ロシア／CIS における材料分野の主研究機関紹介

本資料は、1994 年からの過去 10 年間に ISTC が仲介した研究プロジェクトにおける受託研究費で第１位～第３位までの材料分野の研究所を、ISTC の材料分野の技術分類毎にリストアップしたものです。また、研究所毎にその技術分類での代表的な研究概要も記載しております。

１－１　材料分野／セラミック（**Ceramics**）の研究機関　受託研究費　第１位

機関名	Scientific Industrial Enterprise of Material Science (SIEM)
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保有技術	Materials / Ceramics Materials / Composites Materials / Materials Synthesis and Processing 材料分野以外の保有技術 Manufacturing Technology Chemistry

本研究機関の材料分野／セラミック（Ceramics）における代表的プロジェクト	
プロジェクト名	Rafaelites - Basis for Developing of New Multi-Purpose Glass Ceramics
概要	多目的ガラスセラミクスの開発。 １）電気的な絶縁物としての応用を考慮し、ガラスセラミクス素材の組成により電気的特性（誘電率、誘電損失）の制御を実現 ２）様々な温度特性を持つガラスセラミクスの開発
応用例	電気／電子機器の絶縁物等
プロジェクト概要	In the present project it is intended to study glass forming ability of crystalline alkaline-earth borates and alkaline-earth titanium borates, glass-formation in pseudo-binary and pseudo-ternary systems on their and alkaline-earth aluminum borate basis and developing new multi-purpose glass ceramics on their basis. The glass ceramics in an electron technology were used basically as isolators for many years, and the main efforts of the scientists and specialists were focused on optimization of their properties such as TEC, resistance, dielectric constant and dielectric losses and improvement of a complex of operating characteristics. This problem is still actual now. However, the basic directions of development of dielectrics are connected with study of phenomena conducted in non centrosymmetric or acentric solids (predominantly in piezoelectric and polar dielectrics), capable to convert different kinds of energy and to serve information carriers. It is caused by a lot of circumstances: – by huge requirements of an electron technology for various dielectrics with non centrosymmetric structure (ferro-, pyro-, piezo-electrics and other); – by restricted capabilities of synthesis of single crystals and their seller's price; – by technological difficulties of obtaining of homogeneous, single-phase and high density ceramics on the basis of polar phases; – by low cost and manufacturability of glass shapes and products of their crystallization; Quantity of non centrosymmetric crystalline phases is very great, however the very restricted information is known about their majority till now. It is also correct for glass crystalline materials and the moreover for glass crystalline materials with oriented structure. The oriented glass crystallization with formation of anisotropic glass crystalline structure

	has the greatest scientific and practical interest, the investigations of well known scientists (Prof. Ruessel-Fresnoite basis and bio-glass ceramics, Prof. Sarkisov-Stilvellits basis glass ceramics and others) testify it. The glasses of stoichiometric compositions $RO \cdot Al_2O_3 \cdot B_2O_3$ on the basis of barium, strontium and calcium crystalline aluminum borates having common chemical formula $RAl_2B_2O_7$ were synthesized for the first time within the framework of the ISTC Project A-288, and the new kind of glass ceramics "Rafaelites" was discovered by us. The developed practical compositions of glass ceramics on the Rafaelites basis (pressed powder glass samples) combined in themselves a complex of valuable physicochemical properties: low TEC (0-40)$\cdot 10^{-7}$ K^{-1}, low dielectric constant (4-6) and dielectric losses (7-11)$\cdot 10^{-4}$ (at frequency 10^6 Hz at room temperature). In parallel, the crystalline strontium and calcium titanium borates, which together with known barium titanium borate have common chemical formula RTi $(BO_3)_2$, were synthesized by us for the first time. The glasses of stoichiometric compositions $RO \cdot TiO_2 \cdot B_2O_3$ were melted by us for the first time and the principled capability of obtaining glass crystalline materials on their basis is shown. The alkaline-earth titanium borates presumably have structure identical alkaline-earth aluminum borates and glass ceramics on their basis is possible attribute to "Rafaelites" family also. It can be a major case for revealing coordination environment of aluminum and titanium atoms in glasses of stoichiometric compositions at the presence of three coordinated boron atoms in structure of glasses. Bayer at temperature range 400-500 °C detected by high temperatures X-rays analysis the thermal expansion anisotropy of crystalline barium titanium borate. At the given temperature range the TEC anisotropy of Rafaelites detected dilatometricaly and which is stronger expressed for barium aluminum borate. The crystalline barium meta borate, which is the obviously expressed polar phase and has unique properties, also has a dilatometric anisotropy of thermal expansion at an interval 500-600 °C, and its TEC, for the first time determined by us, changes from −95 up to −115 units (at an interval 20-300 °C). Barium, strontium and calcium meta borates also have low values dielectric characteristics ε=4-5, tgδ=(14-16)$\cdot 10^{-4}$ by our measurements on thermal treated pressed glass powder samples. We are sure, that there is a high probability that the above indicated crystalline compounds and oriented glass ceramics on their basis will have electrically active properties. The process of a directional crystallization is sensing both to quality (homogeneity) of initial glass of stoichiometric or close to it compositions, and to external thermal mechanical and electrophysical influences. The thorough investigation and choice of optimal technological processes of glass melting and glass shapes, and also processes of their oriented crystallization is intended. The essential influencing on efficiency electrical physical properties of the textured glass ceramic sample will have residual glass phase, which shouldn't greatly differ from polar phase compositions, both selection and the formation of which is the relevant stage of the present researches. Usage of developed glasses and glass ceramic materials as more effective fusible glassy bond in widespread today composite materials on the basis of powders of polar crystals and glasses is also intended. Depending on a kind of polar crystals the glasses with wide range of change of electrophysical and rheological characteristics can be developed. Low and ultra low values of a dielectric constant and dielectric losses at one group of the developed by us glass ceramics, in a combination to ultrahigh values of dielectric constant and low losses at other group of also developed by us glass ceramics will allow to use them by manufacture of new kinds of technical ceramics with the increased characteristics, for example LTCC (Low Temperature Co-firing Ceramics).

	The relevant direction of the present researches is the study and development the transparent glass ceramics on the Rafaelites basis. Their interesting properties in the crystalline state and also their resistance to vapors of alkaline metals up to 600 °C in glass state reached within the framework of the ISTC Project A-288, assures us of capabilities of developing of transparent glass ceramic of two kinds: – with zero TEC and low melting temperature up to 1500 °C; – with resistance to vapor of alkaline metals at temperature range 800-1000 °C. During activities under the project will be investigated and selected the optimal techno-logic compositions of glasses permitting to investigate and to develop glass ceramics materials with given properties. For achievement of the purposes of the project the structural-sensing researches for the control over processes of formation both crystalline phase, and residual glass phase will be carried out. We are having a unique case of investigating dynamics and kinetics of processes of transition from crystalline state in glass state and on the contrary on the basis of alkaline-earth aluminum and titanium borates compounds. The investigated crystalline compounds are in fields of multistage phase separation accompanying for some compositions incongruent melting within decompose on melt and crystalline phase, which can itself decompose during dissolution in glass melts at higher temperatures on a crystalline phase of other compositions and melt. For others this is decomposing of a melt on two liquids at temperatures higher than melting points and then allocation of a crystalline phase from one of glass melt. The investigation of the given processes at the presence of boron and alkaline-earth metal atoms will help to reveal influence of aluminum and titanium atoms on processes of stable and meta stable phase separation in glasses of stoichiometric compositions. Having understood the given processes we can regulate residual glass phase compositions in developed glass crystalline materials. It is the major stage of the present researches. The investigation of the phase separation processes will allow to construct and to regulate compositions of residual glass phases in developed glass crystalline materials and is a major stage of the present researches. The aim of the project is as follows: – Study of glass-forming ability of crystalline alkaline-earths borates and titanium borates, glassforming ability in pseudobinary systems on the basis of alkaline-earths borates and titanium borates, alkaline-earths aluminum borates and titanium borates, in pseudoternary systems on the basis of alkaline-earths borates, alkaline-earths aluminum borates and titanium borates, DTA and physicochemical properties of glasses. – Study of crystallization regimes of glasses of stoichiometric compositions and glasses of pseudo-binary and pseudoternary systems on their basis, identification of products of their crystallization and the resistive, dielectric and dilatometric characteristics of the crystallized glasses. – Study of liquation processes in glasses of stoichiometric compositions, their influence on processes of formation of crystalline structure, of residual glass phase and physical chemical properties of both glasses, and products of their crystallization. – Study of structure of glasses of stoichiometric compositions and a coordination environment of aluminum, titanium and boron atoms in them. – Study of dynamics and kinetics of processes of transition of stoichiometric compositions from glassy in crystalline state and on the contrary. – Study of influence of methods and regimes of a directional crystallization of glasses on formation of the textured structure and electrically active properties of the crystallized glasses, realization of frequency spectroscopy of obtained samples. – Study of influence of methods and regimes of polarization crystallized glasses on their electrically active properties.

	The following problems will be solved, as a result of the project: – New glass ceramics compositions with a wide range change of reologic and dielectric properties, including compositions with low and ultra low dielectric constant (3-5) and dielectric losses ($5\text{-}10\cdot10^{-5}$) on the one hand and a ultrahigh dielectric constant (30-800) at dielectric losses no more than $20\cdot10^{-3}$ with another will be developed. – New high-tech compositions of electrically active glass crystalline materials, technology of their directional crystallization and polarization have been developed. – New constructional transparent glass ceramics with zero TEC and low melting temperature up to 1,500 °C have been developed. – New constructional transparent glass ceramics resistant to vapors of alkaline metals at temperature range 800-1,000 °C have been developed. – Reorientation of highly-skilled scientific staff to the solution of peaceful problems. – Integration of scientists into international community of scientists. The SPEMS association of scientists has been dealing with the development and production of glass ceramics with low TEC and glasses resistant to vapors of alkaline metals which have been used as constructional materials for making new kinds of weapons and in nuclear power for a long time. The scientific and technological potential of the SPEMS scientists and their practical experience will allow to solution goals of the project at a high level. The authors of the project offer cooperation with scientific associations, research organizations, as well as private experts from the USA, countries of EC, Japan, Norway and Korea. We suggest conduct of joint scientific researches and seminars.

１－２　材料分野／セラミック（**Ceramics**）の研究機関　受託研究費　第２位

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保有技術	Materials / Ceramics Materials / Materials Synthesis and Processing 材料分野以外の保有技術 Biotechnology and Life Sciences Environment Information and Communications Instrumentation Physics Space, Aircraft and Surface Transportation

本研究機関の材料分野／セラミック（Ceramics）における代表的プロジェクト	
プロジェクト名	Luminescent Optical Ceramics for X-rays Medical Techniques
概要	X 線医療装置に用いられる光学的セラミクスの研究。X 線の映像を、光映像に変換しフィルムを効率的に感光させるスクリーンとして使用される。従来の同様のセラミクスに比べて変換効率を向上させる。
応用例	主に医療用
プロジェクト概要	This work aims at development of monolithic polycrystalline X-ray-luminescent screens (XS), capable of effective X-to-visible image conversion. The material is planned to obtain by the recrystallization pressing process that enables to form polycrystals having density approaching the theoretical one (1.5-2 times higher than that of powders), and a specified degree of transparency. This gives the screen under development substantial advantages over powder luminescent screens that are used today in medical diagnostics devices: - enhanced X-radiation absorption capability; - enhanced registration effectiveness; - the possibility to decrease radiation exposure dose not less than 2 - fold; - higher resolution and contrast sensitivity; - higher mechanical strength and radiation resistance. The use of ceramic screens in the existing models of medical equipment would provide radiation-safe conditions of patients' examination and medical staff activities, upgrade the image quality, make X-ray diagnostics more reliable and economical. It is supposed that X-ray source power and diagnostics equipment energy consumption would be cut down at least by half. The above given set of ceramic screen properties should enable to develop novel, more perfect models of X-ray equipment for medicine and technical defectoscopy. It is suggested to conduct the development of X-ray luminescent ceramics on the basis of gadolinium oxysulfide. Crystalline array of gadolinium oxysulfide

	most closely fits the requirements as regards absorption and conversion efficiency within the energy range requested by computer tomography (CT), mammography, dental and general radiography, i.e. at energies starting from 15 keV and practically to 100 keV. To achieve high efficiency and light output of X-ray luminescence, the radiation spectrum and afterglow kinetics required from luminescent ceramics, rare earth dopants (like terbium, praseodymium, cerium, etc.) will be introduced into the oxysulfide array. The X-ray luminescent monolithic polycrystalline material to be created under this project would be used in scintillation detectors for CT and as X-ray screens of digital registration systems in mammography, dental diagnostics, fluorography. The need to produce novel X-ray screens is dictated by the necessity of furnishing various medical institutions, including X-ray examination rooms, dental clinics, cancer research centres, with safe and highly effective X-ray diagnostics equipment featuring lower dose of radition exposure for the patient. This is especially vital for regions with bad ecological situation, where X-ray examination covering the mass of population could become the source of rapid progress of cancer diseases. The manufacture of novel X-ray screens will take place at experimental production facilities of NITIOM VNC "S.I.Vavilov GOI". It is projected that among the Russian consumers of the X-ray luminescent optical ceramics will be the Vostok works (Novosibirsk), the Institute of Nuclear Physics SO RAN (Novosibirsk), RFJC-VNIITF (Snezhinsk), Rentgenovskaja Laboratoria (St.Petersburg), the Science and Technology Center of Medical Radiology (Moscow), the All-Russia Research and Testing Institute of Medical Equipment (Moscow), and others engaged in the development of new models of X-ray medical equipment.

１－３　材料分野／セラミック（**Ceramics**）の研究機関　受託研究費　第３位

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保有技術	Materials / Ceramics Materials / Composites Materials / High Performance Metals and Alloys Materials / Organic and Electronics Materials 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Fission Reactors Fusion Information and Communications Instrumentation Manufacturing Technology Non-Nuclear Energy Physics Space, Aircraft and Surface Transportation Other / Agriculture Other / Electrotechnology Other / Other Other Basic Sciences / Natural Resources and Earth Sciences

本研究機関の材料分野／セラミック（Ceramics）における代表的プロジェクト	
プロジェクト名	Physico-Chemical Bases of Aluminium Oxide Aerogel Synthesis and Development of Continuous Technology for its Production from a Ga-Al Liquid Metal System
概要	酸化アルミニウムエーロゲルの開発。本研究では、ガリウムアルミニウムからの生成方法が研究される。
応用例	エーロゲルは、多孔性材金属の一種 NASA では、エーロゲルを NASA が開発する宇宙船において、宇宙のチリを収集する部分に使用。
プロジェクト概要	The objective of *ibis* work is to develop continuous technology for obtaining aluminum oxide aerogels from gallium-aluminum melt. This technology will be created by developments within the project proposed creation of laboratory installation with continuous Al supply to gallium, and selective oxidation of aluminum until obtaining aerogels. Principal objectives are as follows. - develop a principal scheme of continuous process technology for aluminum oxide aerogels production from gallium - aluminum melts; - study physic-chemical regularities of the process of selective oxidation of aluminum from gallium - aluminum melt;

	- study the main properties of materials produced (microstructure, sorption, thermal and electrical insulating ones, etc.). *Technical approach and methodology* The main peculiar feature of the laboratory installation for continuous aerogel synthesis is the principle of liquid metal circulation loop. One of its bypasses is used for monitored dissolution of aluminum, and in the other (which is a reservoir with metallic gallium with additional supply of aluminum) the process of selective Al oxidation is effected, aerogels being formed at the gas-metal interface. The installation must be fabricated from material inert to gallium up to 200°C, tight, equipped with gas-vacuum system, heaters and devices for monitoring temperature and composition of gas at the inlet and outlet. In the course of experimental perfection of aerogel synthesis technology, variations are tried in temperature parameters of aluminum dissolution, oxidation process, and composition of gaseous oxidizer, the objective being to optimize the modes. The project proposed is an initial stage of developing the technology of continuous synthesis of aerogels from gallium-aluminum melt using laboratory facility. The project is to result in the fabrication of continuous technological process laboratory facility, study of Al selective oxidation mechanism, and recommendations for the creation of pilot facility. In parallel, research works are planned on fundamental problems of metal oxidation and dissolving, defining mechanisms of chemical reactions, and defining the boundary conditions of aerogel formation.

２－１　材料分野／複合材料（**Composites**）の研究機関　受託研究費　第１位

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保有技術	Materials / Ceramics Materials / Composites Materials / Explosives Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Fission Reactors Information and Communications Instrumentation Manufacturing Technology Physics Space, Aircraft and Surface Transportation Other / Building Industry Technology

本研究機関の材料分野／複合材料（Composites）における代表的プロジェクト	
プロジェクト名	New Composite Multifunctional Coatings Produced Using SHS-Electrodes
概要	本研究所が研究している Self-propagating High-temperature Synthesis (SHS) という手法を用いた金属表面加工技術の研究。本研究所では、本研究も含む多くの表面加工技術研究が行われている。本研究については、2001 年から 2003 年までに 40 以上の論文を国際学会等で発表した。
応用例	機械類全般
プロジェクト概要	The purpose of the Project is the development of scientific and technological principles to produce multi-functional composite thin and thick films by methods of d.c. and r.f. reactive bias magnetron sputtering and thermoreactive electrospark alloying. The problem to produce wear- and corrosion-resistant coatings with the properties, which are superior than analogues known from the literature, consists of two important aspects: the development of new promising super-hard and corrosion-resistant film compositions (aspect of physical metallurgy); the development of effective methods to produce strong adhesion of a coating to the base (technological aspect). As to the method of thermoreactive electrospark surface strengthening (TRESS), it, by its nature, produces high adhesive resistance of a coating to the base because of partial fusion penetration of the base surface and running of the processes similar to micro welding.

	The TRESS method, first proposed by project authors from the MISiS, is based on the exothermal and chemical reaction in the interelectrode space between electrode components under the stimulation by pulse discharge energy. The reaction (synthesis) products are formed on both the charge electrode tip and the workpiece surface. In this case the energy evolved as the result of the chemical reaction is comparable or exceeds the energy of the chemical discharge. Therefore the total energy of the TRESS-process is significantly higher than the energy typical for the known electrospark alloying process. This makes it possible to increase the efficiency of the coating formation process 2÷3 times. Electrical discharge initiates the synthesis reaction which, depending on the mix composition, can carry both in the regime of guided burning, and locally only within spark gap between the consumable electrode (anode) and the base (cathode). The Project's authors carried out a series of experiments to realize the TRESS-process using mixture (charge) electrodes of the following compositions: Ni-Al and Ti-Al. The synthesis of diamond-containing coatings is found as possible by addition of diamond powder directly into the electrode composition. In spite of high local temperatures in the interelectrode gap, the transfer of diamond component from the electrode to the base surface (of steel and titanium tools) is shown to be possible with formation of coatings up to 300 µm thick which consist of ceramic matrix (for example, on the TiB, Ni_xAl_y or Ti_xAl_y based) impregnated with diamond grains of 8 through 250 µm in size. During the fulfillment of this part of the Project, 12 new coating compositions will be developed, the regimes of their synthesis on the part surface (dies, mill rollers, etc.) having hard alloying, wear-resistant including self-lubricating coatings of low friction coefficient. This makes it possible to use the process for surface strengthening and restoration of machine and mechanism parts, die and press tools, farm equipment, choosing the optimal composition for an every given problem. American collaborators will participate in researching the structure and properties (adhesion) of TRESS-coatings and promote this process, equipment and materials in the US market after getting the results of industrial tests. Thin film coatings (less than 5÷10 µm thick) produced by magnetron sputtering of composite targets (cathodes) are the other objective of searching fundamental and applied researches. Multi-component coatings in Ti-C-N and Ti-B-N systems as well as solid solutions containing elements (Al, Si) interest because of their high mechanical properties, physical and chemical stability. Usually these properties are attributed to the crystalline structure, which is characterized by stoichiometric composition, small grain size, compressive residual stresses, strong growth orientation and dense microstructure. However some questions on the existence of solid solutions on the basis of phases of AlB2, NaCl, FeB (Ti-B-N, Ti-Si-B-N, Ti-Si-C-N) types and the solubility limit of the third component for the middle region of a phase diagram are discussed by many authors and remain unsolved. Limited information on Ti-B-N ternary diagram shows that there are minimum boron solubility in TiN and negligible nitrogen solubility in titanium boride phase. Besides coatings, which have a lattice of NaCl type in Ti-B-N, Ti-Si-N, Ti-Si-C-N systems, earlier the authors of the Project have found also the hexagonal state in Ti-B-N and Ti-Si-B-N films and the orthorhombic state of Ti-B-N. It was found that the transition from one type of crystalline lattice to another is defined by B and N to titanium ratio. In addition, a good correlation has been shown between structure, wear-resistance, coating microhardness and their corrosion-resistance in the corrosive environment. The composition of magnetron films is mainly defined by the composition of sputtered targets. The SHS-method makes it possible to produce composite targets of the various compositions. Being experts in the field of combustion and explosion physics, the authors of the Project, jointly with the collaborators from the Colorado School of Mines (USA), developed a method of SHS-pressing targets, for example, on the titanium carbide and borides, titanium and molybdenum silicides, silicon and chromium carbides, aluminum oxide based. Variation of the regimes of reactive bias magnetron sputtering (temperature of the base, voltage bias, partial pressure of nitrogen) and the composition of sputtered targets

	makes it possible to control the composition, structure, and properties of coatings. For example, a composite SHS-target of TiB_2+Ti_5Si_3+Si is promising for deposition of Ti-Si-B-N coatings with a record high microhardness up to 70 GPa, that is half as much again the microhardness of diamond polycrystalline films, high wear-resistance, and good adhesion to steel. The structure of these coatings is a mixture of hexagonal $Ti(BN)_2$ phase crystallites of 2–4 nm in size and amorphous intergranular ingredients. The films in the Ti-Si-C-N system produced by sputtering of TiC+Ti_5SiC_2+SiC ($TiSi_2$) targets are the other example. The film structure is shown to change with the growth of silicon content in the target, and the crystalline state passes into the nanocrystalline one and then into the amorphous one. Simultaneously the last coating has high corrosion-resistance, wear-resistance, and heat-resistance (up to 1000°C in the air). A group of the researchers from the Mine Academy of Colorado (USA) participates in the following phases of the second part of the Project: development and synthesis of new promising compositions of the targets by the SHS-method; study of the magnetron sputtering process; making studies of adhesion properties and mechanical characteristics of the coatings. The authors of the Project have a large experience of international cooperation in the SHS-field and surface engineering. There are 36 joint publications in the SHS-field and surface engineering for the period of 1995 through 1999. During the fulfillment of the second part of the Project, more than 8 new materials of targets, promising for the following application in the processes of magnetron and ion-plasma sputtering, will be developed and produced. During optimization of the regimes of thin-film coating sputtering, a wide fundamental and applied research and development is to be carried out to find an interrelation between the composition and structure of SHS-cathodes (targets), on the one hand, and the composition, structure, properties of coatings, and sputtering regimes, on the other hand. It should be noted that the development data corresponds to the world level. New composite coatings with record high service characteristics as well as the processes of their production are the end result.

２－２　材料分野／複合材料（Composites）の研究機関　受託研究費　第２位

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保有技術	Materials / Ceramics Materials / Composites Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials Materials / Other 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Fission Reactors Information and Communications Instrumentation Manufacturing Technology Non-Nuclear Energy Physics Space, Aircraft and Surface Transportation Other / Agriculture Other / Electrotechnology Other Basic Sciences / Geology

本研究機関の材料分野／複合材料（Composites）における代表的プロジェクト	
プロジェクト名	Elaboration of New Low-Tungsten and Tungsten-Free Nanocrystalline Hard Alloys Based on Titanium Carbide
概要	炭化チタニウムをベースとした低タングステンそしてタングステンフリーのナノ結晶性硬質合金の研究
応用例	機械類全般（ロケットの表面、ジェットエンジンのノズルなど）
プロジェクト概要	Objective of the project is elaboration of a technology for the fabrication of nanocrystalline hard metals based on titanium carbides assigned for the fabrication of articles with wear-resistant, high temperature strength and refractory properties: (e.g. skins of space rockets, jet engine nozzles, combustion engines, radiation resistant first walls of nuclear reactors, metal-working tools, production tools, chemical industry catalysts), elaboration of original installations for research of hard metals, issue of recommendations for industrial designs, pilot production of samples and their industrial testing. Another objective is elaboration of measures for prevention of terroristic attacks, in particular: water-jet cutting nozzle for the neutralization of explosive assembly through their nonexplosive destruction, armor jacket plates and machine armors.

	Novelty of the project: – New hard metal composition with specific structure; – New technology for the fabrication of nanocrystalline titanium carbide as well as metal-ceramic hard alloys based on the above material; original installations for research studies. – Security aids for the defense from terroristic attacks. New technology is based on realization of the methods elaborated by our group. Those are: the first method - preparation of the solutions of titanium metal-organic or complex compounds mixed with the salt solutions of bonding metals (Ni, Mo, W, Nb, Fe), in compliance with composition of the developing hard metals under development. After drying and subsequent pyrolysis in hydrogen flow there occurs selective carbidization and reduction of bonding material: the resulting product is a hard alloy charge where all components are in nanocrystalline (of an order of 200-300 nm) state; the second method – formation of metal-organic or complex compounds upon melting of the salts of the components of the alloy and organic material. After pyrolysis of the melt there are formed evenly distributed nanocrystalline particles of titanium carbide and those of bonding metals; the third method - formation of nanocrystalline hard metal charge as a result of high temperature (~ 900 °C) chemical interaction of titanium hydride and bonding metal salts with hydrocarbon compounds. All the above mentioned methods ensure integrity of nanocrystalline structure in the pieces shaped and sintered by traditional methods. Armor jackets of the elaborated materials will be stronger and 2-2.5 as light as those made of standard hard metal materials. Water-jet cutting nozzle of special construction made of the elaborated materials may successfully be used for the neutralization of bombs by destruction of the corps and the explosives of bombs. *Scientific and practical value of the project:* Will be elaborated compositions of new nanocrystalline metal-ceramic hard alloys based on titanium carbide with a specific structure (inaccessible to be formed by traditional methods), where high physical and chemical properties are successfully combined with mechanical properties. – An area of application will be widened and resource of hard metal pieces increased; in particular, an opportunity to create a new generation of armored materials, metal-working tools, articles for the application in space rockets, nuclear reactors, etc. will occur. – Original installations for research studies will be designed. Technological process for the manufacturing of the pieces will be developed; pilot production of the specimens and their industrial testing will be realized. – Security aids for the defense from terroristic attacks will be elaborated. The goals will be achieved on the ground of scientific elaborations, experience and an equipment installed at the Technical University of Georgia as applied for creating composite materials, in particular hard alloys and the instruments for their testing. Support of the project will be of a great social economic significance for Georgia. First, scientific potential of a group of leading scientists who were basically involved in Defense Institutions of the USSR, will be directed to the creation of peaceful production at minimal financial expenditure necessary for the solution of such kind of problems. Secondly, realization of the project will further progress in the field of science and economy of the country out of the development of a new scientific-technical direction and industry of the product competitive at the world market. Performance of struggle against international terrorism will be increased.

２－３　材料分野／複合材料（**Composites**）の研究機関　受託研究費　第３位

機関名	State Scientific Research Institute of Chemistry and Technology of Organo-Element Compounds (GNIIChTEOS)
住所	38, Entuziastov shosse, Moscow, 111123, Russia
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保有技術	Materials / Composites Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Space, Aircraft and Surface Transportation

本研究機関の材料分野／複合材料（Composites）における代表的プロジェクト	
プロジェクト名	Development of Structure, Chemical Means and Technology of Producing High Temperature Ceramic Composite of SiC/SiC Type for Civil Aviation and Automotive Industry
概要	民生用航空機、自動車産業向け炭化シリコンによる高温セラミック合金の研究
応用例	機械類全般（特に民生用航空機、自動車産業）
プロジェクト概要	The Project is aimed at developing high-temperature ceramic composite of SiC/SiC type for civil aviation and automotive industries. Structure ceramic composites have been playing a significant role in the process of creating new machines during the last decade. A leading place among these materials is held by a composite with silicon carbide matrix and silicon carbide coreless or corebased fiber (SiC/SiC). Currently when developing this material, researchers mainly use coreless fiber and silicone carbide matrix of is Si-C-O type (oxygen content up to 10%, free cabon-up to 3%), where with a temperature increase to 1100-1200 °C active reaction between components and oxygen takes place as well as growth of SiC crystals which destroys the homogeneity of the pseudo-amorphous structure of the fiber. These two phenomena lead to the loss of strength both of the fiber and the composite in general which limits its long term operating temperature in oxidation environment to 1000-1100 °C. Meanwhile this material is a promising candidate not only for defense but for civil industries as well. The analysis of the properties, production technology and economic data leads to the conclusion that the material has further significant reserves. These reserves can be implemented by radically improving both the structure of the material and the production technology which is the basic goal of the Project presented. After that the material will compete well with the expensive super-alloys widely used now for civil aviation engines and in automotive engine industries. The higher efficiency of this material is supposed to be reached by the increase of the long term operating temperature in oxidation environment up to 1500 °C and more. According to scientific forecasts in aviation industry at this temperature the efficiency of gas turbines will increase by 20-25% and specific thrust of engines by two times, which will meet the demands of civil aviation till the year 2000-2005.

	In automotive, industry CMC parts will compete well with thermo-stable super alloys in gasoline, diesel and gas-turbine engines. With these engines the higher thermal stability, high enough thermal conductivity and low density will allow to solve at the industrial level the problems of creating low friction parts, non-cooled adiabatic diesel engines and increase of the operating temperature of engine major components, i.e. increase of the total thermal efficiency and fuel consumption reduction. It will be feasible to use this material for manufacturing reactors for producing semiconductors. The key goals of the Project are the development of new types of oxygen free ceramic-forming components, alloying them with stabilizers of ceramic structure and creating multipurpose (protective and "rheological") interface coating between the fiber and matrix. Expected Results: 1. Synthesis of new ceramic forming polymers for producing fiber and matrix which would exclude oxygen penetration both during spinning and curing. Alloying the polymer with hetero-atoms of refractory metals-stabilizers linked to silicon without oxygen bridges. 2. .Development of new technology of producing coreless SiC fiber with practically zero,oxygen content, i.e. of Si-C type instead of Si-C-O type. 3. Development of multi-layer interface coating on the reinforcing fiber based on the composition of dense and porous layers of modern refractory compounds (molybdenum, germanium, rhenium siliside; silicone, titanium, tungsten carbides and borides, etc.). Coating application with combined methods of chemical reaction between components and the surface, polymers pyrolysis and chemical vapor, deposition. 4. Development of new matrix composition and the technology of its introduction to the composite. 5. Production of specimens of high temperature SiC/SiC ceramic composite of more sophisticated structure with unconventional materials used and comprehensive physic-chemical and materialogical testing. The Project will be carried out by scientists and experts who were involved in developing materials for weapons and weapon carriers. It will make possible to use their knowledge and experience as well as earlier created equipment and methodic potential for producing the material for applications in civil industries - civil aviation, automotive industry, machinery industry, semiconductor technology. It is intended to invite as collaborators same foreign scientists and firms, engaged in R&D and working out the high technical characteristics aviation and automotive engines. Based on common research work intercourse and personal contacts of Russian and USA, Japan, European scientist will enrich the scientific and practical results. The results of the Project are expected to be implemented on the commercial basis in cooperation with Russian and foreign companies. It is supposed that in collaboration with these firms same commercial production based on the scientific and technical project results and intellectual property will be organized.

３－１　材料分野／爆発物、火薬類（**Explosives**）の研究機関　受託研究費　第１位

機関名	Russian Academy of Sciences （ロシア科学アカデミー） Institute of Organic Chemistry (ZIOC RAS)
住所	47, Leninsky pr., Moscow, 117913, Russia
地域／国名	Russia　ロシア連邦
連絡先	Ph: 7+095+1372944 Fax: 7+095+1355328 Em: solcanvn@cacr.ioc.as.ru
保有技術	Materials / Composites Materials / Explosives Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Information and Communications Manufacturing Technology Space, Aircraft and Surface Transportation

本研究機関の材料分野／爆発物、火薬類（Explosives）における代表的プロジェクト	
プロジェクト名	Creation of Scientific Grounds, Techniques and Technologies for the Transformation of the Explosive 2,4,6-Trinitrotoluene (Trotyl, TNT) into valuable Civil Products (Polymeric Materials, Dyes, Biologically Active Compounds, etc.)
概要	ロシア連邦に貯蔵されたトリニトロトルエン（爆薬）の民生用製品への利用
応用例	高分子材料、染料、生物学的化合物など
プロジェクト概要	Currently Russia has accumulated a great amount (hundreds of thousands tons) of munitions liable to disposal, their main component being 2,4,6-trinitrotoluene (TNT). The work on its extraction is being in progress now. The objective of this project is the use of TNT as a cheap raw material for civil products. This approach seems most expedient for utilizing the TNT excess in this country. The project envisages the development of TNT-based aromatic compounds (benzoid di- and polyamines, including N-substituted ones, isocyanates, carbamates, nitroamines, nitro- and aminophenol derivatives, polyatomic phenols, aromatic ethers, fluorine-containing ones among them, and their thioanalogs, and nitrogen-containing heterocycles) which can be further used as monomers and semiproducts. *The following materials are planned to be produced on their basis:* 1) High molecular polymers: polyimides, polyamides and polyurethanes (including polyurethane foams). 2) New dyes of a broad color spectrum. 3) Plant-protecting and other biologically active substances. 4) Additives to polymeric compositions (antioxidants, cross-link agents, etc.). Directed synthesis of the above monomers and semiproducts is accessible only in case the

	following milestone problems in the chemistry of polynitroaromatic compounds are solved: i) nucleophilic substitution of the aromatic nitro group nonactivated either by ortho- or by para-substituents; ii) selective reduction of nitro groups (by number and position) to ammo groups, reducing alkylation of nitro groups; iii) TNT-based heterocyclization. Theoretical (quantum chemistry and electron transfer theories), catalytic, electrochemical and synthetic methods with the further production of target structures will be employed to solve these problems. Polymers, dyes and the other technical products mentioned above will be then synthesized. They will comprise the most promising materials for the production of which the elaboration of technologically expedient methods is planned. The research team for the project effort consists of highly qualified specialists who have been involved in the development of new explosives for mass destruction weapons and other energetic materials.

３－２　材料分野／爆発物、火薬類（Explosives）の研究機関　受託研究費　第２位

機関名	Russian Scientific Center of Applied Chemistry (Applied Chemistry Centre)
住所	14, Dobrolubova str., St Petersburg, 197198, Russia
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連絡先	Ph: 7+812+2389345 Fax: 7+812+2389251 Em: delsi@mail.wplus.net
保有技術	Materials / Explosives Materials / Other 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Information and Communications Non-Nuclear Energy Physics Space, Aircraft and Surface Transportation

本研究機関の材料分野／爆発物、火薬類（Explosives）における代表的プロジェクト	
プロジェクト名	Conversion of the Research and Development System "Investigation of Thermal Explosion of Propellants, Gunpowders and Explosives" to the Research and Development System "Thermal Safety of Chemical Processes and Technology"
概要	爆薬研究を、民生用化学研究に転換
応用例	化学一般
プロジェクト概要	The main purpose of this project is to transfer the scientific and technical expertise of the Russian Scientific Center "Applied Chemistry" (RSC AC) and its achievements and considerable experience in the field of solving thermal explosion problems for highly energetic propellants, gunpowder and explosives intended for space rockets, aircraft missiles, etc., to a solution of thermal safety problems for civilian chemical industrial processes. In particular, this project will: - involve the Russian specialists who formerly worked at creating military technology in Russia, to non-military activities. Through this project these specialists will be drawn into the world market economy and be aware of market driving forces; - introduce new fundamental and applied developments in the field of safety of chemical industry, especially in relation to various demands of human health and environment - protection; - bring the Russian specialists who formerly worked at creating military technology in contact to the world scientific community; - increase the scientific, technological and industrial knowledge base of Russia. *Expected Results* The results of this project are the formulation and validation of necessary theoretical principles (i.e., new theoretical development for adiabatic and non-isothermal calorimetry, methodology of investigation of reaction kinetics by using adiabatic calorimetry, etc.), the elaboration of a new adiabatic calorimeter and pulse-flow heterogeneous fixed bed reactor

	prototypes, and the development of original pieces of software for solving a wide variety of thermal safety problems. These proposed developments and achievements are highly appreciated by the leading open the Russian militarized scientific community towards new industrial applications and to initiate new economic development in Russia and abroad. *Scientific and technical significance of the Project* The Project will expand considerably the theoretical grounds and methods in thermal safety of chemical processes by applying new mathematical simulation methods combined with innovative experimental techniques. It will spur a strong activity in thermal safety investigations in Russia, which is of great importance both for Russia and the world community. *Commercial significance of the Project* Implementation of the Project will provide a new generation of software intended for study of thermal safety of chemical processes. This software will be for commercial use in a short period of time. The estimated volume of sales within a period of two years after finishing the project is in the range of 10-20 software copies with price ranging US $ 50,000 per one copy. In addition, this Project will provide new adiabatic calorimeter and pulse-flow heterogeneous -catalytic reactor prototypes that could be commercialized in a near future. *Scope of Activities technical Approach and methodology* The Project is constructed along four main lines of activity. *The first activity* will focus on the development of a new generation of software for chemical reaction kinetics evaluation, and reactor simulation customized for Windows-95 and NT that can work both in local and network modes. This software will meet current international quality control standards. *The second activity* will focus on the development of a new method of studying gas phase heterogeneous catalytic processes with applying a pulse-flow fixed bed reactor. *The third activity* will focus on the development of an adiabatic calorimeter to study thermal safety of chemical processes with better technical characteristics than those available commercially. *The fourth activity* will focus on presentation of the project development and progress to an international potential market (i.e. to leading Chemical Groups of Europe and the USA; at international conferences; by organizing seminar series on "Thermal safety of chemical processes and technologies" in RSC AC for a wide audience of specialists; and by publications in leading scientific journals). Series of workshops and training courses given by RSC AC experts and organized by RP will be scheduled to facilitate the technology transfer from RSC AC to RP specialists. These courses will provide an opportunity for the software developers to meet and discuss potential improvements of software with RP engineers.

３－３　材料分野／爆発物、火薬類（**Explosives**）の研究機関　受託研究費　第３位

機関名	G.Tsulukidze Mining Institute
住所	7, E.Mindeli Str
地域／国名	Georgia　グルジア
連絡先	無記載
保有技術	Materials / Explosives

本研究機関の材料分野／爆発物、火薬類（Explosives）における代表的プロジェクト	
プロジェクト名	Development of Technology and Creation of Industrial Explosives on the Basis of the Utilized Ammunition
概要	ロシア連邦に貯蔵された弾薬の民生用製品への利用
応用例	化学一般
プロジェクト概要	In the warehouses of military bases of former Soviet Union located in the countries of Transcaucasia, including in territory of Georgia, a plenty of ammunition with the expired working life is saved up. This ammunition represents social danger to the countries of region distinguished by political and economic instability, and will frequently be involved at fulfillment of acts of terrorism. Shadow business on extraction and delivery on items/points on reception of a breakage of metal parts of ammunition that has resulted in cases of a traumatism and destruction of people occupied in this business was generated. Destruction of ammunition with the expired working life in great volumes ecologically is rather dangerous, as realization of this action creates additional sources of environmental contamination, including heavy metals and their connections. Meanwhile, ammunition with the expired working life has the certain value as are energy carriers. Their recycling enables to find effective ways of use of this ammunition to a national economy. Since 2003 under the program of OSCE «Processing of fighting materials and shells on former military bases of Soviet Union in Georgia », have been developed by the Georgian state military scientific and technical center "Delta" ways of utilization ballistic and pyroxylin gunpowder contained in an ammunition. The basic opportunity of their application has been established as explosives. Not investigated there was engineering ammunition, rocket firm fuel and fighting parts of ammunition which application at utilization in the pure state can result in negative ecological consequences. Therefore the problem of utilization of this ammunition and creation on their basis of new assortment of industrial explosives is represented rather actual. Realization of the project will promote development of the mining industry in the countries of Transcaucasia and to growth of their economic potential. One of deterrents of development of the mining industry in Georgia is absence of a factory on manufacture of industrial explosives and, the deficiency of effective waterproof explosive structures caused by it, need (requirement) in which is estimated in 2.0-2.5 thousand tons one year. The purpose of the project is creation of new assortment of industrial explosives on the basis of a utilized ammunition and development of the investment program of construction of the enterprise on release of these explosives. In the project tasks will be solved by definition: – specific energy and full ideal work of explosion, speed of a detonation of a utilized ammunition and explosives on their basis; – compoundings of industrial explosives on the basis of utilized ammunition (UE); – structure of products of a detonation of a utilized ammunition and explosives of (UE); – basic technical characteristics of explosives of UE, including efficiency, brisance,

	sensitivity external influences, critical diameter, ability of transfer of a detonation, water resistance; – seismic influence of explosion of charges UE on engineering constructions and natural objects with development of methods of regulation of their fluctuations; – areas of use UE and classes of all assortment on conditions of storage, transportation and application. At definition of explosive characteristics and technological properties of a utilized ammunition and UE explosive chambers of the Institute of Mines the Academy of sciences of Georgia, equipped by the necessary equipment recording fast proceeding processes, and measuring techniques for definition of structure of products of a detonation will be involved. Degrees of their ecological influence on an environment and seismic effect of explosion will be executed also ground investigations/researches for an establishment of efficiency of UE. *Expected results and their application.* Realization of the project provides: – development of assortment of industrial explosives on the basis of a utilized ammunition with representation of their hydrodynamical characteristics, technological properties and degrees of negative influence on an environment and protected constructions; – development of the computer program on distribution of an optimum compounding of these explosives for concrete conditions of detonation; – development of the investment program of construction of the enterprise on release of industrial explosives on the basis of utilized ammunition with commercial estimation of the project by principles UNIDO.

４－１　材料分野／高性能金属、合金（**High Performance Metals and Alloys**）の研究機関　受託研究費　第１位

機関名	Ufa State Technical University of Aviation (USATU)
住所	12, K.Marks str., Ufa, 450025, Russia
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保有技術	Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing 材料分野以外の保有技術 Manufacturing Technology

本研究機関の材料分野／高性能金属、合金（High Performance Metals and Alloys）における代表的プロジェクト	
プロジェクト名	Processing of Nanostructured Ti-6Al-4V and Ti-Ni Shape-Memory Alloys for Medical Applications
概要	形状記憶合金の研究
応用例	主に医療用

４－２　材料分野／高性能金属、合金（High Performance Metals and Alloys）の研究機関　受託研究費　第２位

機関名	RFNC VNIIEF (VNIIEF)
住所	37, Mira Prospekt, Sarov, N. Novgorod reg., 607190, Russia
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保有技術	Materials / Ceramics Materials / Composites Materials / Explosives Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials Materials / Other 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Fission Reactors Fusion Information and Communications Instrumentation Manufacturing Technology Non-Nuclear Energy Physics Space, Aircraft and Surface Transportation Other / Building Industry Technology Other / Electrotechnology Other / Other Other Basic Sciences / Natural Resources and Earth Sciences Other Basic Sciences / Other

本研究機関の材料分野／高性能金属、合金（High Performance Metals and Alloys）における代表的プロジェクト	
プロジェクト名	Technology Development for Obtaining of Enhanced Magnetic Properties Amorphous Alloys (Metal Glasses) by Shock-Wave Compacting Powder Materials for Magnetic Applications
概要	磁化特性を高めたアモルファス合金の開発
応用例	磁気を利用する製品全般
プロジェクト概要	The proposed Project is devoted to the technique development for producing amorphous alloys (metallic glass) with enhanced magnetic properties by using the procedure of dynamic (shock wave) compaction (DC) at powder materials. Amorphous alloys are of unique practical value and essential, scientific interest. However,

in spite of continuously increasing scope of applications and investigations of these systems, a great deal of key physics problems of amorphous state remain unsolved. The interest in metal glass (MG) proceeds from such outstanding technological features as high magnetic permeability, low coercive force, high mechanical viscosity, yield limit, high corrosion resistance and temperature-unaffected electrical conduction that underlie its wide practical application.

Currently, the following procedures for producing amorphous metals are available: 1) evaporation of metals in vacuum and deposition of their vapors onto a cooled substrate; 2) atomization, with atoms escaping the source due to the accelerated high-energy atoms of an inert gas; 3) chemical deposition, i.e. the procedure involving deposition of ions, resulting from the chemical reaction, onto the substrate in water solution; 4) electrodeposition involving external electrical potential required for a chemical reaction to take place; 5) fast solidification from the liquid state. A number of researches have demonstrated that MG can be produced by employing DC involving high explosives (HE). One of the DC challenges is to produce densities similar to those of monocrystals.

The unique expertise of employing HE for powders' dynamic (explosive-driven) compaction, involving shock waves (SW) with the intensity ranging from 5 to 50 GPa, is available at RFNC-VNIIEF. Under the above conditions, samples preserve their integrity, and densities approaching those of monocrystals are produced. With the materials' explosive –driven compaction, favorable conditions for MG synthesis can be created, i.e. high pressures (5-50 GPa), temperatures approaching that of the melting point (1000-1500 K) and extremely short pulses (2-10 s). As the result of the above conditions, on the one hand, a high level of material compaction is achieved and, on the other hand, SWs enable to generate a disordered crystal structure since the parameters of the crystal lattice change considerably in the shock front.

Under the project, the alloys will be identified that are deemed advisable to produce employing a DC procedure. MG is subdivided into the following two types: metal - metalloid and metal - metal alloys. Proceeding from the intended use of a product produced and the parameters required, Fe-, Ni- or Co - based alloys will be selected with B, Si, Cr, Mo and Mg admixtures.

For instance, to manufacture an isolation transformer, the 2605S-2 alloy (Fe-78%, B-13%, Si-9%) is employed. This alloy offers high saturation induction, low losses in the core and a minimal relative cost. At the stage of selecting and producing alloys, having the required chemical composition, experts in material properties and material science will participate.

Specialists in the area of fabricating HE and charging initiators and firing devices will take part in the project to pick up the type of HE employed, to charge explosive assemblies and to develop the explosive loading techniques.

Once the samples are fabricated, their mechanical, electrical and magnetic properties will be tested and X-ray analysis will be carried out. These investigations will involve the experts in the area of electromagnetics.

The project execution will result in selecting materials that are advisable to synthesize employing the DC procedure and developing procedures for producing alloy powders and their dynamic compaction. During the course of the work, computer codes, describing the aspects of procedures developed, and computational and theoretical models will be used.
The collaborators' role under the project is to identify materials and to search for customers for applying the developed procedures and techniques for industrial manufacturing of electrical equipment units.

４－３　材料分野／高性能金属、合金（High Performance Metals and Alloys）の研究機関 受託研究費　第３位

機関名	Russian Academy of Sciences （ロシア科学アカデミー） Institute of Metals Superplasticity Problems
住所	39, Khalturina str., Ufa, 450001, Russia
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保有技術	Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing 材料分野以外の保有技術 Fusion Instrumentation Manufacturing Technology Other / Electrotechnology

本研究機関の材料分野／高性能金属、合金（High Performance Metals and Alloys）における代表的プロジェクト	
プロジェクト名	Development of Pilot Commercial Technology for Manufacturing of Products from Submicrocrystalline Aluminum Alloys with Enhanced Service Properties and Workability
概要	特性、加工性を向上した微晶性アルミニウム合金の研究
応用例	機械類全般
プロジェクト概要	The project is devoted to the development of basis of technology for manufacturing bulk aluminum alloys products with submicrocrystalline (SMC) structure (grain sizes less than one micron) by use of intense plastic straining (IPS) techniques. Applied research will be deal with examination of the effect of SMC structure on service properties and workability of aluminum alloys and optimization of thermomechanical treatment for processing SMC structure during IPS. Basic research will be carried out with threefold aims: to reveal mechanisms of SMC grain formation during IPS, to study origin of SMC structure effect on properties of aluminum alloys, and to examine mechanisms of recrystallization in intense strained materials. Use of technology developed will allow producing semi-finished products of aluminum alloys with enhanced service properties and workability. The new level of alloys properties obtained will expand a field of their commercial application and give advantages to producers. Nowadays, the laboratory experiments have demonstrated that formation of SMC structure resulted in unique service properties and enhanced workability of a number of conventional alloys, aluminum based included. However, three main problems play a role of barriers for commercial implementation of this technology. First of all, the techniques used allow producing small sized laboratory samples only. It gives a limitation to evaluation of material properties and microstructures, as the commercial application of materials with SMC structure requires the examination of combination of mechanical properties according to standard procedure. This combination should include all main parameters of alloy strength in proposed service conditions. The lack of an information on mechanical behavior and structure stability of bulk SMC materials at elevated temperature has limited the use of

aluminum alloys with SMC structure too. Secondly, scaling up the known laboratory techniques, such as equal channel angular extrusion (ECAE) and torsion straining under high pressure (TSHP), is essentially difficult and even impossible in a number of cases. And it is obvious that new techniques have to be developed for processing the metallic materials with SMC structure. Thirdly, microstructural evolution during IPS in aluminum alloys was poorly examined. It restricts feasibility for development of cost affordable technology for SMC aluminum products processing. As a result, the known methods of manufacturing of materials with SMC structure are rather expensive partly due to non-optimum route of thermomechanical treatment used.

The main goal of the project is to develop basis of commercial technology for manufacturing bulk products from aluminum alloys with SMC structure, evaluation of their service properties and workability. Two novel techniques involving IPS will be examined. The first one is complex angular extrusion (CAE) beings a unique processing technique, pioneered and patented at the Institute for Metals Superplasticity Problems. It could be realized in a specially designed die set to apply intensive plastic straining to bulk samples of different cross-sections. The second one is compression under high pressure (CHP). This technique was previously used for imparting fine grain structures (grain sizes in the range of one to ten microns) to aluminum alloys. In context of the project the CHP technique will be modified to produce SMC bulk billets. The patenting of this modified technology is planned under the frame of the project.

To develop cost affordable technology the following works will be carried out. Aluminum alloys will be deformed with ultra high strains by ECAE, CAE and CHP techniques. ECAE technique will be used in laboratory scale to study the evolution of microstructure during IPS. It will allow optimum regimes (temperature, strain, strain rate) of thermomechanical treatment to produce SMC structure in aluminum alloys to be developed. Regimes obtained will be used to process aluminum alloys by CAE and CHP techniques. Investigation of the effect of deformation scheme (path) on SMC structure formation will be performed. The combination of mechanical properties of CAE and CHP processed billets will be examined on samples of standard size. This combination include parameters of tensile strength, fatigue strength, hardness and toughness at ambient temperature, and superplasticity. Structure and service properties of heat treatable alloys will be studied in two states: before and after standard heat treatment. Evaluation the mechanical behavior of the alloys almost will include the analysis of their workability and the feasibility for cold rolling of thin sheets from aluminum alloys with SMC structure. These parameters are extremely important for beginning commercial use of developing technologies. The resulting microstructures and mechanical properties after CAE and CHP will be compared with those from other severe plastic deformation techniques.

As a result the present work will lead to new knowledge of the effects of phase composition, grain size and grain boundary structure on mechanical properties of aluminum alloys. The mechanisms of microstructural evolution during severe plastic deformation will be also examined. Besides, the work will advance the future commercial applications of SMC materials because of its focus on novel commercial aluminum alloys containing scandium.

Results of the work will allow evaluating feasibility of manufacturing of aluminum sheets with SMC structure and their use for low temperature superplastic forming of complex shaped products. Fulfillment of this project will allow promoting application of IPS techniques to commercial sized billets. The perspective areas of industrial application of aluminum alloys with SMC structure will be evaluated.

The State of the Art in the Field and the Impact of the Proposed Project on the Progress in the Field.

The proposed ISTC Project is a research and development work with high commercial potential for application in civil aircraft, automotive, railway and construction industry. This wok is related to the development of novel technologies for processing SMC structure in

	aluminum alloys and aimed on enhancement of service properties of these alloys and their workability. Recently aluminum alloys with SMC structure have been produced with grain sizes less than one micron by IPS technique. These materials are of particular interest because of their unique physical and mechanical properties. For example, materials with SMC microstructures have been shown to exhibit significant increases in static strength at room temperature and superplastic behavior at low temperatures or high strain rates. The development of an SMC structure in relatively inexpensive commercial alloys produced by traditional casting technology is important for commercial implementation of this technology. The SMC materials could be used for the production of commercially important components with improved service properties using cold rolling, hot isothermal forging and superplastic forming. The aluminum industry is especially interested in the development and application of bulk SMC billets. Several techniques, such as TSHP and ECAE, have been developed to subject materials to large plastic strains and thus develop SMC microstructure. These techniques have been applied to a several grade aluminum alloys with standard as well as non-standard compositions and positive result was demonstrated. However, the sample sizes produced and studied have been small. It restricts the use of these techniques in a laboratory scale. For commercial implementation of this technology, the process of severely straining materials must be scaled up to produce larger sample sizes. Bulk material properties must be established. The Institute for Metals Superplasticity Problems (IMSP) has developed novel techniques for intense plastic straining. These techniques allow producing massive billets with SMC structure, and its main advantageous is scale up feasibility. One of these techniques is CAE consisting in a combination of several deformation schemes in one deformation pass. Method and die design of CAE were covered by Russian Federation patent in 2000. Development and patenting of another technique being compression under high pressure (CHP) is in progress. IMSP team has a great experience in examination of microstructural evolution during plastic deformation; evaluation of effect of deformation induced microstructure on service properties in numerous metallic materials including aluminum alloys. Examination of superplastic behavior is a main field of activity for most of IMSP's researches. Researchers and engineers are perfect familiar with forging and rolling procedures and most of them are experienced with different IPS techniques during the last 10 years. All facilities requiring for proposed project are in good working conditions. SRC team has a great experience (more than 30 years) in producing rocket parts from aluminum alloys, evaluation of service properties and microstructure of aluminum alloys. Weapon specialists are familiar with forging and rolling processing of light alloys. SRC has appropriate equipment to attend the goal of the present project. Pioneer works of IMSP were dealt with examination of microstructural evolution during severe plastic deformation and evaluation of service properties in materials with SMC structure. In the same time, the mechanical behavior of SMC materials has been insufficiently examined. In many cases the evaluation of these properties has been limited by the small sample sizes produced by the ECAE and TSHP techniques. Particularly lacking are studies of fracture toughness and fatigue strength of SMC materials – two properties that are critically required for commercial implementation of these materials. In context of proposing project a number of important service parameters (including crack resistance, toughness and fatigue) will be evaluated in aluminum alloys with SMC structure as well as workability. The last is required for manufacturing of thin sheets by cold rolling and processing of parts by low temperature superplastic forming and forging. An effect of technological processing and final heat treatment on service properties will be evaluated. The mechanisms of grain formation and evolution of mechanical properties during severe plastic deformation are also poorly understood. An examination of the effect of IPS conditions on SMC structure formation is important for development of optimum route of

	thermomechanical treatment. Knowledge of microstructure development during processing will permit efficient procedures to be implemented. It will allow essentially decreasing plastic strain evolved for SMC structure formation and result in a cost decrease. Other poorly known aspect of materials with SMC structure is effect of following deformation and final treatment on its structure and properties. Analysis of microstructure evolution during fabrication and heat treatment is essential to understand microstructure changes that will yield final service properties. This is extremely important for cold rolling of thin sheets with SMC structure. Work outlined in this proposal will be focused on examination of microstructure evolution during both primary and secondary processing. *Project Purpose.* The general project objective is to develop the basis of commercial technology for manufacturing semi-finished products from aluminum alloys with SMC structure. In the frame of the project it is planned to analyze service properties and workability of these materials, examine the physical origin of grain formation during IPS and investigate an effect of SMC structure on aluminum alloy properties. The proposed project has six primary objectives. 1. Manufacturing bulk samples (at least 20 mm thick and weighing 0.5 kg) with uniform SMC structure using the CAE and CHP techniques. 2. Evaluation and analysis of IPS effect on microstructure evolution and the resulting properties. 3. Evaluation and analysis of post-deformation heat treatment effect on microstructure evolution and the resulting properties. 4. Evaluation and analysis of superplastic behavior of aluminum alloys with SMC structure. 5. Evaluation and analysis of the cold rolling of aluminum alloys with SMC structure. 6. Development of recommendation for commercial applications of the SMC alloys. Two aluminum alloys developed in the former Soviet Union (1570 and 1421) and two US alloys (2219 and 6061M) will be studied in this project. The 1570 alloy is an advance non-heat treatable alloy of Al-Mg system and can be used in aviation, railway and automotive industries, and other fields requiring a moderate strength and corrosion resistant aluminum alloys. The 1421 and 2219 alloys are heat treatable alloys and can be used in cryogenic applications as well. The 6061M alloy is a superplastic modification of 6061 aluminum alloy belonging to Al-Mg-Si system. The 6061 alloy is widely used in automotive, construction and aviation industries. It is presumable that the 6061M alloy will find an application in similar fields. The 1570 and 1421 alloys contain scandium, which produces fine dispersiods and is known to significantly influence mechanical properties and provide great thermal stability to the fine grain microstructure. These fine dispersoids should almost provide SMC structure stability in these alloys. Highly stable SMC structures are especially important for the heat treatable 1421 alloy, since fine grain microstructures need to be maintained during heating under quenching to attend high service properties. The 1421 and 2219 alloys contain large amount of reinforcement phases. From one side, such a composition hinders ability for cold rolling in 1421 alloy and, from another side, should provide high stability of SMC structure in these two alloys at a low temperature superplastic condition. The IMSP team has conducted preliminary examinations of these materials in small samples and found that SMC microstructures can be developed. The Project realization will bring to reality the development of basis for commercial scale technology for manufacturing products (rods and sheets) from 1570, 1421, 2219 and 6061M aluminum alloys with SMC structure by CAE and CHP techniques. Service properties and workability of these alloys will be evaluated.

	Following partial objectives will be attended in the context of the project: – increase in ultimate strength and yield stress of aluminum alloys at room temperature at 1.2–2 times as much with sufficient resource of plasticity, fatigue resistance and toughness; – optimization of technological route for manufacturing commercial sized billets from aluminum alloys with SMC structure; – optimization of IPS methods, development design of tolling, manufacturing die sets; – development of technological basis for manufacturing sheets suitable for low temperature superplastic blow forming from aluminum alloys with SMC structure; – development of technology for low temperature blow forming of aluminum alloys with SMC structure; – analysis of the effect of SMC structure on static strength, toughness and fatigue resistance of aluminum alloys; – market evaluation for commercial use of aluminum alloys with SMC structure. Applied research will be focused on service properties and workability of 1570, 1421, 2219 and 6061M alloys. The effect of heat treatment on evolution of SMC structure will be carried out. It can be expected that coherent nanoscale Al_3Sc particles in the 1421 and 1570 alloys will stabilize SMC grains at heating up to a quenching temperature. Examination of microstructure evolution of aluminum alloys during IPS and following deformation and annealing as well as investigation of the effect of SMC structure on resulting mechanical properties will be carried out not only in the context of applied research but almost basic research. It will allow an outlook on the nature of deformation mechanisms and mechanisms of SMC grain formation, as grain boundary structure effects on mechanical behavior of aluminum alloys to be expanded. Results obtained in this work could be used by aluminum industry for manufacturing bulk billets and sheets with SMC structure exhibiting enhanced service properties and improved workability from 1570, 1421, 6061M and 2219 aluminum alloys and alloys of the same series. SMC sheets and billets from these alloys can be suitable for low temperature superplastic forming and forging. Feasibility to produce sheets with improved service properties, especially from the 1421 alloy, will provide market by new products. A growth in market for these products can be expected. *Scope of activities.* The following activities will be performed in the context of the submitted Project: 1. Development of technical conception on tooling design for manufacturing commercial sized billets from the aluminum alloys by the use of CAE and CHP techniques. Development of design documentation and fabrication of tooling for CAE and CHP techniques. Evaluation of ability of these techniques to produce SMC structure in the 1570, 1421, 6061M and 2219 alloys in comparison with ECAE technique. 2. Development of technological route for producing SMC structure in the 1570, 1421, 6061M and 2219 alloys by CAE and CHP techniques. ECAE and small sized CHP (sample size does not exceed 20 mm×20 mm×80 mm) will be used to develop optimum route of thermomechanical treatment. Commercial sized billets will be produced by CAE and CHP techniques with the use of thermomechanical regimes based on ECAE and small sized CHP experiments. 3. Development of regimes for SMC sheets processing. A feasibility of cold (warm) rolling of billets with SMC structure produced by CAE and CHP techniques will be evaluated. Parameters of rolling will be developed for alloys of different nature. Basis for pilot technology of sheet manufacture of aluminum alloys with SMC structure (grain size in the range of 0.3–0.5 μm) will be developed. Pilot lot of thin sheets 150×300 mm in dimension will be produced.

	4. Evaluation of room temperature service properties of aluminum alloys with SMC structure including static strength, hardness, plasticity, crack resistance, toughness and fatigue limit. 5. Examination of superplastic behavior of alloys with SMC structure. Low temperature and high strain rate superplasticity will be examined in tension and by biaxial test (blow forming test). Optimum regimes for blow forming will be developed. An effect of superplastic blow forming on resulting microstructure and properties at room temperature will be examined. 6. Examination the stability of SMC structure under post-deformation static annealing of IPS aluminum alloys. Evaluation of an effect of conventional heat treatment on structure and resulting properties of the 1421 aluminum alloy with initial SMC structure will be carried out. While implementing the Project the following activities will be pursued: – The tooling design will be performed for CAE and CHP techniques to manufacture commercial sized billets from the aluminum alloys with SMC structure (technology development). – Feasibility for SMC sheet processing by cold (warm) rolling will be examined for billets produced by CAE and CHP techniques (technology development). – Superplastic parameters will be determined for alloys with SMC structure at tension and biaxial (blow forming) tests (applied research). The origin of low temperature superplasticity in aluminum alloys with SMC structure will be examined (basic research). Optimum regimes for low temperature blow forming will be developed for alloys with SMC structure (technology development). – An origin of SMC structure formation during IPS will be examined (basic research). On this basis the optimum regimes of thermomechanical treatment will be developed to produce uniform SMC structure in bulk billets (technology development). – Phenomenology and nature of effects of IPS and SMC structure on mechanical properties of aluminum alloys will be analyzed (applied and basic research). – Phenomenology and origin of evolution of SMC structure and mechanical properties during post-deformation annealing will be examined (applied and basic research). Feasibility to use structure hardening effect caused by SMC structure formation will be evaluated in a heat treatable aluminum alloys to enhance service properties (applied research and technology development). – Preparation of annual and final reports and a technology implementation plan for a commercial use of technology developed. *Role of foreign collaborator.* Prof. Taku Sakai is a worldwide known expert in the field of grain boundary formation and grain refinement during plastic deformation of metallic materials, aluminum alloys included. His recent activities are focused on IPS and analysis of the effect of fine grain structure on mechanical properties of metals and alloys. He and his group will take part in technical monitoring of the project activities. The team will take part in discussions of current project tasks, joint publications and patents. Prof. Taku Sakai will focus his efforts on the forecasting of commercial profits from the use of technology and equipment developed for producing SMC structure in aluminum alloys. He will evaluate market in Japan, USA and EC for this technology. Coupling of foreign collaborator and Russian institutions efforts for project fulfillment will assist in acceleration of commercial implementation of the technology developed for manufacturing aluminum alloys with SMC structure and enhanced service properties and workability.

５－１　材料分野／材料合成、処理（**Materials Synthesis and Processing**）の研究機関 受託研究費　第１位

機関名	Joint Stock Company Bogoroditsk Plant of Techno-Chemical Products (JSC BZTKhi Bogoroditsk)
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保有技術	Materials / Materials Synthesis and Processing 材料分野以外の保有技術 Biotechnology and Life Sciences Instrumentation

本研究機関の材料分野／材料合成、処理（Materials Synthesis and Processing）における代表的プロジェクト	
プロジェクト名	Development of the Detector Production Technology for New Generation of Positron Emission Tomographs to Be Used in Medicine and Pharmacology
概要	新世代陽電子放出断層装置向け検出材料製造技術の研究
応用例	主に医療、製薬で使用
プロジェクト概要	Main objective of the Project is development of the technology of scintillation detectors based on new scintillation materials with attractive properties, new types of photo detectors and new approach for data acquisition and processing. Application of these scintillation detectors in medical imaging will allow increasing sensitivity of measurements and reliability of data, with simultaneous drop of the patient dose. This objective will be achieved by solution of the following tasks: – Development of laboratory technology of the lutetium perovskite scintillation crystal for positron emission computed tomography, distinguished by increased conversion and detection efficiency and speed. Gain in sensitivity of at least of factor 10 is expected as compared to currently used BGO. – Development of laboratory technology of detector module consisting of the lutetium based scintillators and new position – sensitive photo detectors such as photo multipliers and avalanche photo diode arrays. – Search and synthesis of a new generation of perspective lutetium based scintillation materials for X-ray and gamma-radiation detection systems for their use in medical radiology. During the Project we plan to perform: – Development of laboratory technology of the lutetium perovskite scintillation material, suitable for industrial assimilation at BTCP, for application in positron emission tomography (PET). – Theoretical and experimental search of perspective lutetium based scintillation materials of a new generation for X-ray and gamma-radiation detection systems used in positron emission computed tomography, X-ray computed tomography and single-photon emission computed tomography. – Theoretical and experimental search of advanced algorithms of data acquisition and processing for a new generation of positron emission tomographs.

	– Design optimization and development of laboratory technology of scintillation detectors for application in positron emission tomography. – Experimental study of the performance of the small animal PET detector module including scintillation detector and read-out electronics. – Preparation and presentation to ISTC materials under the Project.

５－２　材料分野／材料合成、処理（**Materials Synthesis and Processing**）の研究機関 受託研究費　第２位

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保有技術	Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing 材料分野以外の保有技術 Environment Fission Reactors Manufacturing Technology

本研究機関の材料分野／材料合成、処理（Materials Synthesis and Processing）における代表的プロジェクト	
プロジェクト名	Technology for Production of Beryllium Materials and Coatings
概要	ベリリウム材料、コーティング製造の技術研究
応用例	原子炉等
プロジェクト概要	The objectives of this project are to develop: · The experimental database on the properties of high purity Beryllium and beryllium coatings on the surface of construction materials under comditions typical for Thermonuclear Reactors; · The technology for manufacturing of high purity beryllium, beryllium coating and foils. The practical recommendations on candidate materials for the first wall of Thermonuclear Reactors.

５－３　材料分野／材料合成、処理（Materials Synthesis and Processing）の研究機関受託研究費　第３位

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保有技術	Materials / Ceramics Materials / Composites Materials / Explosives Materials / High Performance Metals and Alloys Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials Materials / Other 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Fission Reactors Fusion Information and Communications Instrumentation Manufacturing Technology Non-Nuclear Energy Physics Space, Aircraft and Surface Transportation Other / Building Industry Technology Other / Electrotechnology Other / Other Other Basic Sciences / Natural Resources and Earth Sciences Other Basic Sciences / Other

本研究機関の材料分野／材料合成、処理（Materials Synthesis and Processing）における代表的プロジェクト	
プロジェクト名	Development of the Protection Plate Resistant to Unauthorized Effects of Mechanical, Thermal and Chemical Break Means
概要	保護用プレートの研究
応用例	保存ケース、住宅など温度的、化学的な作用から物質を保護する際に使用可能
プロジェクト概要	The objective of the project "Break protection plate" is development of protection for safes, cases, rooms, etc. against break with various means of mechanical, thermal, thermomechanical and chemical types. The topicality of this project is explained by the necessity of protecting the stored or

	transported valuable or especially dangerous goods from unauthorized opening using various special means or cutters. Currently, there are rather many developments in this area, but all of them have specific drawbacks. In particular, these are as follows: – inability to resist the existing break techniques such as cutting with various mills and cutters, shooting through with small arms followed by drilling out of holes and other methods; – inability to resist fire effects resulting in weakening of the protection facility walls and easy break with mechanical means; – inability to resist chemically active media effects; – they require additional application of power supplies in the protection system (gas cylinders, etc.), the means ensuring their normal operation (valves, pressure regulators) and control instruments, which makes operation more difficult and reduces service safety. The break protection plate is proposed that is resistant to: – effects produced by autogenous welder and electric arc cutters; – effects produced by mechanical cutters and drills; – effects produced by individual small arms; – effects of chemically active media; – simultaneous (combined) effects produced by the above factors. This problem solution is achieved due to appropriate selection of materials having high protection properties and their optimum design combination. The surface density of the break protection plate is no more than 80 kg/m^2 and it is 40 mm thick. This development has no analogs in the domestic and foreign practice. The technical decision has been protected by the Russian Federation patent for the invention (patent № 210659, priority of 31.01.96). It is our opinion that the project results may be of interest for institutions of the Ministry for Atomic Energy of the Russian Federation and for the USA Department of Energy. They may be also of interest for the countries and companies dealing with dangerous chemical and other harmful substances as well as with valuable and expensive items. The partner participation consists in the Project financing and in joint application of the results. Participation of collaborators in the Project consists in joint consultations, discussion of the activities and their results. Scientific research institutes, private firms and companies, experts from the USA, the European Community, Japan, Norway and South Korea are offered to participate in the Project as collaborators.

６－１　材料分野／有機、電気材料（Organic and Electronics Materials）の研究機関 受託研究費　第１位

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保有技術	Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials 材料分野以外の保有技術 Information and Communications Physics Space, Aircraft and Surface Transportation

本研究機関の材料分野／有機、電気材料（Organic and Electronics Materials）における代表的プロジェクト	
プロジェクト名	Development of Silicon Carbide Semiconducting Material for a new Generation of Radiation Hardened and High Temperature Sensors and Electronics
概要	次世代高温センサーなどに使える炭化シリコン半導体材料の開発
応用例	内燃エンジン、ジェットエンジンなど機械類一般への応用を想定
プロジェクト概要	The purpose of the project is to develop a new generation of high temperature and radiation hardened sensors and electronics. Studies and market surveys have shown that a need exists in the commercial sectors around the world for high temperature and or radiation hardened sensors and electronics which can operate up to 600 °C, a fluence of 10^{16} n/cm^2. and a total dose of several hundred megarad. Applications for high temperature and/or radiation hardened electronics include electronics mounted on internal combustion engines and jet turbines (automotive and aircraft industries), power electronics used for all-electric automobiles and all-electric control of aircraft, high speed power electronics for radar and power conditioning, signal processing and power electronics for geothermal exploration and oil well logging, monitoring electronics for high temperature food processing and chemical processing plants, electronics for environmental analysis and restoration of nuclear and chemical wastes and instrumentation and control systems for commercial reactors and space reactors. Currently available commercial electronics can function adequately to 150 °C, 10^{14} n/cm^2, and up to several Mrad. Initial studies show that silicon carbide based electronics have the potential to operate at temperatures as high as 650 °C and in radiation environments several orders of magnitude more severe than silicon based commercial electronics. This project will address the ISTC's objectives by funding SPETU and FTIKKS scientists, engineers, and technicians to produce silicon carbide based electronic materials and sensors which can be applied to the commercial and civil needs listed above, he research staff will be able to carry out both basic and applied research to develop silicon carbide electronic materials technology which can be applied for peaceful purposes in environmental protection, energy production. nuclear reactor safety, and other commercial industries such

	as the automotive and aircraft industries. Funding of this project will allow the research staff to collaborate and work jointly with private companies interested in developing silicon carbide based electronics for commercial applications. Successful development and commercial applications of silicon carbide based materials, sensors, and electronics will ensure the development of long term career opportunities in the civilian sector and will strengthen the scientific research and development capacity of the Russian institutions. Westinghouse and Sandia National Laboratories have met with SPETU and FTIKKS to discuss future joint activities in research and development of SiC materials and sensors. Westinghouse, Sandia, SPETU and FTIKKS jointly agreed that Westinghouse and Sandia would evaluate SiC material and sensors developed under the ISTC proposal; Westinghouse and Sandia would recommend changes to improve the material and sensors throughout the duration of the project. Westinghouse and Sandia will also seek to implement other proposals to develop SiC as an augmentation to the activities of the ISTC proposal. Perhaps the European and Japanese companies will be to test of samples and would recommend change characteristic of growing crystals of the project also. There is interest in development of SiC electronics materials in: France — Thomson CSF, Merlin Gerin; Germany — Siemens, Daimler-Benz, Bosch; Sweden — ABB; Japan — Sanyo, Sharp, Nissan, NKK Steal, Sumitomo; USA — Westinghouse, General Electric, NASA, CREE, ATM etc. The scope of activity will involve developing high quality and purity silicon carbide wafers with a minimum of defects and unintentionally introduced impurities. Studies will also concentrate on developing processes to dope the wafers during growth t create wafers with various electrophysical properties. High quality wafers are the foundation upon which transistors and sensors can be fabricated. The technical and methodological approach to achieving the objective is based upon continued improvement of the modified sublimation technique, an existing silicon carbide wafer growth process. Silicon carbide sensors which can monitor radiation, temperature, and pressure will also be developed and fabricated. Expected scientific results will include understanding defect forming mechanisms during silicon carbide growth, how the sources of unwanted impurities are included during wafer growth, and conditions which are necessary to obtain doping at desired levels and with desired uniformity across and through the wafer. These results will be summarized as a series of process steps to grow silicon carbide wafers. The development of high quality wafers will have immediate commercial significance. Silicon carbide sensors, transistors, and integrated circuits must be grown on high quality wafers. Development of high quality wafers will allow development of high quality electronics. These wafers can also be sold to companies interested in fabricating silicon carbide transistors and sensors but who do not have the capability to produce silicon carbide wafers. The development of high quality sensors will also have immediate commercial significance; sensors which can operate in the severe environments described above can be applied to the market place immediately.

６－２　材料分野／有機、電気材料（Organic and Electronics Materials）の研究機関
受託研究費　第２位

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保有技術	Materials / Organic and Electronics Materials Materials / Composites 材料分野以外の保有技術 Chemistry Environment Fission Reactors Non-Nuclear Energy

本研究機関の材料分野／有機、電気材料（Organic and Electronics Materials）における代表的プロジェクト	
プロジェクト名	Organic Polymer Light Emitting Devices
概要	有機的高分子化合物の発光デバイス材料
応用例	電気／電子機器
プロジェクト概要	The goal of the proposed Project is investigation of the mechanism of electroluminescence in polymeric systems and determination of the optimal conditions of its occurrence in order to select the most efficient macromolecular luminophores and the most suitable polymeric layers which will be able to carry significant injected currents at low voltage. Among these polymers are newly synthesized promising classes of polymers - poly (hydroxyamino-esters), aromatic polyimides, vacuum-deposited polyaniline, intercalated carbon materials, along with highly efficient low-molecular-weight photoluminophores: 2-phenyl-4H-3,1-benzoxazinon-4, oxadiazoles and widely used 8-hydroxyquinoline metal complexes. Photophysical and electrophysical properties of these materials make them suitable for usage in organic light-emitting diodes (OLEDs). We also intend to investigate electroluminescent layers made of thin films of vacuum deposited polyconjugated polymers such as polythiophene, polypyrrole, PPV and others. We intend to increase significantly (up to 10%) the quantum efficiency (photon/electron) of the polymer OLEDs and prolong the operation time of the devices. These parameters depend to a large extent on the physical and chemical aging of the active light-emitting and transporting polymer layers. Therefore we will investigate the influence of the physico-chemical state of the polymers, which is determined by the polymer specific free volume, T_g value, orientation of the macromolecules, the prehistory of polymer specimen etc., on the quantum yield of photoluminescence, the charge carrier transport and hence the efficiency of electroluminescence. In order to develop new injecting layers and methods of manufacturing of stable electroluminescent images, the processes of photodoping of electroconducting polymers and photochemical formation of luminescent elemento-organic complexes will be investigated. Particular attention will be paid to the investigation of charge carrier mobility in polymer matrices and preparation of the trapless polymer layers with high charge carrier mobility.

	This is important for the protection of the OLEDs from the Joule heating. In this context a theoretical analysis of charge carrier transport in disordered and locally ordered polymeric matrices will be carried out. Results of these studies will help us to find out the relationship between the characteristics of the electroluminescence and the transport, physico-chemical and structure properties of the polymer materials. As a final result of the investigation, highly efficient thermostable OLEDs will be produced. Possible roles of international collaborators are: (1) Synthesis and chemical modification of new polymer materials for electroluminescent layers and investigation of the morphology of polymer layers (group of prof. G.W.H. Milburn) (2) Investigation of spectral properties and relaxation processes hi electroluminescent compounds using second harmonic generation methods (group of prof. Rychwalski) (3) Joint theoretical researches on charge carrier transport in disordered organic matrices (groups of prof. Dunlap, prof. Parris, prof. Aoki, prof. Soos, prof. Bassler) (4) Mesurements of charge carrier drift mobilities in electroactive compounds (group of prof. Bassler) (5) Investigation of propagation of chemical reaction fronts in conductive polymers using unique microvisualization technique (group of prof. Aoki).

６－３　材料分野／有機、電気材料（**Organic and Electronics Materials**）の研究機関 受託研究費　第３位

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保有技術	Materials / Materials Synthesis and Processing Materials / Organic and Electronics Materials 材料分野以外の保有技術 Biotechnology and Life Sciences Chemistry Environment Fission Reactors Information and Communications Instrumentation Physics

本研究機関の材料分野／有機、電気材料（Organic and Electronics Materials）における代表的プロジェクト	
プロジェクト名	High-stable Radiation Resistant Semiconductors

７－１　材料分野／その他（Other）の研究機関　受託研究費　第１位

機関名	NPF "Stone & Silicates"
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保有技術	Materials / Ceramics Materials / Composites Materials / Materials Synthesis and Processing Materials / Other 材料分野以外の保有技術 Chemistry Instrumentation

本研究機関の材料分野／その他（Other）における代表的プロジェクト	
プロジェクト名	The New Technology for Production of Better Quality Perlite Fillers and Materials on Its Basis
概要	高品質真珠岩充填材、材料の研究
応用例	建築等
プロジェクト概要	In this project it is planned to develop and research a technology for production of better quality perlite filler with stable and predictable set of characteristics. This technology is an innovation in perlite production practice, as it allows to classify the starting material, i.e. the perlite rock, by its density in order to optimize the parameters for material refinement and perlite expansion. Analysis of scientific- technical literature on production of lightweight porous filler from perlite crude, shows that there are significant achievements in this area - such as designing perlite expansion furnaces and their development, determination and control of physico-mechanical and physico-chemical parameters of the rock, as well as regimes of preheating and expansion. However this is not enough for provision of effective production of expanded perlite and materials on its basis as the used filler has no guaranteed and optimal set of characteristics, as it directly depends on the homogeneity of the perlite rock. The complex structure of perlite deposits as well as non-rational technologies used for their mining, which does not take into consideration the geological particularities of dimensional allocation of perlite rock and their different species, causes a low quality and efficiency in the extraction of perlite rock. A characteristics feature that is often observed, is that the perlite flow can be considered as a zonal body, along the bedding of which different types of perlite (of different densities), as well as obsidians are met. The only method of perlite mining used in the worldwide practice has serious disadvantages – it doesn't ensure the homogeneity of the raw material. The range of changes of physical and technical characteristics of perlite is wide, particularly the density, which is changing along the bedding of the volcanic flow, as well as with its spatial distribution. The density ranges from 900 to 2200 kg/m3. As a result of bore-explosive works and excavations in perlite deposits with complicated structure, we get raw material with mixed perlite species, which have different densities. The narrow grading of primary and secondary crushed raw material, which is provided in normative documents, doesn't solve the problem of ensuring the homogeneity of the perlite

for expansion, instead the heterogeneity even increases during this process.

Getting homogeneous raw material from perlite deposits is a difficult problem, but it is quite possible to solve it. With a scientific approach it is possible to design brand new ways of perlite rock preparation with stable and improved technical and technological characteristics. We intend to use non-traditional methods of perlite mining by selective-thin grooving of layers in order to prevent the mixing of perlites with different density.

Preliminary investigations that we have made (Aragats perlite), show that there is a dependence between physico-technical and technological characteristics of the rock and its density. As a consequence of this, density is chosen as a main criterion for evaluating the quality of the raw material.

The core of the method is the following classification of perlite from a given perlite deposit by its density:

700-1000 kg/m3 – pumice-type
1000-1300 kg/m3 – porous
1300-1600 kg/m3 – slightly porous
1600-1900 kg/m3 – dense
1900kg/m3 and more- massive.

Each density class has its optimal regimes of elaboration and rational ways of usage.

So it is necessary to make selective mining and separate crushing of different types of perlite. This will enhance the efficiency during the expansion process and will allow a considerable decrease in energy expenses. The existing crushers are designed for crushing of durable rocks and have a low elective capacity leading to a significant amount of over granulated material.

The usage of a jaw crusher (brand SM-741) will allow to reduce energy expenditure for crushing porous species by 55%, and for slightly porous species by 15%. So it is recommended to use either low-powered crushers for porous and slightly porous species or use a spare regime for their crushing. If the density of the crushed raw material is constant, the crushed product will have stable characteristics, and its granule-metric composition will be dependent on product density.

Our investigations show the dependence of characteristics of the expanded perlite-such as density, water absorption, specific surface, thermal conductivity, from the size of particle and from the density of bed rock.

Using Aragats perlite deposit raw material, that is homogeneous in density and size, we can get 13.8 m3 expanded perlite from 1m3 raw materials, but using the traditional technology we can get only 9m3. So the new method is 35% higher in efficiency.

So, the proposed technology allows to produce higher quality filler with stable guaranteed characteristics and with improved economy in its production process.

We have also made a comparative analysis of the acoustic and insulation materials characteristics, using common expanded perlite, satisfying the requirements of GOST 25226-96, brand M75, and also using filler with a higher quality. The usage of higher quality filler will give the opportunity to reduce its usage by 10% without changing the physico-technical characteristics, thus to reduce the cost price, as the filler is the most expensive component. Usage of such filler material is also very advantageous in terms of ecology – the stone resources are not revived in the nature, and their rational and careful usage is very important. As ecological aspects of building materials is getting more important in all areas of human activities, we made preliminary measurements for the determination of radioactive parameters in various perlite species. We concluded that the radioactivity decreases with increasing density (from 1000 to 2000 kg/m3) and decreasing size fraction (from 5,0 to 0,14 mm).

Thus, we have all the bases to affirm, that the suggested method of getting higher quality porous aggregate with guaranteed set of characteristics is economically more effective than the widely used method.

The goals of the project are:

	- Investigation and establishment of consistent patterns of changes of physico-technical and technological characteristics of perlite rock and interconnections between them, as well as the exposure of the most reasonable (basic) criterion of its complex evaluation. - Development of methods for determination of basic quality evaluation criteria for the raw material in the quarries, which will enable the operative quality control for the mining and manufactured raw material. - Evaluation of dimensional allocation of the perlite rock and its species in the perlite deposits according to their depth and expansion. This evaluation will allow to specify the main elaboration characteristics for getting quality raw material for expansion. - Development of a rational technology and bases of the characteristics of the mining works especially for mining of raw material for expansion. - Investigation of mechanism for changing the characteristics of the rock, which will influence the process of expanding during its crushing. - Analysis the influence of characteristics set by certain criteria, on the characteristics of expanded perlite and its investigation by modern physico-technical and physico-chemical methods. - Investigation of the possibilities of a controlled change of characteristics of perlite material, produced by using improved aggregate. - Synthesis of new compounds, taking into consideration the structural differences and physico-technical characteristics of expanded perlite. **As a result of this project the following problems will be solved:** - Development of a new low-resource and low-energy consuming technology to produce aggregates with improved and predictable characteristics. - Creation of a new complex evaluation method for perlite-fields and a rational technology for their elaboration. - Development of recommendations for effective usage of perlite rock, expanded aggregate and corrections made in the normative-technical documentation concerning the classification of the rock by densities. - Development of the new wood-substitutes composites, on the bases of improved aggregates and fiber components. - Reorientation of highly qualified scientific staff for peaceful problems solution and for encouragement of investigations and engineering works for peaceful purposes. - Integration of the scientists into the international society. The staff of the CJSC Stone and Silicates" has worked on the investigation of perlite rock, development of effective technologies and production of expanded perlite and perlite materials for a long period. The authors of the project invite scientific collectives, investigation organizations and companies dealing with extraction and production of expanded perlite, as well as individual experts and scientists from Europe, USA, Japan and Korea for cooperation. We also suggest the organization of joint seminars and scientific researches.

７－２　材料分野／その他（Other）の研究機関　受託研究費　第２位

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保有技術	Materials / Ceramics Materials / Composites Materials / High Performance Metals and Alloys Materials / Organic and Electronics Materials Materials / Other 材料分野以外の保有技術 Chemistry Manufacturing Technology Non-Nuclear Energy Other / Building Industry Technology

本研究機関の材料分野／その他（Other）における代表的プロジェクト	
プロジェクト名	Bases of Perlite Rocks Bloating New Theory and Technology; Production of Light-Weight and Higth-Strength Products from Perlite without Using a Foreign Binder
概要	高品質真珠岩充填材、材料の研究
応用例	建築等
プロジェクト概要	The goal of the Project is the development of perlite rocks bloating theory and technology new basis. Utilization of heat-insulation materials and products on the basis of bloated perlite softens to some extent the problem of fuel-energy and raw materials resources saving. The bases of perlite bloating processes are not fully studied at present, which results in incomplete use of properties hidden in natural material. To produce lightweight products it is necessary to use binder of organic or non-organic origin together with bloated perlite. In both cases energy costs and products cost are being increased. Perlite bloating processes have different and contradictory interpretation at present, such as: - In one of the work the author considers that during heating the heat flux front doesn't pass inside the grain at once, therefore peripheral layers bloat first and then deeper ones; - I.N. Yavits assumes that in case of perlite grain abrupt heating the surface layer looses water quickly, increasing therefore the viscosity of the layer which serves as an elastic film covering the glass main floating mass; - According to P.P. Budnikov and A.E. Rohvarger pore-formation takes place only when small grains are placed in high temperature area at once where they undergo sharp thermal shock. In case of slow heating gradual water loss occurs without perlite glass mass bloating; - D. Shackley and M. Alien are of similar opinion. They discovered that small perlite grains bloat while heated at a rate of 9907min; - N.S. Manujlova has studied the bloating process under microscope and found that it begins at 600 °C with pore-formation in the centre of perlite cell from where the

	process is being spread all over perlite full; - Another approach was presented by E. Saakyan: she added 4.5-9.3 mass % of sodium oxide (in form of NaOH), that reduced the mixture viscosity by combining the mass pyroplastic state with gas component evolution. In this case the production of cellular material is getting possible by cellular glass technology. Consequently, adding of alkali into the raw material will cause rise in price of the produced light-weight material and will reduce material heat resistance from 950° to 600°C. We consider this not the best problem solution. The following problems will be solved as the results of Project implementation: - creation of perlite rocks bloating new theory and technology; - designing of new large-scale laboratory production line to produce light-weight products from perlite without using a foreign finder; - reorientation of highly qualified personnel on peaceful problems solution; scientists integration into the international scientists society; - assistance in solving international and national problems in seismostable construction and fuel-energy and raw material resources saving. The following experts participate in Project implementation: Doctor of Technical Sciences: 2 experts Candidates of Technical Sciences: 4 experts. Thus, a completed theory, explaining the bloating processes and allowing to fully use the rock properties, as well as to produce heat resistant and high-strength light-weight products without using a foreign finder is not available at present. It is envisaged under the Project to perform scientific and research works on revealing the floating processes mechanism, establishing the process line new theory and scheme for production of high-strength light-weight products from perlite rocks with high operating temperature at large-scale laboratory installation without using a binder and with controllable structure and properties. It will allow to widen the raw material basis, to reduce the cost of light-weight products manufacturing and to expand their utilization areas, as well as to open a great perspective of glass rocks bloating technology improvement with further products cost reduction by simplifying and automating the technological processes. The Manager of the Project, Varuzhanyan A., defended a thesis in chemical - Technological Institute after Mendeleyev D.I. in 1967 in Moscow on a subject "Investigation of water vapors influence on perlit rocks viscosity and bloating at softening interval under increased pressures " which he had been performing under guidance of the USSR Academy of sciences member-correspondent USSR A.S. academician Pyotr Petrovich Budnikov. The Other Scientific workers and engineers are highly qualified. They dealt with investigation of volcanic glassy rocks porization structure and conditions. The activity of the group consists mainly of founding perlite rocks bloating new theory and of drawing up new theory bases for obtaining high-strength lightweight products from perlite without a binder. What refers to foreign collaborators role, in addition to the foreseen in "Instruction on the proposals preparation" from 09.10.1998, participation is desired in testings of the new technology and especially when obtaining light-weight highstrength products from fine-dispersed powoler (less then 150uJtm), which forms during perlite rock grains production. If desired, they can participate themselves or jointly with others on share bases in the implementation of the new technology into the production of lightweight high-strength products from perlite rocks. The Project conforms completely to the tasks and purposes of 1STC.

７－３　材料分野／その他（**Other**）の研究機関　受託研究費　第３位

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本研究機関の材料分野／その他（Other）における代表的プロジェクト	
プロジェクト名	Study of Processes of Destruction of Freshwater Polycrystalline Ice in Wide Range of Temperatures and Strain Rates
概要	淡水多結晶氷の破壊過程の研究
プロジェクト概要	In spite of the fact that ice belongs to number of most ancient natural materials, its properties have been studied far insufficiently. It can be explained by objective reasons. Because of great variety of structures, compositions, physical-mechanical states, ice properties are also rather various at various parameters of effects (temperature, intensity, duration and scale of effect, etc.). Polycrystalline ice is a model material useful in fundamental researches in the field of mechanics of a deformable solid. Study of physical and mechanical properties of ice is a traditional and ultimately determining from the point of view of the subsequent engineering-

technical applications. Many works are mostly devoted to properties of freshwater polycrystalline ice under static loading. To the present time the properties of freshwater ice under dynamic loadings and regularities of ice fracture are researched much worse.

A small number of works on study of ice crack-resistance have been published.

The concepts existing in fractures mechanics have been just started to be used for description of ice fracture. There are a few works on determination of characteristics of freshwater ice crack-resistance. Researches of crack-resistance of sea ices in the environment of deformation from quasi-static up to dynamic from 10 up to 10^{-3} s^{-1} have not been performed.

Goal of this project is study of processes of fracture of freshwater polycrystalline ice in a wide range of temperatures (from -60 to -1 °C) and strain rates (from 10^{-9} to 10^{4} s^{-1}). Thus in the specified range of temperatures, the physical-mechanical characteristics of polycrystalline ice will be determined.

Within the framework of the Project, it is planed to carry out collection, processing and analysis of data published in Russian Federation on physical-mechanical properties of polycrystalline ice.

It is planned to perform the following efforts under the Project frameworks:

- to develop a series of experimental techniques taking into account peculiarities of polycrystalline ice;
- to determine the physical-mechanical characteristics of polycrystalline ice in a wide interval of boundary conditions of loading and change of thermodynamic state;
- to study influence of deformation changes of ice structure on its physical-mechanical and strength characteristics, and regularities of its fracture;
- to study processes of origin, accumulation and interaction of cracks, and fracture of polycrystalline ice;
- to study interactions of steel cylindrical impactors with ice slabs;
- to study influence of scale factor at dynamic tests.

It should be noted that for the first time, in the author's opinion, it is expected to obtain experimental data at strain rates of polycrystalline ice ε = 10-10^{4} s^{-1}.

During Project efforts, it is planned to manufacture a portable device designed by one of the Project authors (Penetrometer. I/s USSR № 1539583 kl. G01N 3/48. Bull. № 4 30.01.90). This device is intended for collecting data on mechanical properties of ice in the environment of its natural deposition. It is planned to collect data on particular region.

Result of the Project will be accumulation of data on fundamental issues important for thorough understanding of ice fracture processes.

Except for the contribution to fundamental studies, the data obtained in this Project on dynamic characteristics, dynamic crack-resistance, study of interaction of steel cylindrical impactors will be useful for solving of a lot of applied problems, for example, for struggle against ice jams, solving of glaciers problems, etc. The above-mentioned portable device produced during the Project efforts can be used to estimate ice massive state for prevention of catastrophic situations.

Peculiarity of experimental studies planed within the Project framework will be solving of a series of methodical problems, which are taking into account specific properties of ice. In order to reduce scatter of measured values caused by residual stresses and defects in ice structure, it is planned to develop the technique for manufacture of samples of polycrystalline ice in laboratory environment, and the methods for estimation of identity of initial ice samples intended for mechanical tests.

It is planned to up-date the available experimental techniques, and to develop the measuring complex for observations of changes in microstructure of polycrystalline ice directly during

	deformation without need for unloading and micro sections production. This method is based on volume probing of a deformed sample by high-frequency acoustic impulses and recording of amplitude-frequency parameters of AE signals. The method is verified by the authors by testing ice and other structural materials at various types of stress-strain states. For keeping the required temperature during tests, we plan to use cryochambers. The minimum gradient of temperature will be reached with the help of two thermostatic shells and additional cooling of supporting platforms of the testing machine. The processes of origin, accumulation and interaction of cracks, as well as fracture of polycrystalline ice of various structure at static will be carried out with the help of the acoustic methods. Studies of initiation and interaction of cracks in large-sized ice slabs during tests by the split-Hopkinson-bar method will be carried out with the help of high-velocity digital video camera making 10 thousand frames per second. Mechanical characteristics of polycrystalline ice at uniaxial dynamic tension and compression during Project efforts will be determined by the split-Hopkinson-bar method (the Kolsky method). This method for testing of structural materials at strain rates ε = 10-10^4 s^{-1} has correct calculated and experimental substantiation. On the basis of the Kolsky method in VNIIEF more than twenty years ago, the testing facilities with explosive damping loading were developed and used. They allow to perform tests both in the field and laboratory environment. The explosive loading device allows to form impulse loadings of trapezoidal shape, and to vary loading amplitude within a wide range. This enables to perform testing of materials, which are tens times differ in strength. Application of compact cryochambers allows to perform dynamic tests at decreased temperatures (up to -60 °C). Specified temperature will be also kept at end faces of measuring cores, between which a tested sample is placed. Study of process of interaction of rigidly-cylindrical impactor with large-scale slabs of ice will be carried out at unique ballistic facilities with use of energy of explosion and pressure of compressed gas for formation of impulse loadings. Impactor velocity is 350-500 m/s. The principle of operation of the above-mentioned portable device, which is planned to be produced during the Project efforts, is based on studies performed by the authors with ice fracture at dynamic insertion of a rigid spherical indentor equipped with piezoelectric accelerometer. Methodology of the researches fits the world level. It is based on works of G. Kolsky, J. Klepachko, and scientists from RFNC-VNIIEF. This technique allows researching the dynamic crack-resistance of materials at various temperatures that is a doubtless advantage before the known Russian and foreign techniques allowing carrying out tests only at normal temperature. The proposed technique for research of dynamic crack-resistance in application to the problems of research of polycrystalline and sea ices is pioneer, facilitating deeper understanding of complicated regulations of their fracture. The author's team has wide experience in experimental studies of mechanical characteristics of polycrystalline ice and processes of its fracture depending on temperature and loading rate, and in experimental studies of dynamic fracture of materials in various environments of loading. From the early 80^{th}, alongside with the other studies of dynamic strength of materials performed for a long time already, the author's team has studied their dynamic crack-resistance. Competence of the highly skilled participants of the Project in the field of study of physical-mechanical properties of polycrystalline ice, dynamic fracture of materials in various

	environments of loading does not cause doubt, and it is documentary confirmed by large number of publications. It gives reliance that the Project objectives will be reached by efforts of the author's team. This Project meets ISTC goals and objectives: – Project relates to fundamental researches. Experimental data got in the Project frameworks will make large contribution to thorough understanding of processes of destruction of polycrystalline ice. – Project encourages involving of experts producing a nuclear ammunition into international cooperation. The suggested Project provides highly skilled weapons scientists and engineers from RFNC-VNIIEF with opportunities to redirect their talents to peaceful activities. Project duration is 2 years. Role of foreign Collaborators includes discussion of place for arrangement of experiments aimed to determine mechanical properties of ice in environments of its natural deposition.