemically synthesized nanodisperse (10...40 nm) refractory particles of oxides, carbides, borides, nitrides and other components, formed at solid-phase reactions of chemical elements, entered into a matrix and not dissolving in it. In particular, the oxide group of disperse-strengthening elements is formed at interaction of fine-grained particles of highly active, in comparison with copper, elements (aluminum, titanium) with matrix material. As a result, in the material fine-grained shares of corresponding oxides are created. The special group of materials – metal-glass composites on the basis of copper, received at mechanochemical synthesis of powders of copper and special glass, pressing of porous preforms and their hot forging. Such structure in complex with optimum selected content provides high values of temperature of re-crystallization (800…1000°C) and heat resistance, electroconductivity (95% of value for copper) and wear resistance, which is gained by presence in some copper composites of residual ultra-disperse carbon. Presence in materials of nanodisperse and uniformly distributed particles with low electron work function significantly reduces specific energy and temperature on a contact surface, and that causes essential increase of arc resistance of materials. Electroerosive wear take place more uniformly without local ejections of fused metal.

Novelty

Novelty of the technological approach, in comparison to traditional methods of creation of disperse-substituted composites - use of internal oxidizing, implying introduction into charge mixture of highly active additives, which at mechanochemical synthesis and subsequent thermal treatment (heating for hot forging) appear in a role of deoxidizers. It provides improvement of quality of interparticle metal contacts of particles of copper, and appearance of centers of formation of fine-grained strengthening oxide particles. Addition of special glass into charge mixture allows as a result of interaction of glass melt and oxide films on copper particles to provide a high degree of clearing of a surface of the last (due to dissolution of oxides in glass melt). The material has heterogeneous structure from metal matrix and glass impurities, serving as efficient arc-suppressing additives. Novelty of the technology also is connected with application of special methods of hot forging of porous powder preforms for consolidation of mixtures and forming of final products. Shear deformations of metal in a zone of contact surfaces of particles lead to destruction of oxide films, to carrying out of foreign inclusions, adsorbed atoms from a contact zone, promote formation of high-quality contact, i.e. merging of particles, raising strength of metal structure. Intensive plastic deformation promotes dispersion of structure of a material due to simultaneous influence of combination of pressure and displacement on it. Important special feature of structure of materials, created with use of special schemes of hot forging - presence of strongly pronounced structure of material, direction of which can be varied (depending on construction of a contact element) by selection of a specific scheme of deformation.

Advantages

The effect from introduction of the developed technology is provided due to increase (in 2-5 times) of electroerosive resistance and arc-resistance of electrode materials, substitution of import raw materials (in particular, tungsten), significant lowering of cost of electrodes in comparison with analogues from silver-substituted and tungsten-copper materials.

Development stage

The technology is at the stage of creation and introduction.

The planned year of ending of creation of the technology - 2013.

Mechanical Engineering

UKR-16

Production of composite powder materials on the basis of disperse-substituted alloys of aluminum with use of hot treatment by pressure

Assignment

Aerospace, automobile and engine-building industries.

Description

Expediency of introduction of products from disperse-strengthened aluminum alloys is caused by a series of their advantages. Last decades such introduction was restrained by a series of technological difficulties. Experience allows to implement complex solutions, combining non-traditional approaches to development of new structures, providing improvement of physical-mechanical and working properties of products.

The technology is based on use of reaction mechanochemical synthesis of powder mixtures with powders of aluminum and nanodisperse particles of carbides SiC, TiC, B4C, which are exposed to cold pressing with hot treatment by pressure of porous preforms with a significant level of shear components of a deformation tensor.

As a result of creation of a stress state it is possible to influence purposefully a character of dislocations and to receive necessary properties of products. Presence in materials of significant amount of nanodisperse and uniformly distributed particles provides high values of temperature of re-crystallization, strength and plasticity of materials, and also their high wear resistance.

Novelty

Novelty of the offered technology - an organic combination of mechanochemical synthesis and special methods of hot treatment by pressure of pressed performs, that allows to form essentially hetero-phase structure of material, consisting of a strong fine-grained filler and plastic bonds. Contribution of heterogeneous components gives an effect, equivalent to creation of a new material, properties of which differ from the same of each separate structural component. For such materials high values of strength, coefficient of elasticity, fracture toughness, are typical. They keep stability of characteristics in a wide temperature range, have high electro- and thermal conductivity, small sensitivity to surface defects. Special methods of treatment by pressure allow to manage mechanical structure of a material because of grain elongation in the course of deformation and also due to oriented distribution of non-metallic impurities and other structural components.

Advantages

The effect from use of this technology is in substitution (by specially developed composites) of many high-alloy aluminum and other alloys on the basis of nonferrous metals. Economic benefit is in essentially higher material utilization in comparison with a technology of production of such products by machining from bar stocks, because parts, created with use of this technology do not require such treatment (or require minimum machining).

Development stage

The technology is at the stage of creation.

The planned year of ending of creation of the technology - 2013.

Mechanical Engineering

UKR-17

Vacuum ion-plasma creation of antifriction coatings with properties of solid lubricating materials

Assignment
Increase of life time of details and friction pairs at impossibility of use of lubricants

Areas of application
Mechanical engineering and motorbuilding, medicine, aerospace and vacuum engineering.

Description
Vacuum ion-plasma deposition of coatings by magnetron sputtering with use of a specially developed device of a coaxial type allows to receive surface layers with set stoichiometric structure from Cu, Cr, Fe, Ni, Mo, W, Sn. As a result, materials acquire properties of solid lubricating compositions.

Novelty
Creation and use of the developed device of a coaxial type allows to deposit coatings of exact stoichiometric structure, and that improves working characteristics of details of machines and mechanisms.

Advantages
The technology is power efficient and resource-saving. In comparison with foreign analogues production significantly increases life time of details (in 1.3-1.5 times).

Development stage
The technology is at Development stage.
The planned year of ending of creation of the technology - 2013.

Medicine

UKR-18

Biocompatible protective coatings, created by methods of high-energy treatment

Assignment
Creation of biocompatible protective coatings with increased adhesive strength for implants, prostheses and medical instruments.

Area of application
Medicine.

Description
Creation of such coatings by vacuum ion-plasma methods with subsequent modification of a surface by electrical-discharge alloying and laser treatment.

Novelty

Use of high-energy methods provides necessary physical-mechanical and biological properties of a surface layer, high adhesion.

Advantages

Increase of time of residence of implants and prostheses in a human body, reduction of a number of repeated surgical operations, induced by transplant rejection, improvement of regenerative treatment.

Production in comparison with foreign analogues decreases reaction of transplant rejection by human cells by 10-15%.

Development stage

The technology is at the stage of creation.

The planned year of ending of works - 2014.

Information Technologies

UKR-19

Formation of stable nanoscale magnetic films FePt for record and storage of information with super-high density

Assignment

Formation of stable nanoscale magnetic films with improved thermal stability, controlled by orientation of grains, axis of easy magnetization and a coercive force at creation of magnetic data carriers of new generation with recording density up to 1 Tbit/cm^2.

Area of application

Information technologies, aerospace and military industries.

Devices for recording and storage of information

Description

Production of nanoscale films with width of 10-30 nm on the basis of a magnetic-ordered phase L10-FePt (face-centered tetragonal - FCT) by a magnetron deposition method with use of mosaic targets from Fe and Pt with doping elements C, Ag, Ni, B, Cu, Au, Sb on a substrate of SiO_2 or MgO, CrRu, CrMo. Thermal treatment is carried out by annealing in nitrogen or vacuum at 620-970 K with various heat rates and holding time. For magnetic recording of information with use of film of L10-FePt (FCT) it is possible to use thermal activation of records (TAR) at cooling from a paramagnetic state.

Novelty

Creation of devices with super-high density of recording and storage of information is actual for modern science and engineering. Increase of density of recording by traditional methods has already reached its limit. For storage of digital information people use magnetic disks, for production of which a layer of a magnetic material is deposited on a non-magnetic substrate, thus information is recorded in the mentioned magnetic layer. The recording medium represents itself a polymeric coating, containing magnetic one-domain particles (as a rule Fe_2O_3) or thin (50-150 nm) films of a magnetic metal, alloy or oxide (on the basis of Co, for example, Co-Ni, Co-Ni-W, Co-Pt-Ni). The size of magnetic domains, which are located in several grains ~ 100 nm. Thin magnetic films have structure with a grain size of an order of thickness of a film. Coercive force of magnetic materials, used for storage of information is equal to 8-37 A/m, residual induction reaches 1.5 T. Density of

recording and storage of information - 10-15 Gbit/cm^2. For increase of density it is required to create new nanomaterials with minimum magnetic domains, located in an isolated grain with size of 5-15 nm. It allows to create a carrier of a new generation with density of magnetic recording and storage of information up to 1 Tbit/cm^2.

The magnetic-ordered film of L10-FePt with FCT structure can be a suitable material for such devices due to its large enough magnetic-crystal anisotropy of energy ($7 \cdot 10^6$ J/m^3). It is more than one digit higher, than in currently used magnetic carriers of information. Methods of creation and thermal stabilization of FCT nanoscale (10-0 nm) films, control of orientation of an axis of easy magnetization and a magnitude of a coercive force are developed.

It is possible to decrease temperature of magnetic ordering and to increase thermal stability of magnetic films L10-FePt (FCT) with the size of grains up to 5-15 nm due to introduction of energy of interface with use of additional layers of Cr (Au, Ag) or combination of Pt/Cr (Pt/Ag) in film composition FePt / additional layer / substrate or multilayer film composition Fe/Pt/Fe/Pt/..., which, using energy of stress between film of FePt and an additional layer, will provide super motive force for its ordering and will accelerate this process. Doping by the third element with low surface energy - Co or (Au, Ag, Sb, Bi), by means of diffusion of which it is supposed to stimulate reorganization of atoms Fe and Pt, will provide ordering. Doping atoms on boundaries of grains FePt allow to control their size and to decelerate movement of a domain wall of FePt at demagnetizing, and that promotes increase of a coercive force. For controlled orientation of grains – texture in films of L10-FePt (FCT) various substrates (SiO_2/Si (001), amorphous particles SiO_2 of the spherical form, glass, polystyrene - at room temperature and warmed up to 620-770 K) will be used. For amorphous substrates it is supposed to use seed layers, in particular Cr (100), MgO (100). Economic benefit from introduction: USD11-50 mln.

Advantages

Currently data recording density is equal to 10-15 Gbit/cm^2.

The offered technology will allow to reach a level of 1 Tbit/cm^2.

Development stage

The technology is at the stage of creation.

The planned year of ending of creation of the technology - 2014.

Novel Materials

UKR-20

Creation of highly efficient thermoelectric materials on the basis of nanoscale films of $CoSb_3$

Assignment

Increase of thermoelectric efficiency - the basic characteristic of thermoelectric materials.

Area of application

Space and military industry, household appliances, thermal energy engineering.

Description

Nanoscale film compositions of $CoSb_3/SiO_2$ (100 nm) / Si (001) with nanoscale thickness (10-50 nm) can be created by co-deposition of cobalt and antimony in vacuum (10^{-9} Pa) on substrates of single-crystal silicon Si (001), coated with a layer of oxide SiO_2. Deposition of Sb will be carried out by an electron beam method with effusion. For film doping Ba, Yb, Tl, Ce, La will be used. For thermal treatment annealing of the film in nitrogen or vacuum at 570-970°K will be used.

Novelty

Thermo-electricity is a priority direction of development of science and engineering, it is based on direct translation of thermal energy into electric energy. Absence of moving parts and functioning in extreme conditions provide it with high reliability and almost unlimited life time. Special feature of this technology – possibility of direct use of thermal energy.

Dimensionless thermoelectric figure of merit ZT is the basic characteristic of these materials. It can be represented by the formula

$ZT=S^2\sigma T/(k_e + k_\phi)$,

where σ - electric conductivity, S - Seebeck coefficient, T - temperature, k – general thermal conductivity ($k = k_e + k_\phi$, where k_e - thermal conductivity, provided by electrons, k_ϕ - thermal conductivity, provided by phonons). In spite of attempts to receive a material with high value of ZT, current thermoelectric elements, in the majority synthesized by powder metallurgy, have the figure of merit, not exceeding 1. In a nanoscale film state ZT, according to calculations, can be ≥ 2. This can be explained by the fact, that at transition to nanoscale electron-phonon interaction decreases, and a phonon subsystem, being adiabatically isolated, almost does not take active part in heat transfer from a heater to a cooler. Therefore, nanostructuring of such materials is efficient enough for achievement of high ZT values. It is suggested to use a nanoscale film on the basis of a skutterudite phase of antimonide $CoSb_3$ as a thermoelectric material with high properties. Crystalline thermal conductivity can be significantly lowered due to decrease of the size of grains at the expense of additional dispersion of phonons on boundaries of grains and presence of pores in films. One of special properties of skutterudite compounds is also possibility of decrease of crystalline thermal conductivity when small sized atoms fill in pores in material structure. Atoms of a dopant (pores filler), for example, of Ba, Yb, Tl, Ce, La at a resonance frequency additionally dissipate heat, brought by phonons, and that provides much lower thermal conductivity of the film. Due to this process thermoelectric figure of merit ZT can become more than 1.

Advantages

ZT=1.4 at 500-700°K (foreign analogue - ZT=1.2).

Development stage

The technology is at the stage of creation.

The planned year of ending of creation of the technology - 2014.

Cooperation proposals

Creation of the joint center on transfer of technologies.

Creation of the international bank of technologies.

Developers

Institutes of the Academy of Sciences of Ukraine and higher educational institutes of the country

Contact information

UkrISTEI
Gorky St., 180 Kiev MSP 03680, Ukraine
Tel.: (044) 5210973
Fax: (044) 5282541
E-mail: uintei@uintei.kiev.ua

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5. Перспективные направления развития новейших технологий на основе экспертных оценок результатов анализа диссертационных работ и научных исследований / Кочеткова Е.П., Задорожняя Г.П., Паладченко Е.Ф., Новицкая А.В. // Научно-техническая информация. – 2011. –. №3. – С. 15-19.

REPUBLIC OF SOUTH AFRICA

Report of the ICSTI-South Africa Workshop on Nanotechnology and Materials

Lucky Sikhwivhilu, Department of Science and Technology,
Mintek Nanotechnology Innovation Centre, Advanced Materials Division, Mintek

Vuyani Lingela, Chief Director, International Cooperation and Research,
Department of Science and Technology

Introduction

The Centre for Scientific and Technical Information (ICSTI)-South Africa workshop on nanotechnology and materials took place at Farm Inn Lodge in Pretoria, South Africa on 9-11 November 2011. The workshop was part of the implementation of the plans agreed in Baku, Azerbaijan at the 61st Meeting of the Committee of Plenipotentiary Representatives (CRP) of the ICSTI member states on 21-22 May 2010. The CPR is the supreme governing body of the ICSTI.

The main objectives of the workshop were:

a) To complement existing science and technology bilateral cooperation between South Africa and individual ICSTI member states.

b) Explore areas of mutual interest and identify available expertise and infrastructural capabilities in various scientific institutes between South Africa and ICSTI member states.

c) To promote the development and application of nanostructured materials, jointly with ICSTI member states, in support of the following industries: health, water, energy, space, mining and minerals, and bio and chemical processing. Thus, to create opportunities to initiate new collaborations and partnerships within ICSTI and its member states.

The expected outcomes of the workshop were:

a) To identify and scope modalities for cooperation (infrastructure, exchange visits for students and experts). Joint research projects and knowledge generation and co-funding of joint projects in the areas nano-structured materials.

b) To develop an outline of research and development cooperation in the production of new and novel nanomaterials for industrial application in South Africa and ICSTI member states.

The Department of Science and Technology (DST) of South Africa supported the operational costs for the workshop. Participants included representative of higher education, science councils, industry and government. There were 2 delegates from ICSTI, 1 from Georgia, 3 from Mongolia, 1 from Hungary, 8 from the Joint Institute for Nuclear Research (JINR), 4 from Russia and 37 from South Africa.

The programme commenced with an introduction to opportunities, success and challenges to be addressed by ICSTI member states. Dr. M. Tumanova (Deputy Director of the ICSTI) and Mr. Vuyani Lingela (Chief Director: International Research, Department of Science and Technology) outlined the

objectives of the workshop and how we could use it as a vehicle to improve collaborative efforts within ICSTI framework.

There were about 20 presentations, which focused on nanotechnology and its application in various areas of societal and economic impact. They covered fundamental as well as advanced aspects of nanomaterials with specific emphasis on nanomaterials synthesis, water treatment, energy, photonics, biomedical and sensor applications. Nanomaterials synthesis was identified as a crosscutter at the helm of other application areas. There was a consensus that Water and Energy were identified as two common problems ICSTI member states are still grappling with and needing different solutions.

Outcomes of the workshop

Below is a list of subject areas covered during the workshop and the institutions that have expressed interest to be involved in research collaboration activities:

a) Materials synthesis. The focus here is on the development of novel methodologies for material synthesis, fabrication and engineering. This also includes uncovering novel properties that hold promise in development of new materials and characterisation of such nanostructures. The following ICSTI member states and South African (SA) institutions are already involved in this field: DST/CSIR Nanotechnology Innovation Centre (NIC) (SA); Mongolian Academy of Sciences (Mongolia); DST/Mintek NIC (SA); Georgian Technical University (Georgia); University of Western Cape (UWC) (SA); Ithemba Labs (SA); UniZul (SA); Laboratory of Neutron Physics, JINR (Dubna); Wits University (SA); Russian State Technological University; MATI (Russia); Institute for Theoretical and Applied Electromagnetics of the Russian Academy of Sciences (Russia)

b) Water treatment. This process is involved with the removal of undesirable chemical, materials, and biological contaminants from water in order to produce adequate levels of usable water for any specific purpose. The use of nanomaterials to develop efficient and effective nano-based technology is envisaged. The following ICSTI member states and South African institutions are already involved in this field: DST/Mintek NIC (SA); UWC (SA); Ithemba Labs (SA); and Lőrincz and Co. Kft. (Hungary)

c) Biomedicine. This filed involves combining the design and problem solving skills of engineering with medical and biological sciences to improve healthcare diagnosis, monitoring and therapy. This field seeks to utilize novel nanomaterials to solve problems that could not, otherwise, be solved. The following ICSTI member states and South African institutions are already involved in this field: DST/ Mintek NIC (SA) and the JINR Laboratory for Neutron Physics (Dubna).

d) Energy. Renewable energy projects in many developing countries have demonstrated that renewable energy can directly contribute to poverty alleviation providing the energy needed for creating businesses and employment. Renewable energy technologies can also make indirect contributions to alleviating poverty by providing energy for cooking, space heating, and lighting. Renewable energy can also contribute to education, by providing electricity to schools. It is in this context that renewable energy sources are being explored to improve the quality of life. Various technologies are being developed to avert worsening the effects of greenhouse emissions. The following ICSTI member states and South African institutions are already involved in this field: Ithemba Labs (SA); and the Azerbaijan State Oil Company (Azerbaijan).

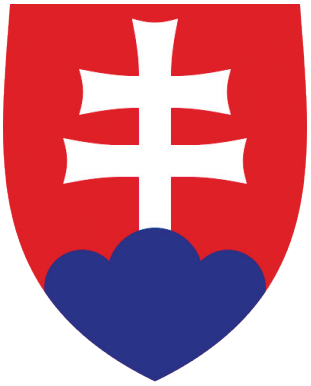
e) Sensors. Sensors are used in everyday objects such as touch-sensitive elevator buttons, machines, etc. Gas sensors maybe very useful for South African Mines as they may help detect all noxious gases such as carbon monoxide, methane, etc. which are responsible for many deaths in mines. Nanosensors and nano-enabled sensors have applications in many industries, among them transportation, communications, building and facilities, medicine, safety, and national security, including both homeland defense and military operations. The following South African institution is already involved in this field: Wits University (SA).

f) Photonics. The science of photonics includes the generation, emission, transmission, modulation, signal processing, switching, amplification, detection and sensing of light. The development of laser is a good example of photonics and perhaps the very first invention in the field. Other inventions, that soon followed, included laser diode and optical fibers for transmitting information. The following South African institutions are already involved in this field: National Laser Centre, CSIR (SA).

Conclusion

It was agreed that materials synthesis, water treatment and energy are priority areas that require should be supported. A proposal encompassing the three areas will be drafted and communicated to ICSTI member states to promote international research collaboration.

SLOVAK REPUBLIC



Materials Science in Slovakia

An overview of Slovak institutions engaged with materials science and engineering

Jaroslav Jerz, Institute of Materials and Machine Mechanics SAS, Bratislava

R&D in the field of materials science and engineering in Slovakia is carried out in particular at universities, institutes of the Slovak Academy of Sciences and legal entities which have been established by state administration central bodies (state departments research institutions) that are mostly financed from state budget and in several private research institutions financed by business sector.

The materials science is a forerunner of a sustainable economic and social development in Slovakia. It strengthens the knowledge generation stages and its transfer into various industrial sectors is therefore unavoidable. An effective transfer of knowledge acquired by materials research and related technological development accelerates appropriate economic development and supports regional enterprises by development of competitive industrial products with extremely high added value in order to increase their competitiveness by unique applications of newly developed advanced engineering materials and technologies of their production and processing. The industrial enterprises especially SMEs with high innovative potential, research institutions, universities and industrial regions intensively cooperate in this scientific field in various domestic and international collaborative projects in order to create very important and significant synergy effects.

Legal and physical entities with offices in Slovakia active in R&D are integrated in high education sector, state sector and private sector.

The state R&D sector in Slovakia consists of research institutions of the Slovak Academy of Sciences (SAS) and several legal entities established by state administration central bodies. The SAS is a self-governing scientific organization of the Slovak Republic established by special Act, the activity of which is aimed at the development of Slovak science, education, culture and economy. The SAS provides its research activities by means of scientists working in research institutes established on the basis of either full or partial public funding.

R&D in the field of materials science and related technological development is carried out in particular in these institutes of Slovak Academy of Sciences:

- Institute of Materials and Machine Mechanics, Bratislava, www.umms.sav.sk
- Institute of Materials Research, Košice, www.imr.saske.sk
- Institute of Electrical Engineering, Bratislava, www.elu.sav.sk
- Institute of Physics, Bratislava, www.fu.sav.sk
- Institute of Inorganic Chemistry, Bratislava, www.uach.sav.sk
- Polymer Institute, Bratislava, www.polymer.sav.sk
- Institute of Construction and Architecture, Bratislava, www.ustarch.sav.sk
- Institute of Measurement Science, Bratislava, www.um.sav.sk
- Institute of Geotechnics, Košice, www.saske.sk/UGT
- Institute of Technology, Bratislava, www.ti.sav.sk

The higher educational sector in Slovakia consists of 20 public higher institutions, 3 state higher institutions and 11 private higher institutions. R&D in the field of materials science is carried out in particular in these public universities:

- Slovak University of Technology in Bratislava, www.stuba.sk
  - Faculty of Materials Science and Technology in Trnava
  - Faculty of Mechanical Engineering
  - Faculty of Electrical Engineering and Information Technology
  - Faculty of Civil Engineering
  - Faculty of Chemical and Food Technology

- Comenius University in Bratislava, www.uniba.sk
  - Faculty of Mathematics, Physics and Informatics
- University of Žilina, www.uniza.sk
  - Faculty of Mechanical Engineering
  - Faculty of Electrical Engineering
  - Faculty of Civil Engineering
- Technical University of Košice, www.tuke.sk
  - Faculty of Metallurgy
  - Faculty of Mechanical Engineering
  - Faculty of Electrical Engineering and Informatics
  - Faculty of Manufacturing Technologies
  - Faculty of Civil Engineering
  - Faculty of Aeronautics
- Technical University of Zvolen, www.tuzvo.sk
  - Faculty of Wood Technology
- Slovak University of Agriculture in Nitra, www.uniag.sk
  - Faculty of Engineering

in state institutions:

- Armed Forced Academy of General Rastislav Štefánik in Liptovský Mikuláš, http://aos.sk

and in private institution:

- Dubnica Institute of Technology in Dubnicanad Váhom, www.dti.sk

Besides institutes of SAS and institutions of higher education, basic and applied R&D in the field of materials science or related services is carried out by the state institution:

- International Laser Centre, Bratislava (Medzinárodnélaserové centrum), www.ilc.sk

non-profit R&D institution:

- Welding Research Institute – Industrial Institute of the Slovak Republic, Bratislava, www.vuz.sk

R&D centres:

- Centre of Excellence for R&D of Structural Composite Materials for Engineering, Construction and Medical Applications – CEKOMAT, www.cekomat.sav.sk
- Centre of Excellence for Materials, Layers and Systems for the Extreme Condition Applications, www.machina.sk
- Centre of Excellence in Nano-/Micro-electronic, Optoelectronic and Sensoric Technologies, www.fei.stuba.sk
- Centre of Excellence in SMART Technologies, Systems and Services, www.fiit.stuba.sk
- Centre of Excellence for Development and Application of Progressive Diagnostic Methods in Processingof Metal and Non-metal Materials, www.mtf.stuba.sk
- Centre of Excellence in 5-axis Machining, www.mtf.stuba.sk
- Centre of Excellence for New Technologies in Electrical Engineering - CENTE, www.elu.sav.sk/cente
- National Centre of Excellence in Renewable Resources Research and Application, www.nc-oze.stuba.sk
- Centre of Excellence for Intelligent Transport Systems and Services - CEIDS, http://ceids.uniza.sk
- Centre of Excellence of SAS for functionalized multiphase materials – FUN-MAT, www.sav.sk

clusters:

- Automotive Cluster - West Slovakia, Trnava, www.autoklaster.sk
- Slovak Plastics Cluster, Nitra, www.plasticportal.eu
- 1st Slovak Engineering Cluster, Banská Bystrica, www.1ssk.sk

and several R&D institutions and industrial companies from private sector:

- BASF Polyuretány Slovensko s.r.o., Malacky, www.basf.sk
- Bauer Gear Motor Slovakia s.r.o., ZlatéMoravce, www.bauergears.com/sk
- BRUTO s.r.o., Sereď, www.bruto.sk
- BSH Drives and Pumps s.r.o., Michalovce, www.bhs-group.com
- Central European Institute of Technology, Žilina (CEIT SK, s.r.o.), www.ceit.eu.sk
- DanubiaNanoTech s.r.o., Bratislava, www.danubiananotech.com
- Delta Elektronics (Slovakia) s.r.o., DubnicanadVáhom, www.deltaelectronics.com

- COBA Automotive s.r.o., Terchová, www.cobaplastics.com
- COMAT s.r.o., Bratislava, www.comat.sk
- C2i s.r.o., DunajskáStreda, www.c2i.com
- EDAG Slovakia s.r.o., Bratislava, www.edag.de
- ELEKTROKARBON a.s., Topoľčany, www.elektrokarbon.sk
- FagorEderlanSlovensko a.s., ŽiarnadHronom, www.fagorederlan.sk
- FIRST WELDING Inc., Bratislava (PRVÁ ZVÁRAČSKÁ, a.s.), www.pzvar.sk
- Geothermal Anywheres.r.o., Bratislava, www.geothermalanywhere.com
- GoldenSUN Slovakia s.r.o., LiptovskýMikuláš, www.goldensun.sk
- Hydac s.r.o., Martin, www.hydac.sk
- HTS BB s.r.o., Vlkanová, www.htsbb.eu
- HTP Slovakia s.r.o., Vráble, www.htp-slovakia.sk
- INTEGRITA A BEZPEČNOSŤ OCEĽOVÝCH KONŠTRUKCIÍ a.s., Bratislava (IBOKa.s.), www.ibok.eu
- IPM Engineering s.r.o., Zvolen, www.ipmeng.sk
- IVMA STU s.r.o., Bratislava, www.stuscientific.sk/content/ivma-stu-s-r-o
- KONŠTRUKTA Defence a.s., Trenčín, www.kotadef.sk
- Krauss Maffei Technologies s.r.o., Sučany, www.kraussmaffei.com
- KVANT s.r.o., Bratislava, www.kvant.sk
- KWD s.r.o., Zvolen, www.kwd.sk
- Magneti Marelli Slovakia s.r.o., Bratislava, www.magnetimarelli.com
- METRODAT s.r.o., Bratislava, www.metrodat.sk
- NanoDesign s.r.o., Bratislava, www.nanodesign.sk
- Pulp and Paper Research Institute, Bratislava, www.vupc.sk
- RELKO s.r.o., Bratislava, www.relko.sk
- SAPA profily a.s., ŽiarnadHronom, www.sapagroup.com/sk/profiles
- ON Semiconductor Slovakia a.s., Bratislava, www.onsemi.com
- Semikron s.r.o., Vrbové, www.semikron.com
- SPINEA s.r.o., Prešov, www.spinea.sk
- STU Scientific s.r.o., Bratislava, www.stuscientific.sk
- TEN Slovakia s.r.o., Šamorín, www.ten.sk
- THERMO/SOLAR Žiar s.r.o., ŽiarnadHronom, www.thermosolar.sk
- Transport Research Institute Inc., Žilina, www.vud.sk
- Viena International s.r.o., Martin, www.viena.sk
- VUJE a.s., Trnava, www.vuje.sk
- VÚTCH - CHEMITEX s.r.o., Žilina, www.vutch.sk
- VÚSAPL a.s., Nitra, www.vusapl.sk
- VÝVOJ Martin a.s., www.vyvoj.sk
- ZTS VVÚ Košice a.s, www.ztsvvu.eu

Support service in development of innovative processes and technology transfer for SMEs is provided by:

- Business and Innovation Centre (BIC Bratislava, s.r.o.), www.bic.sk
- Knowledge transfer platform INNOVMAT, www.innovmat.eu
- Slovak Investment and Trade Development Agency (SARIO), www.sario.sk

The complete database of Slovak R&D organizations can be found on the web sites:

- www.vedatechnika.sk
- www.euraxes.sk

The main activities of Slovak R&D institutions and innovative industrial companies in the field of materials science

- **Institute of Materials and Machine Mechanics SAS, Bratislava (IMMM SAS)**

IMMM SAS has been dealing for more than 50 years with synthesis of advanced metallic materials, especially composites and with controlling reactions on the interfaces of components or phases. At present the institute performs basic and applied research in the field of materials science and applied mechanics.

Materials research is preferably oriented to the development of advanced non-ferrous metallic materials, especially metal matrix composites, metallic foams, intermetallics, light alloys and nanostructured materials prepared by modern technologies, such as pressure infiltration, vacuum diffusion bonding, PVD, CVD, plasma spraying, unidirectional solidification of eutectics, powder metallurgy, hot and cold isostatic pressing, hot extrusion, severe plastic deformation (ECAP), etc. The physical and mechanical properties are studied on the basis of knowledge of materials structure laws. The development of materials is supported by research facilities for evaluation of the structure (electron microscopy, EDX-microanalysis, computer image analysis, metallography, ion milling, etching, X-ray analysis, X-ray diffraction, DTA, thermogravimetry, mass spectroscopy, microtomography, etc.) and determination of almost all basic materials properties (tensile and compression testing, fatigue endurance under random loads, creep, wear resistance, surface roughness measurement, acoustic emission, hardness and microhardness, thermal and electrical conductivity, wettability, surface tension, etc.). Applied mechanics deals with modelling of elastic and plastic continua, modelling of fatigue endurance under stochastic loading, theory of noise and vibration control, acoustoelasticity, dynamic analysis of machine aggregates, vibrodiagnostic of rotary machines, etc.

In the field of metal matrix composites (MMC) various types of composites reinforced with continuous monofilaments, wires, short fibres, particles or ceramic or graphite skeletons e.g. Al-B, Cu-W, Al-C, Mg-C, Cu-C, Al-SiC, Al-Fe, Sb-C have created a main subject of Institute's interest a long time ago. However, in distinction to previous years, where the main attention was paid to the improvement of mechanical properties, recent activities are mostly devoted to explore unique functionality of composites especially in components for thermal management, where the improvement of thermal conductivity has to be combined with possibility to control coefficient of thermal expansion (CTE) and with sufficient structural stability under thermocyclic loading. This topic has been investigated recently within the frame of integrated project of the 6thFramework Programme (FP) of EU ExtreMat, where IMMM SAS plays an important role in coordination of one of 4 subprojects, which is devoted to development of novel heat sink materials with high thermal stability and high thermal conductivity. Beside coordination the main attention of Institute's activities was focused on R&D of copper matrix composites reinforced with tungsten wires and high modulus carbon fibres. These are aimed for divertors of the new generation of fusion reactors (high thermal stability) and for different applications in power-electronics, opto-electronics, microelectronic packages, novel SiC chips, etc. respectively. Further activities in MMC field included development and study of properties for MgLi composites reinforced with short alumina fibres, interactions of components and interfaces in magnesium based composites, development of the manufacturing of ceramic/lead composites by the melt infiltration process for the battery applications, optimization of properties and joining of metal matrix composites, impregnation of carbon-graphite preforms with copper and copper alloys for electric contact materials.

In the field of intermetallics, based on the original expertise in design, directional solidification and characterization of nickel based alloys for high temperature structural applications, R&D has been redirected to multiphase intermetallics since 1994. Design of new advanced multiphase nickel based intermetallic alloys, development of unique processing techniques for iron based intermetallics and titanium based intermetallic matrix composites including extended characterization of microstructure and properties of these systems were performed within several national and international (COST) projects and extensive international cooperation. The high level of IMMM SAS competence in this field was recognized by acquirement of integrated project of the 6th FP EU IMPRESS - Intermetallic Materials Processing in Relation to Earth and Space Solidification, managed by the European Space Agency, where Institute`s role is to coordinate the research on fundamentals of solidification of TiAl based alloys, whereas IMMM SAS takes part on microgravity solidification experiments, alloy selection and characterization of mechanical and microstructural properties of new developed systems.

Development of metallic foams represents one of the highlights of Institute`s R&D activities. Some of the most important contributions to the particular knowledge in the field of metallic foams include:

- development of novel aluminium foam composites reinforced with expanded steel mesh by in situ foaming,
- development of a method for reinforcement of solid metal foam (European Patent EP1611262)[5],
- development of a method and equipment for manufacturing of foamed parts with precise dimensions,

- design and production of foamed panels acting as heat exchangers for wall and ceiling cooling/heating,
- design and production of device for large scale production of reinforced aluminium foam panels,
- design and production of computer controlled expandometer for determining the foaming properties of various foaming precursors,
- description of the effect of thermal treatment of aluminium foam,
- description of foam and foam sandwich behaviour under cyclic loading,
- comprehensive study of sound absorption ability of metal foams, etc.

Several aluminium foam prototypes were developed, tested in industrial conditions and produced (stiffeners for side rail of Ferrari Modena car; crash absorber for railway carriages; lightweight folding table for railway carriage; lightweight WiFi-box with enhanced electromagnetic field shielding ability applied for signal transmitter of wireless internet; lightweight crash box for trucks allowing enhanced absorption of deformation energy in case of impact of personal vehicle into the rear part of truck or trailer; oil pan applied for the purpose of noise damping of combustion engine; damping insert for chain wheel of combustion engine applied for the purpose of vibration and noise reduction;damping part for machine tool applied for the purpose of attenuation of Z axis shaft vibrations induced during machining process; etc.). In 2006 the large scale production of aluminium foam crash absorber developed by IMMM SAS for Audi Q7 car which is used for enhancement of passenger's safety has started. With an annual production of 200.000 pcs is this part worldwide the first large volume series aluminium foam application in automotive industry.

In the field of nanostructured aluminium alloys some of the most important contributions to the particular knowledge include:

- development of new dispersion strengthened material based on hot extrusion of ultrafine aluminium powders exhibiting high strength, ductility and structural stability up to the temperature of 450°C,
- development of unique composites based on ductile aluminium matrix created by compaction of ultrafine aluminium powders reinforced with high-strength ribbons prepared by rapid solidification of AlFeV alloys,
- development of compaction route for hypereutectic AlSi alloys that has resulted in the large scale production (300.000 pc/year) of stators of camshaft phaser for automotive engine BMW (in cooperation with SAPA profily a.s. ŽiarnadHronom).

One of the most successful R&D projects currently coordinated by IMMM SAS is a project of 7th FP of EU SILTRANS –Micro and nanocrystalline silicide - refractory metals functionally graded materials for materials innovation in transport applications. Dr. Simančík – director of IMMM SAS coordinates this project and several reputable foreign institutions from Germany (EADS Deutschland GmbH, Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V., Dr. Kochanek Entwicklungsgesellschaft), Austria (Cleanair GmbH, University of Technology Vienna), Switzerland (Ecole Polytechnique Fédérale de Lausanne) and UK (Archer Technicoat Ltd.)participate in the project tasks.

- **Institute of Materials Research SAS, Bratislava (IMR SAS)**

IMR SAS is one of the leading institutions of Central Europe in the field of powder technologies/materials, nano-materials and ceramic matrix composites. The scientific orientation of IMR SAS is focused on the development and testing of new materials (physical and mechanical properties and the deformation and fracture characteristics of different materials at low, room, and high temperatures) and of new technologies with potential applications in transportation, energy, information technology, etc. The main fields of research activities include:

Advanced steels

- research of the formation and development of the microstructure of steels during thermal and thermo-deformation treatment (the aim is to analyze and define the influence of the microstructure and chemical composition on strength, deformation and fracture properties, including life-time and reliability predictions of steels under various operational conditions),

Advanced powder technologies/materials:

- application of innovative approaches (thermodynamic prediction of chemistry and transportation phenomena, modelling of micro-mechanical behaviour) for the control of the processes at the particle interfaces at nano- and micro-scales to improve the static and dynamic properties of the advanced Cr

and Mn alloyed sintered steels developed for the production of the materials with nano- and micro-graded composite microstructures,
- study of the physical and chemical processes of surface modification of cutting tools by nano- and multilayer coatings for industry,

Nano-structured materials:
- fundamental research of the relationships between the processing, microstructure and mechanical properties of the bulk nanocrystalline materials designed for high temperature applications,
- microstructure simulation and analysis of physical and mechanical properties of metallic nanocomposites,
- development of complex microstructural models for the verification of the behavior of real materials,
- creep behavior of metallic composites, analysis of the role of interphase boundaries and development of strain and fracture models,
- synthesis of nanocrystalline metal matrix materials via mechano-chemical methods,

Structural and functional ceramics:
- R&D, microstructure characterization, testing of mechanical properties and fracture behavior of advanced ceramics, ceramic matrix composites, nano-composites, layered composites and nanocomposite coatings designed for structural, functional and bio-medical applications,
- high temperature behavior of brittle materials - creep, slow crack growth, oxidation,
- failure analysis of brittle materials, life-time and reliability predictions and pre– and standardization activities in the frame of ESIS, CEN and VAMAS.

- **Institute of Electrical Engineering SAS, Bratislava (IEE SAS)**

IEI SAS is presently engaged in basic and applied research in the field of semiconductors and superconductors. Research into technology deals with: the preparation of thin film layers of superconductors, semiconductors, semiconductors structures for microelectronics and optoelectronics. Vacuum deposition and plasma deposition techniques aswell as the low pressure metal organic chemical vapour deposition (LP MOCVD) are used. Metallurgical preparation techniques are used to prepare bulk superconducting materials and superconductors. Considerable attention is paid also to the development of new structures, elements, instruments and systems applicable in electronics and electrical engineering. The results of research activities are published mostly in the Journal of Electrical Engineering, which is co-published with the Slovak Technical University.

- **Institute of Physics SAS, Bratislava (IP SAS)**

The main task of IP SAS is to carry out basic theoretical and experimental research in physics. The research areas are solid state physics, quantum optics, nuclear and subnuclear physics. In solid state physics the effort is focused to rapidly solidified materials, (e.g. metallic glasses), thin films and multilayers and to special diagnostic methods like the deep-level transient spectroscopy, positron annihilation, scanning probe microscopy, thermophysical properties measurements, atomic absorption and emission spectroscopy and X-ray diffractometry and reflectometry. Research in solid state theory is focused to low-dimensional systems, phase transitions and quasicrystals. In theoretical quantum optics, nonclassical properties of optical fields (such as a reduction of quantum fluctuations, quantum entanglement, creation and destruction of quantum coherence, etc.) in nonlinear quantum-optical parametric processes are investigated. In the field of nuclear and subnuclear physics the nuclear structure, phenomenology of high-energy collisions, and properties of hadronic spectra are studied.

- **Institute of Inorganic Chemistry SAS, Bratislava (IICH SAS)**

The mission of IICH SAS isbasic research of inorganic and bioinorganic systems aimed at the optimization and development of new materials and technologies, upbringing (education) of new scientists in relevant areas within the framework approved by the Ministry of education of the Slovak Republic, contribution to the R&D in joint fields of interest in the Slovak Republic and abroad by expertise and collaboration with universities, profit and non-profit institutions. The research comprises mainly relationships between composition and structure of inorganic compounds, i.e. advanced ceramics, molten systems and hydrosilicates, phenomena and chemical reactions in inorganic systems and on phase boundaries, thermodynamics of many component systems, development and application of theoretical and experimental methods for the estimation of the structure and properties of compounds.

- **Polymer Institute SAS, Bratislava (PI SAS)**

The research of PI SAS is concentrated on intentional and spontaneous structural changes in polymers in relation to their properties. Research projects are focused on modification by introduction of functional groups, grafting, cross-linking, thermal and light stabilization of polymers, on mechanism of emulsion polymerization, preparation of new polymer materials based on polymer mixtures and composites, materials for biotechnology and biomedicine and supports for liquids chromatography. The thermodynamics of polymeric systems, conformation and mobility of polymer chain of synthetic polymers and biopolymers is investigated. New chromatographic separation and characterization techniques for complex polymer systems are being developed.

- **Institute of Construction and Architecture SAS, Bratislava (ICA SAS)**

ICA SAS performs fundamental and applied research and new developments in the field of civil engineering and architecture. Over a period of more than forty years the institute has developed to address the changing needs of theoretical, numerical and experimental research for professionals, companies and enterprises involved in structural engineering, mechanics, architecture, design, materials, building research and constructions in civil engineering and building science generally.

- **Institute of Measurement Science SAS, Bratislava (IMS SAS)**

IMS SAS is a scientific institution whose activities encompass the following basic domains of fundamental and applied research: measurement theory and mathematical-statistical methods for processing of experimental results; systems for measurement of selected physical quantities; measuring systems for biomedicine, mathematical and computer modelling of bionic structures and processes, biosignal processing; measuring methods and systems designated to solve non-standard measuring problems in research and industry applications, development and realization of unique measuring systems. Besides of the basic research in the area of the selected measuring methods, the IMS SAS is oriented to the following tasks with an impact to the industrial domain: measuring systems for spatial stability of the large energetic objects; measuring complexes for automatic measurements of selected physical quantities (temperature, pressure, infra-red radiation) in real time; tomographic methods and instrumentation for non-destructive investigation of structural changes of 3D objects based on nuclear magnetic resonance; magnetometric systems SQUID for low concentrations measurements of powder ferromagnetic materials in biological structures; multi-channel systems of heart electrical activity and gastro-intestinal human tract scanning using surface electrodes.

- **Institute of Geotechnics SAS, Košice (IG SAS)**

The main fields of research activities of IG SAS include:

- basic research of processes in the field of continuous disintegration of the rock mass and underground constructions stability, the transport of energy and mass in the rock disintegration processes;
- basic research of solid dispersions origin patterns and their properties modifications by physical, mechanical, chemical and biotechnological processes;
- qualitative and quantitative evaluation of phase interactions at the disperse systems origin and at their spreading in working and living environment;
- application of theoretical knowledge from mentioned areas for detailing the top technologies principles in the following fields: rock disintegration, mineral processing, monitoring of selected components of working and living environment, monitoring of environmental, chemical and geological changes in the waste repositories with the aim of ecological revitalizations.

- **Institute of Technology SAS, Bratislava (IT SAS)**

IT SAS has been established in 2008 by cooperation of ten partner institutes of SAS in Bratislava, including about 250 scientists in order to support technology transfer in the field of new advanced materials and technologies. Main target of this partnership is the promotion in the multidisciplinary material research having background in broad areas of natural sciences and to support innovation and application potential of concerned research institutions. R&D and innovation activities are realized in four competence centers (CC) working in the fields of the multifunctional materials and nanotechnologies. Multifunctional materials are new construction materials having different attributes and functions in a given system. Nanotechnologies give new possibilities to prepare multifunctional materials on the nanometer scale.

Following Competence centers (CC) are associated within IT SAS:

- CC NANO– nano-materials and nano-technologies,
- CC ELEKTRO– materials of electronics and electrotechnology ,
- CC MATER– structural materials,
- CC EXTMATER– materials for extreme conditions.

CC NANO is coordinated by IP SAS - surveys on the R&D of fundamental physical processes at meso- and nano-scopic level, features of electronics and magnetic structures of functionalized constructive components at very low temperatures and large magnetic fields. Main focus is in the magnetic features of nano-particles, nano-sized electronics and spintronic structures.

CC ELEKTRO is coordinated by IEE SAS - investigates materials and structures with aims to use them in electronics and electrotechnology. The modelling of the transport in mesoscopic structures and analysis of electro-magnetic effects in composite materials are serving to the preparation of mesoscopic structures. Structures and components are prepared on the basis of:

- GaN, III-V semiconductors,
- oxide surfaces for the communication technologies, sensors, memory elements,
- superconductive materials for high-current load applications,
- biosensors based on selfassembled structures, etc.

CC MATERis coordinated by IMMM SAS - focuses on the R&D&TT of new composite, nano-composite and nano-structured materials for industrial applications in building industry, machine building, especially stiff construction elements and systems, such as:

- stiff abrasion resistant and optical layers,
- multifunctional nano-structured coating films for nano-catalysis and anti-corroding systems,
- plastic materials with lowered energetic and ecological weight,
- biodegradable and recycling materials, etc.

CC EXTMATER is coordinated by IICH SAS - is directed for the R&D&TT of new composite, nano-composite and nano-structured materials for applications in extreme conditions, e.g., ultra-light high-stiff structural elements and systems on the basis of gradient submicron powder substances or surface and protecting dispersive nano-materials and coatings; modelling and simulation of the properties prepared composite materials.

- **Slovak University of Technology in Bratislava (STU)**

STU is a modern educational and scientific institution. Since its foundation in the year 1937 more than 125.000 students have graduated. In average, 19.000 students study at the STU every year. At present, the STU consists of seven faculties. All the STU faculties provide a study in accredited study programs within the complex system of a bachelor, master and PhD study. In the area of scientific and research activities the STU successfully joins European Union programs.

STU is R&D oriented university. During its existence, the university significantly contributed to development of scientific knowledge, enrichment and utilisation of scientific knowledge for the benefit of mankind. The university pursues research in all the areas in which university education is provided, thus in the areas of architecture, civil engineering, geodesy, cartography, chemical technologies, food processing, machinery, electrical engineering, electronics, informatics, information and communication technologies and applied physics, mathematics, economics, social science as well.

The Faculty of Materials Science and Technology (FMST) STU in Trnava realises the university system of education in all three degrees of accredited study programmes with priority to materials science and production technologies and provides the transfer of science and R&D findings into the educational process and entrepreneurial practice. The graduates gain complete master's degree education in the field of engineering materials, development of their production, their technological processing to industrial products, as well as control of their quality and operating diagnostics, influence of chemical composition and structure to their mechanical and physical properties. The graduates of PhD study are familiar with scientific methods of R&D and processes leading to his own scientific formulation of problems in the field of engineering materials and its solving, with ethical and social aspects of scientific work, the rules of presentation of R&D results, and they understand relations between R&D – production – implementation – recycling, etc.

The R&D content of FMST STU is oriented to the following-fields:

- materials research with a focus on the R&D and technological processing of the basic and new advanced engineering materials,
- R&D of new advanced technologies of industrial production oriented particularly on the technological processing of modern engineering materials and ecologically clean processes and products,
- process identification, automation and control, information support for technological production and organization systems,
- development and verification of managerial control principles and their organization structures,
- quality control and certification of processes and products,
- safety and reliability of technological equipment and systems, while emphasizing the analysis methods and systems, etc.

The Faculty of Mechanical Engineering (FME) STU in Bratislava carries out R&D which helps to create answers to the perennial question: how to make better use of human resources and those of the world we are living in. The program covers a broad spectrum, first of all, a number of technology areas, certain aspects of economics and environmental protection. The high professional competence and reputation of FME STU members creates the basis to attract the attention of different companies and industries to solve various tasks of industrial design, product and production planning, process control, equipment maintenance, and to find many other solutions to problems of industry and society. In the premises of the FME STU, the STU Technological Incubator was established. Initiated and supported by companies in Slovakia and abroad, further important projects are realized, e.g.: the Centre for Technological Quality Transfer, the Centre of Education for PSA Peugeot Citroën and the Mechanical Engineering Consulting Centre.

The Faculty of Electrical Engineering and Information Technology (FEEIT) STU in Bratislava has in the field of pregradual education the mission in preparation of universally profiled and flexible graduates of bachelor and master study programs with an adequate theoretical and practical level of knowledge and ability, thus in preparation of academically educated specialists for a wide social practice. The postgraduate study is academic preparation of specialists for the manager posts in companies and institutions and experts for the R&D in the field of electrical engineering and information technology. The mission in these scientific fields is granting teachers, researchers and students on behalf of intellectual potential utilization with maximum multiplicative effects of research through the pedagogical activity an environment for free scientific research and creative investigation. FEEIT STU has to be primarily oriented on these most important R&D areas:

- electronics and electrical engineering and their applications,
- automated systems and methods of their control,
- power and nuclear engineering,
- information and telecommunication systems and technologies, etc.

The Faculty of Civil Engineering (FCE) STU in Bratislava provides a high level of education in the field of civil engineering based on Slovakia`s traditional and cultural heritage and the latest scientific knowledge. Graduates of FCE STU are qualified to design projects, are trained in the preparation and management of structures of buildings and structures of civil engineering works, are qualified specialists in water management and can perform and supervise work in the field of geodesy and cartography.

They can hold positions in the investment and economic sectors, in scientific research or educational institutions, as well as they can also carry out various entrepreneurial activities in industrial sector of civil engineering.

The Faculty of Chemical and Food Technology (FCHFT) STU in Bratislava educates graduates in both chemical and food engineering, as well as in postgraduate doctorate courses in chemical and technical sciences. FCHFT STU has a widely oriented scientific program, leading to the development of basic scientific fields in chemistry, chemical technology and food processing. This wide scientific orientation of R&D activities allows goal-oriented training of undergraduates and thereby their quicker transition to industry.

- **Comenius University in Bratislava (CU)**

CU is the oldest university in the Slovak Republic. It was founded in 1919 and follows the university tradition of the Academia Istropolitana which was established in Bratislava by Matthias Corvinus, the Hungarian King, in 1465. As a higher education institution which aspires to be a member of leading European centres of academic excellence and as an internationally oriented university, the university's core strategic objectives are:

- to sustain and develop its identity as a research and teaching institution of the highest international quality,
- to provide an outstanding educational environment, supporting study across a broad range of academic disciplines,
- to enhance the scientific and cultural vision of society as well as its economic well-being.

As a Centre of Excellence, the University pays special attention to the steady evaluation of its research and teaching in order to ensure that its students are led by outstanding experts - researchers and lecturers. As the greatest, oldest and outstanding national university of the Slovak Republic, CU especially values its intellectual and universal relationship with the Slovak nation, where it has its roots and at the same time provides the foundation from which it will continue to look to the widest international horizons, enriching both itself and Slovakia.

The Faculty of Mathematics, Physics and Informatics (FMPI) CU in Bratislava contributes to the University's mission by enhancing creative knowledge, education and research in mathematics, physics and informatics. It provides R&D in full range of the above mentioned disciplines. Education provided by FMPI CU is based on the latest knowledge in science and technology, including the results of its own research. Students are offered excellent conditions for study in wide spectrum of programs. R&D in the field of materials science is one of the preferable objectives in the Department of Experimental Physics of FMPI CU. The main research activities are oriented to the fields of solid state physics, optics and lasers, radiophysics and plasma physics.

In the field of solid state physics, technological and experimental procedures for fabrication and analysis of micro- and nanostructures for cryoelectronics and sensorics, as well as preparation and study of new dielectric, semiconducting, superconducting and composite materials have been developed. Mesoscopic quantum and tunnel phenomena applicable in quantum computers and single particle detectors are studied both experimentally and theoretically. Strongly correlated electron systems and nonconventional superconductivity are being focused on in theoretical approaches. Another branch of research in condensed matter physics is represented by computer simulations. Here the main focus is on study of pressured-induced phase transformations in crystals using the original metadynamics-based approach. This R&D is relevant for crystal structure prediction and high-pressure physics and results are important in geophysics and materials science.

- **University of Žilina (UŽ)**

UŽ is the only university located in the northwest region of the Slovak Republic and is unique in Slovakia as it has a long tradition of providing education in the fields of transport and communications. Furthermore, during the last period of development the University became an educational institution with a broad profile in many areas of science, technology, economics, management, and recently, educational and natural sciences. UŽ enjoys a very close cooperation with transport, telecommunication and industrial companies as well as public and private institutions across Central European region. The University contributes to the technological and operational development of transport and telecommunication systems, networks and services as the main conditions for the future economic and social development of the Slovak Republic.

The Faculty of Mechanical Engineering (FME) UŽ offers a technical education and produces university-educated experts, who are able to solve complicated technical problems with reasoning in all views of social, ethical, economic, ecological, cultural and historical matters. FME UŽ consists of 10 departments, which in cooperation with the other parts of the faculty and University guarantees the pedagogic process and scientific and research activities. Department of Material Engineering provides materials science courses in three of the University faculties and is certified in materials engineering specialization.

The department produces completely prepared engineers – specialists oriented in the fields of choice, control, evolution, and processing of metallic and non-metallic structural materials and the development of new materials with unconventional properties. Students of the Department of Mechanics and Strength of Materials are educated in the basics of solid mechanics, computational mechanics (solids, fluids and other mechanical fields and coupled field problems; theoretical and numerical basics and principles of modelling; optimal design), experimental methods in mechanics and reliability of mechanical systems. The department solves industry problems from the fields of linear and non-linear statics and dynamics of structures, fluid dynamics, solid-fluid interaction, optimal design, strength of materials, etc. Static and quasistatic characteristics of materials are experimentally investigated. Department of Technological Engineering provides study in the areas of machine technology and materials. Education, research and scientific activities are mainly focus on

machining technology. The department offers technology of machining and assembly, basics of mechanical production, technologies without chip removal and other subjects for general study in the first one to three years. Subject structure of specialized study in the last one to two years is in two specializations: machining and manufacture mechanics; and machine production. Theory of machining, forming, welding, casting, etc. creates the basis for a student's subject structure.

The Faculty of Electrical Engineering (FEE) UŽ is oriented to technical aspects of transport industry, strongly supported by information and communication technologies. It concerns especially areas of information and communication systems, networks and services, development of power semiconductive systems and modern control of electrical networks. Study of interdisciplinary branches is also increasing, namely Mechatronics and Biomedical engineering.

The Faculty of Civil Engineering (FCE) UŽ is focused by R&D activities to solving theoretical problems of designing transport structures and buildings, new technology in construction, modelling, strain analysis and computer based numerical simulations. Significant results have been achieved in theoretical analysis, measuring and diagnostics of transport structures subjected to dynamic loading.

- **Technical University of Košice (TUKE)**

TUKE provides its environment with scientific and technological knowledge basis, innovation and workforce, in order to form beneficial and sustainable future and high quality of life. This is achieved at TUKE by innovative research and excellent education in all scientific branches of respective University faculties.

The Faculty of Metallurgy (FM) TUKE is oriented on the following R&D fields:

- pig iron and steel production,
- ladle metallurgy of steel and continuous casting,
- metallurgy of non-ferrous metals,
- modern foundry technologies,
- metals forming,
- metals finish and protection,
- refractory materials production and application,
- energy balances of the thermal processes and aggregates,
- energy resources efficient utilization,
- environmental aspects of the metallurgical production,
- wastes recycling and utilization,
- R&D of new engineering materials and advanced technologies,
- development of new methods for the material properties evaluation,
- physical and mathematical process modelling,
- quality control and environment protection in the industrial enterprises, etc.

R&D activities of the Faculty of Mechanical Engineering (FME) TUKE are based on a solution of grant projects as well as projects resulting from the real tasks of technical and industrial practice. Some of important solved problems are listed thereinafter:

- intensification of technical ability of heavy supporting structures,
- risk-management in complex logistic systems,
- prototype of a new type of two-stage turbine,
- modernization and automation of a gas-boiler plant,
- reconstruction and innovation of engineering products,
- new technologies in manufacturing and operational processes – individual applications
- new application and implementation of CA-technologies and software products – individual activities,
- preparing for innovations of engineering companies and technologies,
- rehabilitation system for paraplegic patients,
- systems for handling of immobile persons,
- experimental and testing stands, testing methods of driving systems and modules, etc.

The scientific research activities of the Faculty of Electrical Engineering and Informatics (FEEI) TUKE are realized in the form of solving scientific and scientific-engineering projects that cover a wide spectrum of scientific disciplines, which are divided to three main groups:

- electrical engineering and electric power engineering,
- informatics sciences, automation and telecommunications,
- earth and universe physics.

The Faculty of Civil Engineering (FCE) TUKE concentrates its R&D activities on projects aimed at the knowledge and technologies transfer from R&D into practice in the fields, e.g.:

- architectural, structural, technological and economic aspects designed for energy efficient buildings,
- development of progressive technologies for waste utilization in road construction,
- effective rainwater harvesting and utilization,
- advanced design and technology in road construction, etc.

R&D activities of the Faculty of Aeronautics (FA) TUKE are focused on basic and applied research in aviation equipment and aircraft operation, airfield support and air force operations. They cover a wide scale of branches including aviation electronic techniques, mechanical engineering and air traffic control. Among the principal areas are e.g. modelling, simulation, virtual reality and visualization of modes of aviation engines, aircraft and flight simulators, etc.

- **International Laser Centre, Bratislava (ILC)**

ILC was founded in 1997, by the decree of the Slovak Republic Government # 652/96, as an independent budgetary organization under the Ministry of Education of the Slovak Republic (ME SR), with the aim to create a base institution of ME SR for lasers and laser technologies. ILC is an interdisciplinary research organization formed to foster collaborative research in the areas of progressive methods and technologies of photonics, and their application in industry and health care. ILC was created by the ME SR as an independent research and educational institution, on the basis of the Faculty of Electrical Engineering and Information Technology STU and the Faculty of Mathematics and Physics CU, in cooperation with the Moscow State University. The creation of ILC was aiming at building an excellent research centre equipped with up-to-date sophisticated laser and optoelectronic technologies.

ILC provides a cross- and inter-disciplinary research infrastructure for the high-level interdisciplinary R&D in all fields of laser-based and photonic technologies in cooperation with Slovak universities, academic institutions and industry. ILC implements this mission by fostering scientific, engineering and biomedical talents. Specifically, ILC:

- conducts actual scientific and technological projects, and co-operates with associated institutions;
- provides a platform for technology transfer and create contacts among scientists, engineers and other specialists sharing interest in the field of photonics, presentation of scientific and technical results, consulting and information services;
- cooperates with universities in under-gradual and post-gradual education covering applications of lasers and optoelectronics in microelectronics, biomedicine, industry, organization of training and courses, workshops, etc.

- **BASF PolyuretánySlovensko s.r.o., Malacky**

BASF is the leading supplier of Polyurethane Solutions for Systems, Specialties and PU Basic Products. With its global network of 38 polyurethane System Houses and its comprehensive product and service portfolio, BASF is the preferred partner of its customers in many industries. Through its System House network, BASF provides fast local support, from technical service and sales to production and marketing during the development of customized solutions. With its world-scale plants, BASF secures its leading market position in the production of polyurethane basic products in all regions of the world. BASF`s Polyurethanes division (including BASF PolyuretánySlovensko Ltd.) is one of the world`s largest producers of polyurethane – important versatile specialty plastics used to produce a wide spectrum of rigid, flexible, foamed and compact components for consumer products in automotive, construction, footwear and appliances.

- **BSH Drives and Pumps s.r.o., Michalovce**

BSH Drives and Pumps Ltd. is subsidiary of BSH Bosch und Siemens Hausgeräte GmbH (BSH), which is the largest manufacturer of home appliances in Europe and one of the leading companies in this sector worldwide. The company stemmed from a joint venture set up between Robert Bosch GmbH (Stuttgart) and Siemens AG (Munich). BSH operates 41 factories in 13 countries in Europe, the USA, Latin America and Asia. Together with a global network of sales and customer service firms, the BSH family is made up of about 70 companies

in 46 countries, with a total workforce of nearly 43.000 people. Within the brand portfolio the main brands are Bosch and Siemens. With its seven special brands (Gaggenau, Neff, Thermador, Constructa, Viva, Ufesa and Junker), BSH caters for the individual wishes of consumers. Four regional brands (Balay, Pitsos, Profilo and Coldex) ensure a broad presence in their respective homemarkets. The product range encompasses large and small home appliances, floorcare and hot water appliances.

- **Central European Institute of Technology, Žilina (CEIT SK)**

CEIT SK is a dynamically growing company focused on R&D solutions for the industry. CEIT SK professionals are experienced in the area of mechanical engineering, industrial engineering, informatics and electrotechnics. They are developing its innovative solutions by using the newest technologies. From the projects implemented by CEIT SK should be mention in particular:

- 3D parametric modelling and simulation on the basis of Digital Factory Concept,
- proposal of innovative module for interactive 3D design of manufacturing systems on the basis of Digital Factory Concept,
- R&D of intelligent bearing for Wind Power Station,
- analysis of restrictions and assumptions for the design of effective and safety modular workstation,
- development of the on-line monitoring system, controlling and analysis of logistic devices, etc.

- **COBA Automotive s.r.o., Techová**

Company COBA Automotive Ltd. is subsidiary of COBA International Ltd., which is a privately funded group of manufacturing and distribution businesses. The key activities are invested in the design, manufacture and distribution of thermoplastic products. COBA International Ltd. specializes in the extrusion of thermoplastic tubes and profiles in a wide range of materials. It provides customers with support throughout their design and development stages, and then provides a world-class quality of service during serial production.

- **DanubiaNanoTech s.r.o., Bratislava**

DanubiaNanoTech Ltd. is a startup company which combines a highly qualified team with wide ranging experience in nanoscale physics, along with close connections to some of the best centres of R&D in Europe. Fields of specialization include:

- preparation of carbon nanotubes by arc-discharge and laser ablation methods,
- purifying of as prepared carbon nanotubes using centrifugation,
- final material characterization by Raman spectroscopy and optical spectroscopy, X-ray diffraction (XRD), atomic force microscopy (AFM), measurement of electrical and thermal conductivity,
- mixing of pure and well characterized material with various polymers to obtain composites with high electrical and thermal conductivity and mechanical performance,
- production of conductive transparent networks of nanotubes with great potential applications (sensors, field-effect transistors),
- computer simulations (density functional theory, semiempirical methods, scientific visualization, electronic and phonon band-structure, etc.).

- **Delta Electronics (Slovakia) s.r.o., DubnicanadVáhom**

Delta Group is the world's largest provider of switching power supplies and DC brushless fans, as well as a major source for power management solutions, components, visual displays, industrial automation, networking products, and renewable energy solutions. Delta Group has sales offices worldwide and manufacturing plants in Taiwan, China, Thailand, Mexico, India and Europe. As a global leader in power electronics, Delta's mission is to provide innovative, clean and efficient energy solutions for a better tomorrow. Delta is committed to environmental protection and has implemented green, lead-free production and waste management programs for many years. The production factory of Delta Elektronics Ltd. in DubnicanadVáhom is equipped with modern technologies for production of complex product portfolio of power supplies, components of power systems (rectifiers, inverters and control units), solar inverters, as well as complete power systems. These products provide power supply for telecommunication, IT, industry automation and medical equipment. Production concept of Delta Elektronics Ltd. is based on realization of reliable and innovative custom designed solutions according customer needs. Modern facility in DubnicanadVáhom operates as interoperation of quality equipment, structured processes and skilled and qualified employees and has ambition to become Central office of Delta in eastern Europe for production and service.

- **EDAG Slovakia s.r.o., Bratislava**

The EDAG Group, the world's largest independent engineering partner, develops ready-for-production solutions to ensure the mobility of the future. The EDAG Group covers the entire supply chain of sustainable, holistic mobility concepts in the automotive, commercial vehicle, rail and renewable energy industries. EDAG Group product range includes the planning and implementation of wind power, photovoltaic and battery system plants, the application of energy-efficient plant engineering, and the development of intelligent charging systems for electric vehicles.

- **ELEKTROKARBON a.s., Topoľčany**

The main entrepreneurial activity of ELEKTROKARBON Inc. is the manufacturing and sale of final and semi-finished products made from carbon materials. The supplementary production program is aimed at products based on thermosetting plastic material with carbon fillers. The company principal shareholder is HTC Holding Inc., Bratislava. ELEKTROKARBON Inc. has its own R&D facilities including material and testing laboratories of carbon products. The aim of the company is to continue the tradition of the manufacturing of carbon products, to stabilize quality and to actualize the assortment of products according to current requirements of customers.

The main business areas:

- R&D, production and consumption of carbon materials and products,
- production of contacts from rare and coloured metals,
- designing, production and sales of tools, machines and spare parts,
- phys.-chem. analysis of samples and processing the raw materials and semi-finished products,
- production and sales of moulded reactoplastics, plastics, gums,
- R&D of contacts from rare and coloured metals,
- co-operation assembly of electric motor and parts,
- production and sales of cooper wires,
- R&D and production of machinery and equipment for processing carbon and steel materials and products from wood, etc.

- **PRVÁ ZVÁRAČSKÁ a.s. (FIRST WELDING Inc.), Bratislava**

FIRST WELDING Inc. is a R&D – manufacturing – certification – consulting company acting in the field of modern technologies of welding, cutting and heat treatment of materials. Its scope of business activities includes the following main fields:

Field of welding technologies and automation:

- R&D in the field of HIGH-TECH technologies and high-productive welding processes,
- research and deliveries of electron beam welding equipment, plasma cutting centres, robotic welding complexes, single-purpose welding equipment, vibrators for reduction of residual stresses,
- providing services in the field of electron beam welding, laser processing of materials, classical arc welding technologies, plasma cutting, brazing/soldering, vibrational treatment,
- repairs in the field of nuclear power equipment, etc.

Field of material diagnostics and strength research:

- material diagnostics,
- laboratories of strength research and metallography.

Field of certification activities and education in welding:

- courses for attaining the qualification in welding,
- courses of non-destructive testing of welds (NDT),
- courses of quality management systems,
- welding school.

Field of publication activities:

- professional journal ZVÁRAČ (WELDER),
- professional literature in the field of welding.

- **HTP Slovakia s.r.o., Vráble**

HTP Slovakia Ltd. is subsidiary of HTI High Tech Industries AG, located in St. Marien (Upper Austria), which is an international technological group, specialized in the fields of Lightweight Construction, Engineering and Energy Technology. The HTI Group is globally active with approx. 1.500 employees at 16 locations and

produces hightech products that secure mobility as well as provides dependable infrastructure and reliable energy supply. HTP Slovakia Ltd. provides the complete services for injection moulding of polymers from analysis of manufacturability, design of components, proposal of alternative materials and technologies, production of forms to the proposal of logistics solutions.

- **HTS BB s.r.o., Vlkanová**

HTS BB Ltd. provides commercial services in the field of thermal and chemical-heat treatment of metals to the highest qualitative and quantitative measures for small and large customers. Its ultimate goal is to satisfy the requirements of all clients and seek to build long-term partnership.

- **INTEGRITA A BEZPEČNOSŤ OCEĽOVÝCH KONŠTRUKCIÍ a.s., Bratislava (IBOK)**

IBOK Inc. is a specialist in the field of material behaviour under various operating conditions from the viewpoint of the security of industrial structures and machinery. Its solutions are based on combination of both, the material (including the welding metallurgy) and the numerical analyses. IBOK Inc. is able to find an optimum solution to problems due to flaws or wrong use of material. In case of occurrence of a flaw in the material, IBOK Inc. assesses its significance from the viewpoint of safety of the piece of industrial equipment. If necessary, IBOK Inc. proposes a technological procedure for the repair, or carries out the repair, if required.

- **KraussMaffei Technologies s.r.o., Sučany**

KraussMaffei is one of the world's leading manufacturers of machinery for processing plastics and the only company supplying machinery covering tree key technologies for the international plastics and rubber processing industries. As a technology partner KraussMaffei Technologies Ltd. links core process know-how with innovative engineering to deliver specialized and intergraded complete solutions. The KraussMaffei Group markets its products under the KrausMaffei, KraussMaffeiBerstorff and Netstal brands. The KraussMaffei brand covers the whole spectrum of injection and reaction moulding technology, while KraussMaffeiBerstorff specializes in extrusion solutions. The Swiss subsidiary Netstal is firmly established as a premium supplier of high-precision injection moulding machinery. R&D has always played a key role in the success of the KraussMaffei Group. Company invests continuously in these activities and R&D at KraussMaffei is essentially application-related. As the only company worldwide with comprehensive expertise in the three major processing technologies - injection moulding, extrusion and reaction moulding – KraussMaffei delivers solutions that include both innovative turnkey production units and integrated system solutions. KraussMaffei develops future-oriented system solutions, products and services that increase the practical benefits for our customers and simultaneously reduce costs, time and effort.

- **MagnetiMarelli Slovakia s.r.o., Bratislava**

MagnetiMarelliis an international company committed to the design and production of hi-tech systems and components for the automotive sector, based in Italy (Corbetta, Milan).With about 32.000 employees, 77 production units, 11 R&D Centres and 26 Application Centres, the Group has a presence in 18 countries (Italy, France, Germany, Spain, Poland, Czech Republic, Russia, Slovakia, Turkey, United States, Mexico, Brazil, Argentina, China, Japan, India, Malaysia and South Africa) and supplies all the leading car makers in Europe, North and South America, and Asia. MagnetiMarelli confirms its mission of excellent automotive components and focuses its efforts especially on intelligent systems for the active and passive safety of the vehicle, making the most of its great expertise in electronic systems. MagnetiMarelli is structured along the following business lines: Lighting, Electronic Systems, Powertrain, Suspension Systems, Exhaust Systems, After Market Parts & Services and Motorsport.

- **ON Semiconductor Slovakia a.s., Bratislava (ONS)**

ON Semiconductor Slovakia Inc. is a premier supplier of high performance silicon solutions for energy efficient electronics. The company`s broad portfolio of power and signal management, logic, discrete and custom devices helps customers efficiently solve their design challenges in automotive, communications, computing, consumer, industrial, LED lighting, medical, military/aerospace and power applications. ON Semiconductor operates a world-class, value-added supply chain and a network of manufacturing facilities, sales offices and design centers in key markets throughout North America, Europe, and the Asia Pacific regions. Global corporate headquarters are in Phoenix, Arizona. The company operates a network of manufacturing facilities, sales offices, and design centers in key markets throughout North America, Europe, and the Asia Pacific regions. ON Semiconductor:

- enables energy efficient solutions for a greener world,
- provides a broad array of products and solutions,
- helps customers solve their unique design challenges,
- operates a world-class, value added supply chain.

- **Pulp and Paper Research Institute, Bratislava (PPRI)**

The research of PPRI is focused on pulp production technology (reduction in the raw material consumption, chemicals and energy as well as decrease of environmental impacts), pulp bleaching technologies (oriented towards the environmental regulation limits satisfaction at minimal production costs), recovery of chemicals and power engineering at pulp production, environmental issues and pulping process chemical engineering.

- **SAPA profily a.s., ŽiarnadHronom**

SAPA profily Inc. is a traditional manufacturer of aluminium extruded profiles. Company is well established on the Czech and Slovak markets in its field of operation and have customers in the electrical engineering, transport, building, general engineering and telecom industries. SAPA profily Inc. is a dynamically growing company with both production and human potentials available. The Recent customer-oriented investments, measures and activities result in an enhanced efficiency, higher performance and improved customer services. Hot extrusion technology makes it possible to manufacture, just in a few operations, simple as well as complex aluminium profiles with accurate dimensions and quality surfaces. The aluminium profiles help constructors and designers to create new solutions, which satisfy almost any customer expectations, hopes and requirements. In-depth knowledge of aluminium properties and available production capabilities are essential to maximise the value which SAPA profily Inc. adds to its customers. The production resources have been permanently conformed to customer`s requirements, and this ambition is resulted in establishing new, modern development centres and new technology facilities used for extrusion, surface treatment and fabrication of aluminium profiles. The branch of Institute of Materials and Machine Mechanics of Slovak Academy of Sciences - INOVAL - the innovation centre for aluminium processing (www.inoval.sav.sk), which cooperates very intensively with SAPA profily Inc.,has been established recently in order support knowledge transfer acquired by R&D activities of IMMM SAS in the field of aluminium and its alloys to industry in the region of ŽiarnadHronom.

- **SPINEA s.r.o., Prešov**

SPINEA Ltd. is a modern private engineering company, active in research, development, manufacture and sale of high precision reducers TwinSpin with constant ratio. Activities of SPINEA Ltd. are aimed to development and production of:

- TwinSpin® - high precision gearbox with a radial thrust bearings integrated into a compact unit (Technical solutions TwinSpin is protected by several worldwide patents),
- RotoSpin- positioning a table based on a bearing reducer TwinSpin®, which can be supplied without actuator with the required dimensions and connecting with the actuator according to customer requirements,
- DriveSpin- TwinSpin® connection with the actuator into a compact unit.

- **Viena International s.r.o., Martin**

Viena International Ltd., a member of the REJLEK Metal & Plastics Groupspecializes in the design, development and manufacture of stamping tools, metal parts stamping and hardware and metal parts assembly. Viena International Ltd. produces precision machined parts and components in small and mid-sized quantities, small welded structures and fixtures. The target industries are the automotive, electronics and appliance manufacturing industries for household, furniture and industrial automation in the EU marketplace.

- **VUJE a.s. - The Nuclear Power Plant Research Institute Inc., Trnava**

VUJE Inc. is an engineering company that performs design, supply, implementation, research and training activities, particularly in the field of nuclear and conventional power generation. VUJE Inc. was established in 1977 as a state research institute; in 1994, it was transformed into a joint stock company whose shares are owned by company employees and former employees. The change from the state-owned company into a 100 % private company meant also a change in company operations, i.e. a change from an originally research organization into an engineering company that presently implements large projects, mainly in the field of nuclear power generation.

The company performs all activities related to the design, construction, operation, reconstruction and decommissioning of the following energy installations and systems:

- nuclear power plants, hydro-electric power plants, fossil-fuel power plants and heating plants with coal, gas and oil used as fuel, power plants and heating plants for waste wood combustion, wind power plants,
- high-voltage transmission lines 100-400 kV,
- high-voltage distribution plants,
- development and supply of simulators used for training the operating personnel of power plants, distribution plants, ships, chemical plants,
- information systems designed for the control of energy systems,
- automated control of water supply systems, etc.

- **VUSAPL a.s., Nitra**

VUSAPL Inc. builds on its tradition and participates in R&D in the area of modifications of polymer materials, their processing technologies as well as the use of qualitative application of new polymer materials. It has made a number of economic and scientific realizations, which were awarded at home and on foreign forums.

VUSAPL consists of four divisions:

- injection moulding division – during its scope gained valuable experience is currently a highly reliable supplier of precision and technological demanding products,
- division of films and composites– focuses on the production of special types of technical films of blowing technology in the form of tubular and flat films (this division produces the high-filled materials based of polyolefins and construction plastics material in a high quality, in the all colour RAL),
- tool shop division– uses the highly progressive methods for model simulation and design of injection moulded plastic products, thus providing maximum customer service and reducing the time necessary to deliver the instrument,
- division of certification and testing laboratories– certified quality management systems in accordance with the standard STN EN ISO 9001: 2009 (Q-008) and environmental management systems according to EN ISO 14001:2005 (R-002), for products certification is granted accreditation by Slovak National Accreditation Service according to STN EN 45011, VUSAPL Inc. holds credentials MDPA SR for testing and verification into vehicles in accordance with the Act. 725/2004 Z.z.

- **Welding Research Institute – Industrial Institute of the Slovak Republic, Bratislava (WRI)**

WRI is internationally recognized R&D and production workplace in the field of welding and allied technologies. It is a complex workplace focused on research and testing of materials and their welded joints, development of joining technologies, evaluation of reliability of welded structures, education, certification, production of welding consumables, equipment, weldments and welded structures.

WRI handle problems of welding, surfacing, brazing/soldering, spraying technology, thermal cutting and heat treatment of materials for industry, building industry, power engineering, transportation, agriculture, etc. In selected fields it carries out accredited tests, it organizes education of welding and Non Destructive Testing (NDT) personnel in compliance with EWF/IAB directives, it certifies welding and NDT personnel, management systems, quality systems in welding and products.

WRI is the member of the International Institute of Welding – IIW, the European Federation for Welding, Joining and Cutting – EWF, Slovak Welding Society. It co-operates with welding companies in the Czech Republic, Germany, Belgium, Japan, and USA as well as with standardisation technical Slovak institutions (Office for Standardisation, Metrology and Testing of the Slovak Republic and Slovak Institute of Technical Standardisation).

The case studies of engineering materials and advanced technologies successfully developed in Slovakia applied in industry

One of the most active Slovak institutes which long time successfully apply newly developed engineering materials and advanced technologies in industrial practice is IMMM SAS in Bratislava. The development of innovative products by scientists of IMMM SAS is systematically focused preferably on those with great potential to achieve particularly high added value thanks to effectively utilized know-how. Several successful case studies of modern engineering materials and advanced technologies for production of innovative

products developed in this institute with the aim to improve competitiveness of cooperating industrial partners on world-wide markets has been outlined in this contribution.

• **Aluminium foam crash absorber for railway carriages**

Aluminium foam is a part of crash absorbing box used for enhancement of passive safety in railway carriages (Fig. 1). The crash box is placed behind conventional spring-based damping element and chassis of carriage, whereas there are 4 such boxes for one carriage, two for each front side. The main objective to use aluminium foam part is to reduce high crash forces in case the absorbing capability of conventional damping elements is exhausted. In such excessive crash between adjacent carriages aluminium foam crushes as the last part of all energy absorbing components in the assembly. It is expected from the crash box to protect chassis of 22 ton heavy carriage in a case of frontal crash at the velocity of 8 km/h. The kinetic energy must be dissipated within about 30 mm deformation length.

Figure 1. Crash box of railway carriage containing Al foam (left) and Al foam component (right).

These expectations set quite challenging requirements for aluminium foam part, i.e. very high yield stress in compression (above 17 MPa) at rather higher porosity (above 75 %). To meet these requirements special 3D shape aluminium foam component was designed comprising natural "foam skin" and cell walls made from heat treatable aluminium alloy and preferred orientation of pores in the compression direction. Compared to conventional deformation elements as i.e. hollow profiles or honeycomb structures, it was possible to reduce the deformation length needed for required energy absorption by almost 50 %.

The supplier of assembled crash absorber is the German company Gleich GmbH, Kaltenkirchen. Aluminium foam components with the weight 1250 g are manufactured and supplied under subcontract by IMMM SAS in series 500 pieces per year. There are two world-wide leading manufacturers of railway carriages as end users of this innovative crash absorber.

• **Aluminium foam automotive component produced in high volume series**

Crash absorbers in automotive sector protect passengers from the effect of sudden impact. This is achieved by converting the impact energy into plastic deformation of absorber, keeping the peak force acting on the protected object below the level which could cause damage. The material of impact energy absorber must also provide a long deformation path to sufficiently reduce rest of the kinetic energy affecting the protected object.

IMMM SAS has developed in cooperation with Austrian company Alulight International GmbH, Ranshofen the crash energy absorber (Fig. 2), which is produced fully automated in high volume series (200.000 pieces per year) since August 2005 and mounted into the cars Audi Q7. This crash energy absorbing component is part of the upper segment safety net build in to separate the trunk from the passenger area. In case of sudden rear impact the net has to protect the passengers against serious injuries caused by catapulted

Figure 2. Aluminium foam crash energy absorber mounted into the dividing net of Audi Q7.

luggage items. One part of the impact energy gets absorbed by the net itself, the other part has to be transformed in the anchorages of the net to avoid them from breaking. Large energy is absorbed by the net in the case that a plateau stress stays constant for a long deformation path. This characteristic gets fully achieved by above-mentioned aluminium foam crash energy absorber. The tube-shaped absorber made of aluminium foam mounted in the upper profile channel of the net gets strained by pressure via a pin during impact and the kinetic energy of approximately 100 kJ is transformed by deformation of absorber.

- **Cooling and heating panels using aluminium foams**

Cooling/heating wall and ceiling panels developed recently by IMMM SAS which utilize aluminium foam as heat spreader has also the great potential for industrial applications (Fig. 3). The Institute has developed and owns European patent for invention of their production (granted in 2007) [10]. The basis of innovative approach to the new design of cooling/heating panels is aluminium foam panel with integrated copper or stainless steel tubes for distribution of cooling/heating medium. Aluminium foam in wall and ceiling panels in the combination with thin surface layer of plaster is the unique technical solution utilized firstly in industrial praxis. Uniformity of the temperature distribution in the panel, enhancement of its radiating emissivity and considerable reduction of reaction time after the temperature changes are the main advantages that can not be achieved by any other technical solution as yet.

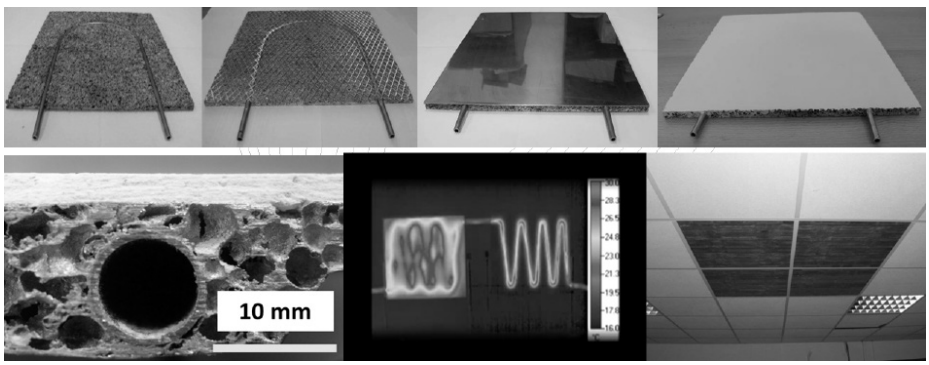


Figure 3. Cooling/heating wall and ceiling panels utilizing aluminium foam as very effective heat spreader. The lower figure show the comparison of the temperature distribution in innovative cooling panel made of aluminium foam (left) and standard plasterboard panel with integrated tube for distributing cooling medium (right).

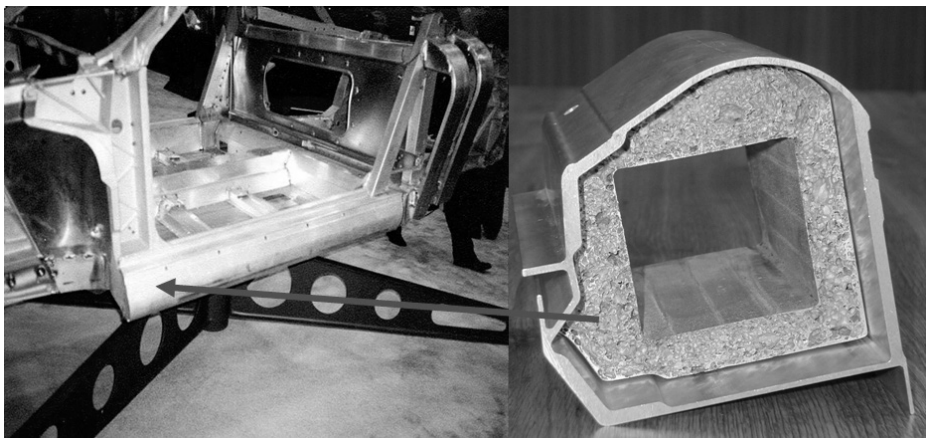


Figure 4. Aluminium foam stiffener of a hollow aluminium car frame of cabriolet Ferrari.

This kind of innovative cooling possesses very low operating costs. Energy consumption is very low as well as it is almost maintenance-free and the natural water sources can also be utilized as source of cooling medium. Using these systems the air inlet volume can be reduced to a minimum, just up to a necessary fresh air volume and for sufficient thermal comfort (because of radiant heat exchange) is already 26°C enough. Beside the all benefits, a drawback of cooled ceilings is only their limited cooling power, because they operate with low temperature difference.

This difference can not be wider because of danger of dewing (dew point is about 14 °C; the cooling water circulating in panels must be above the dew point). On this account, rooms with cooled ceilings may be equipped with additional fan air-conditioning in order to ensure cooling ability also during the temporary extreme conditions.

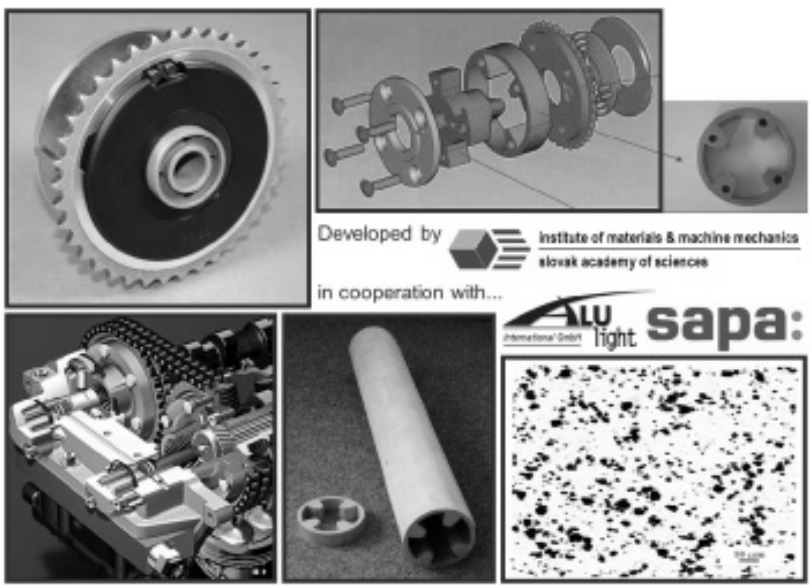


Figure 5. Aluminium alloy component of Cam Phasing Adjustment System developed by IMMM produced by SAPA profily Inc.ŽiarnadHronom for BMW engine.

There are many further examples of successful cooperation of IMMM SAS with industrial companies. Very profitable industrial innovations are e.g. aluminium foam stiffener of a hollow aluminium profile mounted in the frame of cabriolets Ferrari produced in the series of 6.000 pieces per year (Fig. 4), stator ring for adjusting the position of camshaft in automobile engines produced for BMW by company SAPA profily a.s .ŽiarnadHronom using novel powder-metallurgically prepared aluminium alloy (Fig. 5), sliding electrical contacts for trolleybuses and railway locomotives made of graphite infiltrated with copper developed in cooperation with Slovak company Elektrokarbon Inc. Topoľčany, ceramic/lead composite plates prepared by the melt infiltration process for the new type of bipolar batteries based on lead-infiltrated-ceramic plates developed for Swedish company EFF – Power, HisingsBacka, etc.

Acknowledgement

The article was elaborated within the project "Establishment of a cross-border platform for technology transfer focused on the application of advanced engineering materials in the region of Vienna – Bratislava" co-financed by the European Regional Development Fund under the program of Slovak-Austrian cross-border cooperation 2007-2013.

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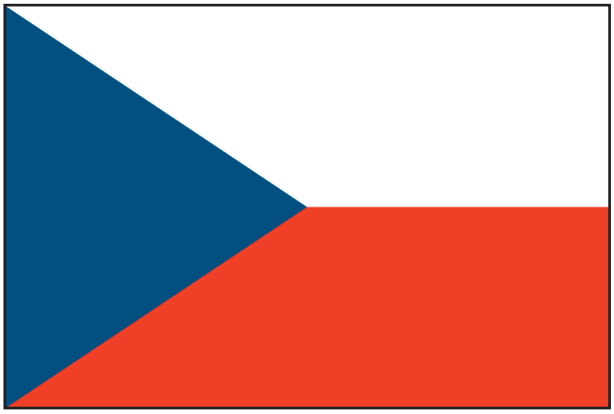
CZECH REPUBLIC



Technologies and developments are presented by the Association of Innovative Entrepreneurship of the Czech Republic

Material Science

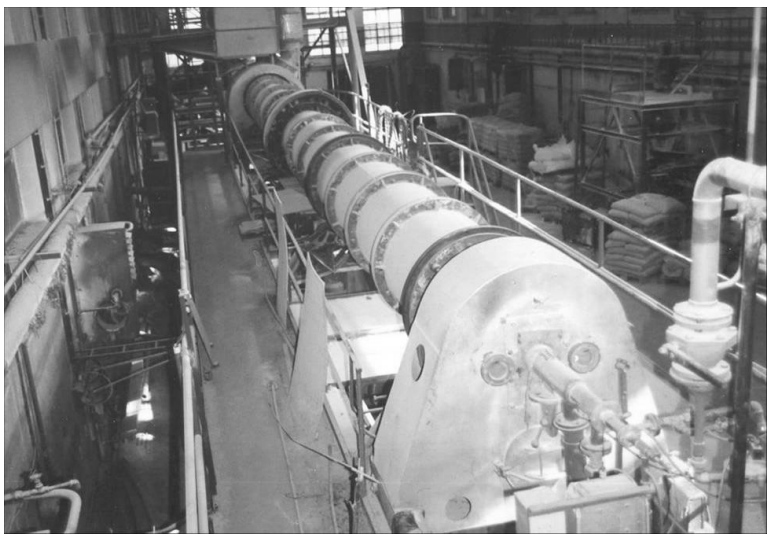
CZH-01

Quicklime for special purpose – soft burned

Description

The "Quicklime for special purpose – soft burned" was manufactured from specially selected high-calcium carbonate limestone in optimized conditions of burning.

Quicklime is very pure and very reactive, with high viscosity of lime putty and high volume of sedimentation. Product is used for preparation of special hydrosilicates, especially for xonotlite and tobermorite based high porous materials that are used as filling of steel pressure cylinders for acetylene storage and transport.



Picture 1. The pilot rotary kiln for product

Technical parameters

- The reactivity determined according to EN 459-2: over 75°C after 1 min.
- Free CaO content (saccharate method): over 95% weight.
- Dynamic viscosity of lime putty (by special method, 11% of solids in the suspension): over 3000 mPaxs
- Sedimentation volume per 20 hours (by special method, 8% of solids in the suspension): min. 30 vol.%

Fig 2. Quicklime for special purpose – soft

Development stage

Product "Quicklime for special purpose – soft burned" was certified in the June 22nd, 2010 by Technical and Test Institute for Construction Prague, branch 0600 Brno, certificate No. 060-032228, valid until June 30th, 2013.

Small batches production.

Cooperation proposals

Documentation supplying.

Supplying of small batches of product.

Contact information

Research Institute of Building Materials, JSC.
Hnevkovskeho 30/65, 617 00 Brno, Czech Republic
Phone: +0420 543 529 200, fax: +0420 543 216 029
vustah@vustah.cz, www.vustah.cz

Material Science

CZH-02

Total temporomandibular joint replacement MEDIN

Purpose

Treatment and replacement of the body parts.

Description

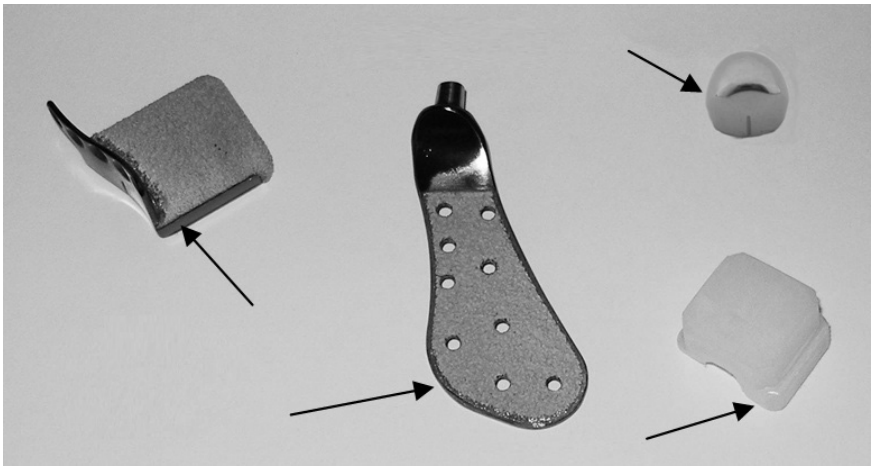
The Temporomandibular joint is one of the most complex joints in the human body. Furthermore as a natural part of eating, talking etc. this anatomical unit is subjected to high stresses and wear. It is the one and

only joint in the body which is located on the same bone twice. For this reason any defect in one joint affects the function of the second one.

Reasons causing damage to the temporomandibular joint:

1) microtraumas and macrotrumas
2) infection
3) degenerative joint diseases
4) tumors

The main objective of the temporomandibular joint reconstruction is to restore the correct function of the joint and positively affect quality of patient's life (improvement of speech, food intake and oral hygiene).



Modularity of the implant makes easier to fulfill the demands of surgeons and enables to respect the anatomical individuality of treated patients. Temporal and mandibular components are made of titanium alloy, the surface is covered with DLC layer and anchoring parts are coated with porous titanium and hydroxyapatite. Both components are produced in three sizes. The condyle replacement is made of CoCrMo alloy and it is produced in five sizes. The insert is made of ultra high molecular weight polyethylene (UHMWPE). All components are designed to reach the highest similarity compared to the anatomical structure of lower jaw and base of the skull.

Experience gained with the development of the total temporomandibular joint replacement can be used in difficult cases of maxillofacial surgery, where the individual solution for each patient is essential.

MEDIN Orthopedics, a.s. is probably one of the very few producers in Central and Eastern Europe which can offer the complete creation of individual implants (from the digitization of CT data through three-dimensional computer modeling up to the technical design of the specific implant and its manufacturing).

Development stage

Compete creation of individual implants.

Cooperation proposal

Supplying of implants by order.
Documentation supplying.

Contact information

MEDIN Orthopaedics, a.s.
Ringhofferova 115/1, 155 21 Prague 5
Tel.: +420 234 252 346, Fax: +420 234 252 347
ortho@medin.cz, www.medin.cz

Material Science

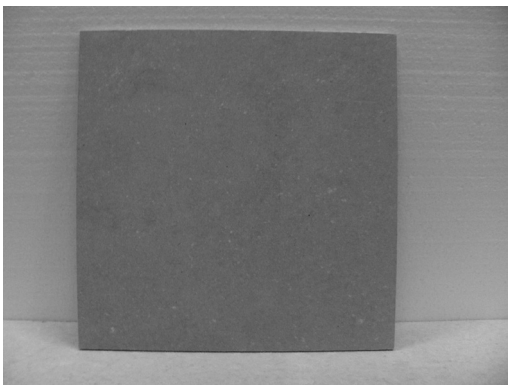
CZH-03

The lightweight interior board Cemvin Light

Purpose

Restoration and construction works.

Description



The innovative solution consists in the lightweight interior board based on cement and fibre.

Cemvin Light is the lightweight fibre-cement interior board with the density below 1000 kg/m3; it has a good effect on environment compared to competitive products; using less than 50 % of original amount of cement and being lightened with waste material.

The technical solution concerns the design of the structure of interior board which is environmentally and economically convenient, contains decreased amount of cement compared to similar products and exhibits good physical – mechanical parameters at the same time.

The major criterion for a new product was the decrease of environmental burden by decreasing the cement dosage to 50 % of its original amount in the batch. Thus the product is environmentally friendly compared to similar competitive products. Moreover, the lightening of the product is realized by waste-products from expanded perlite production, which additionally increases the environmental value of the product.

Long - term testing of various compositions revealed that the adequate product of the original quality can be attained by decreasing the cement dosage down to 40%.

An important fact is that the novel interior board exhibits good mechanical parameters even though the amount of fibre reinforcement is not increased and hence the final product does not become more expensive.

Technical parameters

Flexural strength - dry: 13 MPa
Flexural strength - wet: 7 MPa
Bulk density: <1000 kg/m^3
Thermal conductivity: 0,20 W/mK
Reaction to fire tests (CSN EN 13501-1): A1
The Utility model no. 20750 Lightwave interior Board was issued for the novel unique solution.

Development stage

This new product was developed within the cooperation of the Research Institute of Building Materials, JSC. and Czech Wood Company Prague, JSC., plant Cernousy during the project no. FI-IM4/068 supported by Ministry of Industry and Trade of the Czech Republic.

Small amount production.

Cooperation proposal

Documentation supplying.
Supplying of small batches of product.

Contact information
Research Institute of Building Materials, JSC
Address: Hnevkovskeho 30/65, 617 00 Brno, Czech Republic, IC 26232511
Phone: +0420 543 529 200
Fax: +0420 543 216 029
vustah@vustah.cz, www.vustah.cz
Contact person: Ing. Michal Frank, Assistant head of section of Composite materials
E-mail: frank@vustah.cz

Material Science

CZH-04

Total wrist replacement MEDIN

Purpose

The modern joint replacement device with the high degree of modularity.

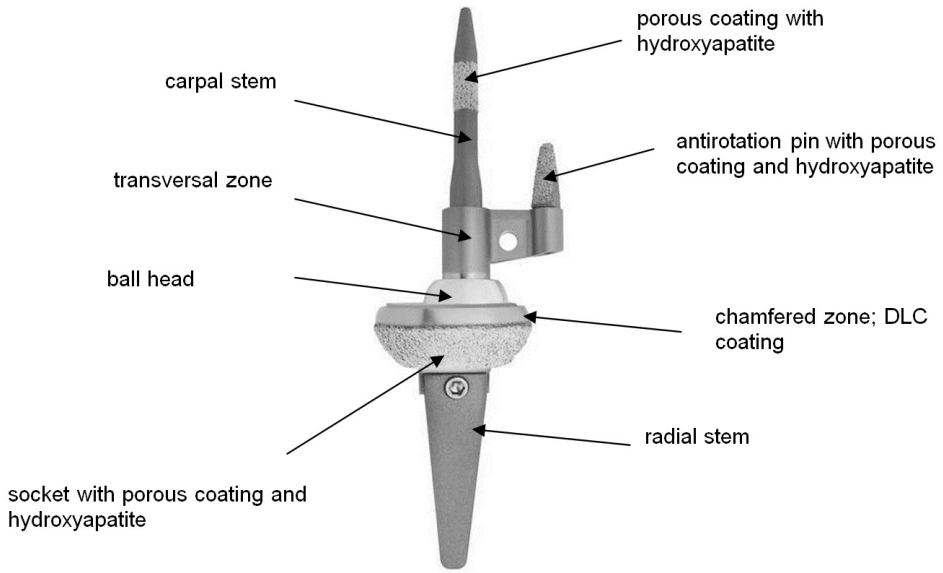
Description

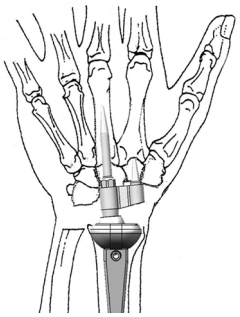
The main parts of the prosthesis are radial component, ball head and the carpal component.

Indication

- Rheumatoid destruction
- Osteoarthritis
- Psoriatic destruction
- Posttraumatic deformities

All metal parts except the head are made of the titanium alloy. Ball head is manufactured from the CoCrMo. Components are carefully designed to reach the high functional similarity compared to the anatomical structure of the wrist.





In order to meet the demands of the varying anatomy of patients each of the component is provided in several sizes. The implant is fixed in bone with the special osteointegrative elements – layers with the porous coating and hydroxyl apatite on its surfaces.

These areas are located both on the radial (socket) and carpal (stem and anti rotation pin) components. The carpal component consists from the main fixation shaft (carpal stem) which is inserted in the third metacarpus and from the short, anti rotation pin intended to be fixed in the second metacarpal base.

A Co-alloy head is assembled on the tapered stem extended from the trans verzal zone of the carpal component. The radial component is fixed in the distal radius. The socket for the Ultra High Molecular Weight Polyethylene (UHMWPE) liner is chamfered and coated with the Diamond Like Corbon (DLC) for better tribologic characteristics considering the soft tissue movements in this area.

The prosthesis was designed with the leading czech surgeons, using the state of the art methods. The first results with the use of this prostheses show that this total wrist replacement is in the correct indications fully capable to preserve or restore the wrist range of motion and to improve the grip strength. On the figures it also can be seen the positioning of the implant in the hand anatomy and the example of radiograph.

Development stage

The prosthesis method is developed.

Cooperation proposal

Documentation is supplying.

Supplying of small amounts of prosthesis.

Contact information

MEDIN Orthopaedics, a.s.
Ringhofferova 115/1
155 21 Praha 5, Czech Republic
Phone: 234 252 346, fax: 234 252 347
ortho@medin.cz, www.medin.cz, www.endoimplant.cz

New Materials

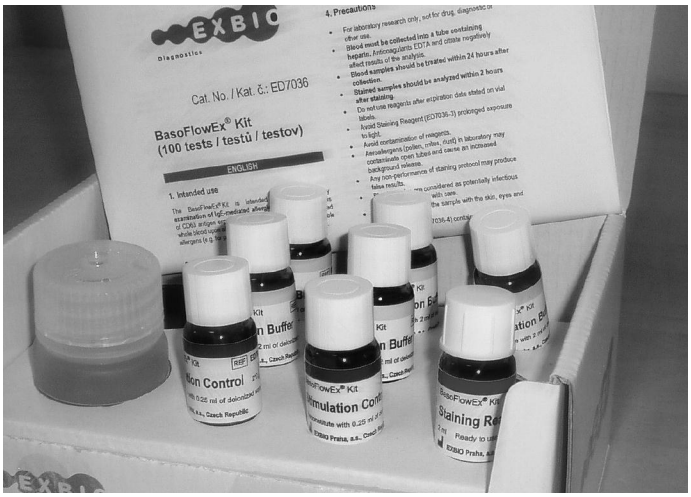
CZH-05

Cutting edge in diagnostics of allergy

Description

BasoFlowEx® kit – an innovation for determination of the causal allergen.

A rapid increase in cases of allergic hypersensitivity in developed countries has been observed over the last decades, which indicates that this condition is about to become a serious social issues.



The physiological regulation of allergic mechanisms depends on maintaining a delicate balance between the processes responsible for optimal modulation of immune strategies in an organism. This balance can be impaired by many factors, affecting various levels of immune regulation. To be able to diagnose what the exact cause of a particular patient's condition is, and what the optimal therapy would be, is still only achievable in rare instances.

When diagnosing allergies, the crucial task is determining the causal allergen(s). The commonly used method of skin prick tests (SPT) is not optimal due to its low reliability and the risk of further aggravating the condition. More suitable are in vitro approaches, such as the determination of specific IgE in the serum (sIgE) or the analysis of basophil activation markers. In most cases, the specificity of sIgE detection is high enough, but the sensitivity is usually only about 75%, and in cases of some allergens (mainly food and drug) both sensitivity and specificity of sIgE detection are substantially lower.

The BasoFlowEx® Kit enables the determination of the causal allergen by the analysis of basophil activation using the flow cytometry method. This test is highly sensitive and specific. The principle of the test is in vitro induction of basophil activation in the presence of a sensitizing allergen, followed by the measurement of the basophil activation marker (CD63) on the cell surface, where it is detected by a monoclonal antibody. The basophils are identified by a CD203c-specific antibody. As a positive control a sample is used, in which the basophils are activated by anti-IgE monoclonal antibody, which mimicks the stimulation effect of the specific antigen, and by a chemotactic peptide N-formyl-Met-Leu-Phe (fMLP), which activates the basophils in a non-specific way. Compared to other similar tests, the BasoFlowEx® Kit contains optimum markers and enables easier application. The innovation enables affordable price for the target customer.

Advantages:

- Hope for allergic patients – a reliable, simple and affordable in vitro test
- High sensitivity and specificity
- No risk of sensitization of the patient
- Precise results
- Optimum components and method
- Most advanced activation test in the market

The kit is sufficient for performing 100 tests. Its use is simple and suitable for every laboratory with basic equipment and with a flow cytometry device, which uses blue laser excitation (488 nm) and detection channels for FITC (FL1) and PE (FL2).

Development stage

Sample preparation and measurement is described in detail in the product datasheet, which is accessible also from the web pages www.exbio.cz, or can be requested by e-mail: orders@exbio.cz.

Cooperation proposals

Supplying of small batches of kits.

Joint cooperation.

Contact information
EXBIO Praha, a.s.
Nad Safinou II 341
252 42 Vestec, Czech Republic
www.exbio.cz, orders@exbio.cz, technical@exbio.cz
Tel.: +420 261 090 666
Fax: +420 261 090 660

Coatings

CZH-06

Abradable thermally sprayed coatings in energy industry

M. Kašparová, F. Zahálka, Š. Houdková

Abradable coatings can mean an effective solution of fundamental issues in mechanical engineering, such as excessive wear of machine parts in case of moving parts´ fixing against stationary units. This issue occurs especially in gas and steam turbines and rotating compressors, which are used in aircraft and energy industry. These systems are equipped with array sealing. Improving the dynamic sealing between rotating and stationary turbine parts can significantly increase the parameters of energy-power machines. The abradable coating is one type of the sealing. This coating serves for decreasing the clearances between blade tips and stators and between individual levels of a compressor and a turbine.

Abradable materials are deposited on the stationary part of the system and stand against the rotary part (blade, labyrinth, etc.) to minimize the clearance and simultaneously to prevent the rotating components from damage.

Most producers of energy machines concentrate on abradable materials, which are produced by thermal spray technology due to several reasons:

- high abradability with minimum wear of counterpart at specific operating temperatures,
- high erosive resistance, good bond strength at temperature fluctuation – crack resistance,
- low affinity to the counterpart – no weld joint occurs, during abrading only fine elements, which have minimum mechanical or chemical influence on the components, are created,
- high corrosive resistance, reproductive application with high lifetime,
- repeating process.
- Increasing in the turbine efficiency and performance can reach tenths.

For the steam turbines the MCrAlY/bentonite thermally sprayed material plays a significant role and is successfully used at present. For this coating a higher degree of porosity is

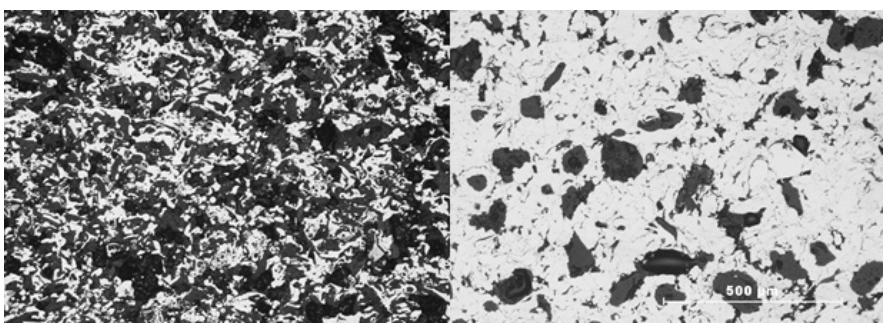


Fig.1. Typical microstructure of abradable thermally sprayed coatings

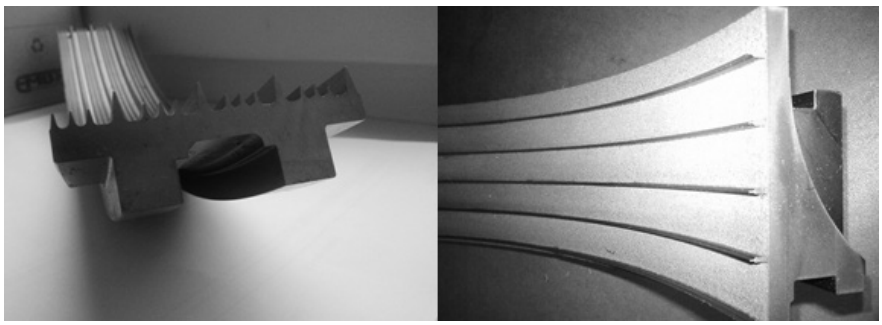


Fig.2. a) cross section of the labyrinth ring, b) machined abradable coating between the blades

intentionally created. High porosity enables easier wear of coating in case of the parts contact. The abradable coating microstructure is documented in Fig.1.

For reduction of narrowness it is possible to use the following basic possibilities: the maximum number of labyrinth blades, the minimum fixing area and fine geometry of the labyrinth. For thermally sprayed coating the fine geometry of labyrinth is very restricting. The surface roughing by grit blasting precedes the thermal spraying process. "Grit blasting" can damage the fine geometry of labyrinth seals.

The basis of this innovation was to cope with the application of a thermally sprayed abradable coating between the tips of the labyrinth ring. The tips are placed on the inner diameter, one type of fine geometry in the ring cross section is documented in Fig.2a.

In the first step it was necessary to find the optimized deposition parameters for spraying the MCrAlY materials (powders) to achieve the required coating porosity and surface hardness. The second step consisted in shielding the labyrinth parts that didn´t need to be grit-blasted and coated. The shielding must comply with the following requirements: resistance against mechanical damage – erosion during grit blasting, thermal shock resistance – high temperature of flame, technological feasibility and economic acceptability.

Excellent results were achieved during a long-term research and development, experimental tests and evaluating. The MCrAlY thermal sprayed coating between the blades with specified fine geometry is documented in Fig.2b. Prototypes of these labyrinth rings are already tested in operational conditions by Ansaldo Energia Company, Italy.

Literature:

[1] Zahálka, F. & al., Vývoj aplikace obrusitelných povlaků na labyrintových kroužcích s břity, Research report VYZ 1333/10, VZU Plzeň, 2010.

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