THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE

# SCIENCE AND INNOVATION

SCIENCE AND PRACTICE JOURNAL

Published bimonthly
Founded in Marth 2005

Volume 2 # 4 2006



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**FOUNDERS** –
The National Academy of Sciences of Ukraine

**PUBLISHER** –
Publishing House "Academperiodika"



Publishing House "Academperiodika".
01004 Kyiv, Tereshchenkivska str. 4.

**State Registration Certificate** –
**KB 9759 of 13.04.05**

**Subscription index:**
Individuals – **91942,**
Institutions – **91943**
**ISSN 1815-2066**

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**INFORMATIONAL CHAPTER**

# The STCU Workshop
# "From Science to Business"

# Семінар УНТЦ
# "Від науки до бізнесу"


NATO OTAN

*This project is supported by:* The NATO Programme for Security through Science

# WELCOME FROM STCU EXECUTIVE DIRECTOR

The STCU Workshop "From Science to Business" is an excellent forum for commercial and business exchanges with scientists of Ukraine.

The STCU is ideally positioned to match an unexploited supply of scientific and technical expertise to meet your commercial or non-commercial needs. Through its primary mission of non-proliferation of WMD expertise, the STCU has compiled a treasure trove of experience and knowledge about the many highly talented scientists and technologists in Ukraine, Azerbaijan, Georgia, Moldova and Uzbekistan. And the STCU is a well-established, western-style organization with nearly 10 years of operational experience that can help steer you through the uncertainties of the business and investment environments in these emerging economies. The STCU has:

– Legal status, diplomatic accreditation, tax and customs exemptions for financed projects and activities, all guaranteed under the international agreement establishing the STCU;
– Proven experience in project management: nearly 1000 research projects totalling nearly $145 million;
– Over 150 private sector and governmental agencies which have joined the STCU's Partnership Program to finance their own, tailored S&T projects (totalling more than $45 million) through the STCU.

The STCU's staff of professionals is experienced in working with industry and business representatives, including protecting their business-sensitive information and interests. In this way, the STCU can serve you as a trustworthy and cost-effective bridge to the yet-to-be-tapped opportunities for contract research and technology development in Ukraine, Azerbaijan, Georgia, Moldova and Uzbekistan.

I hope that you will find the STCU worthy of a closer look. It is a win-win-win situation you should not pass up: win for you, win for these former military institutes looking for a chance to perform, and win for the STCU's non-proliferation mission (which, actually, is a win for global security)!

Let us know if STCU can be of service to you in matching your business and technology needs.

***Respectfully,***

***Andrew A. Hood***
***STCU Executive Director***

# ENVIRONMENTALLY FRIENDLY GASIFICATION OF MUNICIPAL SOLID WASTES

## *Description*

Environmentally friendly gasification technology for processing of municipal solid waste (MSW) is proposed. The technology allows to treat MSW effectively and to obtain medium-calorific producer gas with minimal negative impact upon environment. Twin fluid bed gasifier consists of two fluid bed reactors – gasifier itself and combustion chamber – connected with each other by a chute.

Steam gasification takes place in the gasifier; sand is an inert material of the bed. Sand is heated in combustion chamber at the expense of burning of char coming from gasifier through chute. Heated sand goes back to gasifier. The construction of the unit is suitable for further scaling up so that the technology is brought to demonstration level and then to commercial application.

## *Innovative Aspects and Main Advantages*

The proposed gasification technology has advantages over other types of gasifiers as well as over other thermochemical processes for MSW treatment such as combustion and pyrolysis, namely:

- low formation of dioxins and furans due to optimal construction of the gasifier and combustion chamber;
- comparatively simple gas cleaning system;
- low negative impact upon environment;
- compacting effect from gasification is much more than that from pyrolysis. Unburned charcoal remains after pyrolysis while only ash remains after gasification;
- gasification is a less power-consuming process than pyrolysis;
- as gasification takes place under limited amount of oxygen, formation of dioxins is much less intensive than during direct combustion of MSW;
- due to lower temperature during gasification as against combustion, formation of $NO_x$ is also much less intensive.

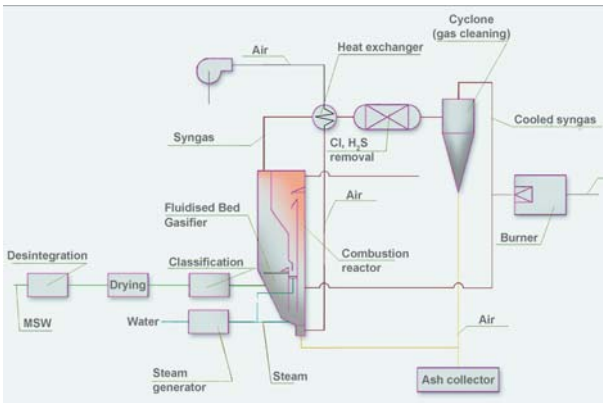


**Fig. 1. Layout of a 50 kW twin fluid bed gasifier**

## *Area of Application*

The installation can be used by municipalities or landfill operators for MSW utilization. As producer gas is of high quality the unit can be equipped with gas engine for power production.

## *Stage of development*

A 50 kW experimental unit has been constructed and investigated in the laboratory. Detail design and design documentation is available. The unit can be scaled up to 5 $MW_{th}$ without significant problems.

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# HIGH PRESSURE HYDROGEN ELECTROLYZER FOR AUTO AND INDUSTRIAL APPLICATIONS

## *Description*

Offered electrolyzer design employs a new method of separating the processes of gas (hydrogen and oxygen) liberation in time. Therefore, operation of electrolytic system becomes cyclic, that is, it consists of alternative cycles of hydrogen liberation and oxygen liberation.Separating in time the processes of gas liberation is possible if one of the water electrolysis products is accumulated in an electrochemically active compound found in the electrochemical cell in the liquid or solid phase (active electrode). This does not result in a dramatic change in the volume of this compound, and allows obtaining the second component on the passive electrode in the form of gas without any separating membranes. Then, with polarity reversal, the cycle of the accumulated component liberation takes place on the electrodes. During the processes, gas pressure can be limited only by solidity of constructional elementsand the threshold of gas solubility in electrolyte. In practice, the actual pressure level is within 70.0 MPa. The proposed electrolyzer option can ensure production of 5 $nm^3$ of hydrogen per hour under the pressure of 120 atm without using a compressor.

Key electrolyzer cost-effectiveness indices are:

- installation efficiency is 75–80 %;
- power consumption for producing 1 $m^3$ of hydrogen and 0.5 $m^3$ of oxygen is up to 4.3 kW;
- dimensions of the plant: width 670 mm, depth 560 mm, height 2550 mm.

A method has been developed which allows maintaining the activity of electrode materials at a sufficiently high level, and to extend the nomenclature of materials suitable for design of fuel cells. This method involves practical implementation of technology which allows to maintain activity of electrode materials at a specified level by selecting operation regimes which provide for self-regeneration capability of electrochemical systems.

## *Innovative Aspects and Main Advantages*

The advantage of using a high pressure electrolyzer is that it can utilize non-conventional electric power and accumulate high-pressure hydrogen. So, it can generate electric power by operating as a fuel element. The novel feature of the technology offered is that the reversible electrochemical cell employs a unique regeneration technology allowing to remove the sponge (dissolve or transfer it to an auxiliary electrode), and then deposit it on the working electrodes in the same electrolyte that is used when the fuel cell operates in the standard regime. The proposed system excels other known systems of hydrogen accumulation and use in:·

**Fig. 1. Operating prototype of a high pressure electrolyze**

**Fig. 2. Electrode stack**

- technical level;
- simplicity of assembling and service;
- reliability and safety.

## *Area of Application*

High pressure electrolyzer is intended for wide use on objects with renewal sources of energy , and also in the industries using hydrogen as the technological product (chemical, metallurgical, food industries etc.)

Generation of high-pressure hydrogen allows to consider developed electrolysis equipment as an element for the infrastructure of automobile hydrogen filling stations.

## *Stage of development*

Operating prototypes of a high pressure electrolyzer have been developed.

The system has undergone laboratory and full-scale tests at SDB "Yuzhnoye" (Dnepropetrovsk) and in Southern regions of Ukraine, in particular, in Crimea. It is patented.

A stand model of electrochemical cell working as fuel cell has been developed. It is patented.

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# PIEZO-ELECTRIC VALVE FOR REAL-TIME AND ACCURATE CONTROL

## *Description*

A motorized control valve is developed to regulate any kinds of liquids, steam, gas or vacuum streams. It can be used in energy industry, chemical industry, food industry etc.

At the basis of the piezoelectric control valve is a special piezoelectric mechanism which, on one hand, allows very fast action (analogous to the cut-off valve), and on the other hand, it allows very precise control (analogous to the controller valve). At the present time these two valves work separately complementing each other. Our single valve can replace either one of them, or both.

The suggested piezoelectric valve is intended for using simultaneously as a fast valve with working time less than one second, as well as a precise valve with high angular resolution (minimum angular increment ~ 1 arc-sec, response time ~ 50 μs).

In case a piezoelectric valve is jammed, the piezoelectric mechanism, unlike an ordinary electric motor, will not burn itself out. The piezoelectric valve, unlike an ordinary motor, also generates no sparks.

## *Innovative Aspects and Main Advantages*

Generally, a control valve comprises three primary components: a valve, (such as a ball valve,) a DC motor and a control circuit (see control valves manufactured by companies such as Siemens, Johnson Controls, Sauter, Danfoss, Belimo, Joventa).

Such control valves are characterized by low speed (duration of "closed-open" mode ranges from 30 to 140 seconds ), low resolution (1–5 angular degrees), a response time of 1–2 seconds, high weight (1–2 kilograms) and high cost ( $400 – for a valve with resolution 1–5 ang. degrees; $1000 for a valve with 0.2–1 ang. degree resolution).

The suggested valve will be an inexpensive noiseless piezoelectric valve with high speed (duration "closed-open" mode less than 1 second), high resolution (less than 1/3,600 angular degree or 1 arc-sec), rapid response time (1/20,000 second or 50 μs), and low weight (250–300 g) – all in one product.

Technical data for piezoelectric ball valve for a 1/2" (half-inch) pipe:

| | |
|---|---|
| – Working time (duration "closed-open" mode) | < 1 “ |
| – Angular resolution (min. angular increment) | 1 arc-sec |
| – Response time | 50 μs |
| – Weight (with the 1/2" valve) | 250 g |
| – Voltage | 12 V |
| – Power | 4–6 W |

**Fig. 1. Piezoelectric ball valves for a 1/2" (half-inch) pipe and a 1'' (inch) pipe**

## *Areas of application*

Such a valve will find use in all systems in the world, which contain tubes: steam heating, water pipelines, gas pipelines, oil pipelines, power reactors, chemical reactors, power motors, vacuum systems, etc.

The Piezoelectric Valve will enable development of a new generation of power systems (engines of internal combustion, turbojets, steam and gas generators, and nuclear reactors), various hydraulic systems with small response times and with high control accuracy. Thus, "thermo-gas-hydraulic" systems working in real time, with speed approaching that of electronic systems, can be developed.

In addition to the broader industrial uses described above, the piezoelectric valve offers significant commercial potential at an individual household level. The valve would enable precise regulation of household water supply and household heat supply with a noiseless, small-sized, energy-efficient, and simple to control element. In particular, the Piezoelectric Valve could offer a significant safety improvement on existing systems for regulating household gas supply, by reducing the risk of spark and explosion.

## *Stage of development*

LILEYA's Piezoelectric Valve is being patented in UA and USA. LILEYA can produce 500–1000 Piezoelectric Valve in years.

## *Contact details:*

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**E-mail:** tyl1@naverex.kiev.ua
www.piezomotor.com.ua

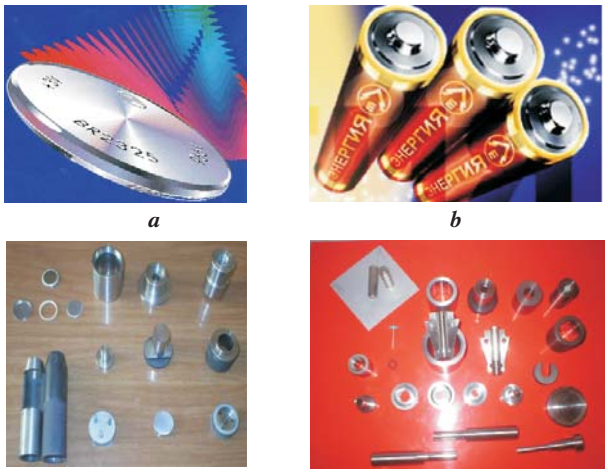
# NOVEL "ENERGETIC" MATERIALS & EQUIPMENT FOR PORTABLE BATTERIES ASSEMBLY

## *Description*

Electrochemical methods of energy storage and conversion are of great interest for many practical applications. The market of portable batteries and fuel cells for electronic devices is showing a strong tendency to expansion. Answering the needs of environmental protection, a lot of research work is devoted to development of fuel cells and promising batteries for electrical vehicles. There is a great demand, therefore, for relatively low cost and environmental friendly electrode materials and catalysts used in batteries and fuel cells.

However, there is a huge discrepancy between experimental data obtained in the laboratories of different scientific centers and battery manufacturers. The main reason is that most research laboratories can not carry out electrochemical testing of their materials in full battery samples of industrial sizes. It is impossible, therefore, to carry out standard tests required by industry.

We have developed reliable, precise and relatively low cost sets of laboratory equipment and technology for making battery samples of standard industrial sizes.



*a* *b* *c* *d*

**Fig. 1. Coin (*a*) and cylindrical (*b*) batteries of different chemistries, as well as laboratory equipment for assembling of batteries (*c*) and (*d*)**

## *Innovative Aspects and Main Advantages*

Kyiv National University of Technology and Design (KNUTD) has developed a set of Lab equipment and technologies in order to assemble the coin cells of 2016 and 2325 sizes (Fig. 1 a, c) for testing the Lithium, Lithium-Ion, Lithium-Polymer and alkaline manganese dioxide batteries (Table 1), as well as novel materials for these types of batteries.

KNUTD has developed unique sets of equipment and Lab. technology for assembling the following types of cylindrical batteries:

– alkaline manganese dioxide battery AA size;
– carbon/Zinc batteries of AA and D sizes (Fig. 1 b, d).

Different promising active materials, electrolytes, separators, conductive and other types of additives, current collectors and other novel materials could be tested in battery samples of some standard industrial sizes of different chemistries.

For example, materials for negative electrodes of lithium – ion batteries with specific capacity from 400 to 600 Ah/kg have been developed in cooperation with superior Graphite Co., Chicago, IL.

**Table 1. Characteristics of coin batteries attained in standard industrial sizes**

| Type of battery | Size | Voltage, V | Capacity, mA·h |
|---|---|---|---|
| Lithium-Ion battery | 2016 | 4.2 | 10-15 |
| Li/$MnO_2$ primary battery | 2016 | 3.4 | 110 |
| Alkaline Zn/ $MnO_2$ battery | 2016 | 1.6 | 91 |
| Li/$MnO_2$ primary battery | 2325 | 3.4 | 226 |
| Alkaline Zn/ $MnO_2$ battery | 2325 | 1.6 | 190-250 |

**Table 2. Characteistic of cylindrical batteries attained in standard industrial sizes**

| Type of battery | Size | Voltage, V | Capacity, mA·h |
|---|---|---|---|
| Alkaline Zn/ $MnO_2$ battery | AA | 1.6 | 2600 |
| Carbon/Zinc battery | AA | 1.6 | 760 |
| Carbon/Zinc battery | D | 1.6 | 5044 |

## *Areas of Application*

Different electronic and electrotechnical equipment (like watches, flashlights, calculators, computers, children's toys, remote-control stations, mobile telephones, cameras, camera-recorders, etc.).

## *Stage of development*

Tested, available for demonstration.

## *Contact details:*

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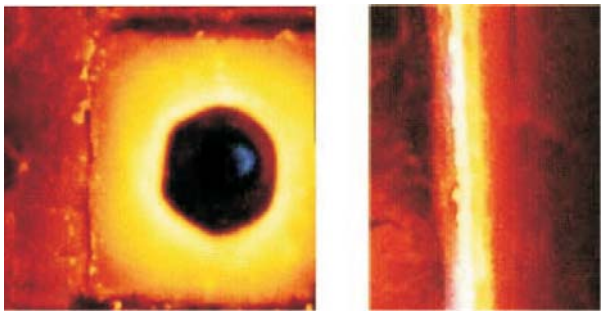
# SUPER-STABLE, LOW-EMISSION, FLAT-FLAME BURNERS FOR INDUSTRIAL FURNACES

## *Description*

The proposed burner facility concerns development of the concept and designs of environmentally compatible burners of super stable combustion performance, each of them being available within wide temperature range for reheating and heat treatment furnaces. It's assumed that the furnace operation ensures high power efficiency and minimum $NO_x$ emissions. The Flat Flame burners represent radiation type of facilities. They are intended to provide high intensive uniform heat input for the industrial furnaces of various purpose, beginning from those operating at low (750...1050 K) to high temperature (1550...1900 K) furnaces. LE FFB provide technological, energetical and environmental advantages to furnaces.

## *Innovative aspect and main advantages*

- LE FFB ensure uniform distribution of temperatures (non-uniformity is ± 5...10 K and heat fluxes deviation not more than ± 2...10 %) in the interface of the heating surface.
- The use of the burners in industrial furnaces ensures 20...30 % of fuel saving.
- LE FFB represent universal burner design as for the temperature range of the furnace operation (800...1900 K) in the conditions with variation of the furnace thermal capacity and air excess factor.
- LE FFB ensure super-stable low-emission fuel combustion in the wide ranges of the furnace temperatures (500...1900 K) and combustion air preheating (till 600...800 K).
- Each of the burner facilities ensures the furnace operation in the wide range of furnace temperatures, and thus, provides the possibility for realization of complicated operating practices (usually for heat treatment furnaces).
- Environmental advantages (concentration value of the main pollutants):
  - [$NO_x$] – no more than 20...80 ppm (depending on air preheating (300...600 K) and the furnace temperature up to 1773 K);
  - [CO] – not more than 10 ppm.



*a* *b*

**Fig. 1. Front (a) and side (b) views of the flame formed by operation of LE FFB**

## *Areas of Application*

LE FFB are developed for use in the reheating, thermal and chemical-thermal treatment of ferrous and non-ferrous metals, as well as non-metallic materials: firing of ceramics, radio-ceramics, ferrites, metallic compounds, salts and oxides of metals, pyrolysis of the petroleum products; melting of glass and mineral glass wool.

## *Stage of Development*

The prototypes of the burner are tested at a fire test bench and in industrial conditions; available for demonstration. The previous version of this burners (series GPP)(FFB) have been patented in many countries, commercialized, and various standard sizes have been widely used in various branches of the industry.

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# TECHNOLOGY FOR BIOGAS UTILIZATION

## *Description*

Biogas (methane ($CH_4$) and carbon dioxide ($CO_2$) gaseous mixture) is fuel gaseous mixture with $CH_4 > 50$ %. The use of biogas is an important task as it would solve ecological (limitation of biogas atmospheric emission) and economical (additional energy source) problems. We have developed a technology and a facility for biogas utilization.

The facility consists of 6 separation modules working alternately and ensuring continuity of the technological process. Depending on input biogas composition and requirements to products, facility can contain a set of all modules or one of them.

Facility allows to divide biogas into the components:

- liquefied almost pure methane in standard vessels with volume 40–50 litters under the pressure 20 MPa and with purity 96 %;
- liquid carbon dioxide in similar vessels under the pressure 5–6 MPa;
- solide carbones dioxyde (dry ice ).

Technical parameters of the facility:

- overall dimensions, mm – 1700×1050×650;
- productivity in biogas terms – 50 $nm^3$/hour;
- admixtures of the other components in the separated methane and carbon dioxide – ~ 4 %;
- facility weight – ~ 150 kg.

Pressure swing method was used for this work. Method uses different concentrations of biogas components in the gaseous phase at the upper and lower pressure levels in absorber, that is caused by different absorbability of the carbon dioxide and methane. When gaseous phase is sampled from the absorber at the upper pressure level, we obtain mixture enriched with less sorbent component – methane, when it is done at the low pressure level – more sorbent carbon dioxide.

Facility block scheme, its general view and motor-generator are shown at the pictures.

## *Innovative Aspects and Main Advantages*

The main innovative aspect is the use of the Pressure Swing Method (PSM). The cycle is short and the process requires room temperature. These two factors combined with motor-generator working at the produced methane ensure autonomous facility operation.

## *Areas of Application*

The facility can be used in different fields in which organic wastes are concerned:

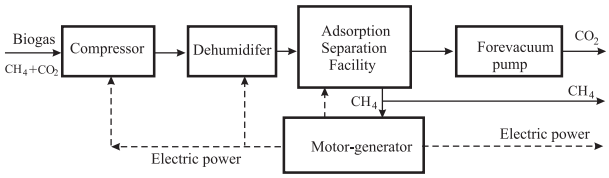


**Fig. 1. Block diagram of the autonomous complex facility for biogas utilization**

**Fig. 2. Model of an experimental-industrial facility for biogas separation. General view**

**Fig. 3. Motor-generator**

- Agriculture;
- Factories of the food industry;
- Plants of biological purification foul water;
- Solid domestic waste dumps.

## *Stage of development*

Development phase – laboratory tested, available for demonstration

Patented: Patents of Ukraine: U 38746 A, bulletin №4, 2001; U 44512 A, bulletin №2, 2002; 8870, bulletin №8, 15.08.2005

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# SOLAR ARRAYS FOR PORTABLE ELECTRONIC EQUIPMENT

## *Description*

The increased number of complicated portable electronic equipment containing electrical accumulator batterys in last 5–10 years, tendency to widening of the equipment functions and reduction of dimensions, and also pressing need for mass application of ecologically pure renewable sources of energy – these are the necessary prerequisites for mass application of decentralized photovoltaic chargers.

Portable solar arrays are intended for professional and everyday portable electronic equipment power supply (mobile and satellite phones, satellite navigation systems, portable computers, modern photo- and video- cameras, ecological monitoring equipment, audio equipment etc.) in autonomous conditions.

The principle of electrical energy generation by solar arrays is based on photovoltaic effect in semiconductor structures with p-n- junction. The monocrystalline silicon as material for solar cells is used. It allows to ensure high efficiency of photoconversion and long service life. The hermetic sealing is carried out with the use of hot lamination in vacuum technology.

On Fig. 1 a vacuum laminator VL540/290 is presented which was developed and made in SDTB of V. Lashkaryov ISP of NAS of Ukraine and was used for experimental samples of solar arrays manufacturing.

On Fig. 2 an experimental sample of solar array for mobile phones SBMT-S-8.0-0.23 is presented, which can be used for other portable equipment as well.

## *Specifications of solar array SBMT-S-8.0-0.23*

| | |
|---|---|
| Charging current* | – 0,23 A |
| Open-circuit voltage* | – 8,0 V |
| Dimensions | |
| in operation position | – 75,0×270,0×3,8 mm |
| in transportation position | – 75,0×55,0×15,0 mm |
| Weight | – 120 g |

*AM (1,5), 1000 Wp/м$^2$, 25±2 °C.

**Fig. 1. Vacuum laminator VL540/290**

**Fig. 2. Folding solar array for mobile phones SBMT-S-8.0-0.23 (experimental sample) and its case**

## *Innovative Aspects and Main Advantages*

The main innovative aspect is in applying the principle usually used for space equipment: in the transportation position solar array is in compactly packed condition and has minimal weight and dimensions parameters.

The design and technology guarantees its high resistance to negative climatic and transport factors, high reliability and considerable operation resource (up to 8 years and more).

## *Areas of Application*

Portable solar arrays can be used in such areas as:

- Communication;
- Computer equipment;
- Military equipment;
- Photo-, video- audio- equipment;
- Tourism and everyday life.

As solar arrays are useful in any case when electric energy is needed but stationary electrical grid is absent, there can be other areas of application for them as well.

## *Stage of development*

Experimental samples have been made. Laboratory tests have been carried out. Laboratory technology has been developed which is based on the technological equipment made in SDTB of V. Lashkaryov ISP of NAS of Ukraine.

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# GOLD-BEARING PROBIOTIC DRUG *OKARIN-AU* FOR TREATMENT OF INFECTIOUS DISEASES SUCH AS ANTHRAX, RABBIT-FEVER AND BRUCELLOSIS

## *Description*

The deterioration of the epidemic situation in Ukraine during the last years as to tuberculosis, different hepatitis forms, infectious diseases of gastrointestinal tract, as well as constant threat of ecological disasters or terrorists attacks are stimulating the research directed to creation of new generation of more effective drugs. New type of combined probiotic drug "***Okarin-Au***" for prophylactic and treatment of both disbacteriosis and especially dangerous infectious diseases was developed. 3 strains of *Escherichia coli* and one *Enterococcus faecalis* strain were represented in the preparation with the ratio of 1:1:1:3. Based on four bacterial strains taken from normoflora of gastrointestinal tract of people in good health as an active ingredient, the drug is also modified by gold in colloidal form. Our previous investigations showed that modification of initial probiotic drug by metals in colloid form variates the properties of the microorganisms' cultures, which formed the basis of preparation, and stimulates their biological activity. "***Okarin-Au***" preparation is available in the form of gelatinous capsules containing dried bacterial cultures bearing colloidal gold particles. This approach leads to deliverance of the whole preparation without any losses directly to the part of gastrointestinal tract which demands probiotic treatment.

## *Innovative Aspect and Main Advantages*

Probiotic drug "Okarin-Au" has a number of prominent advantages:

- Wide range of antagonistic activity to pathogenic organisms causing anthrax, rabbit-fever, salmonellosis, brucellosis etc. (according to results of clinical trials);
- Selective bactericidal activity as to pathogenic microflora and simultaneous stimulation of normoflora. This feature deals with the presence of colloidal gold metals (Fig. 2);
- Could be used for treatment of oncological patients due to high resistance of probiotic's microbial cultures to antibiotics and chematherapeutic agents. Also this drug has the ability to increase the lysis of atypical pathological cells;
- Ability to stimulate the nonspecific immunoresistance of the whole organism;
- Low cost in comparison with other probiotic drugs which are available on the market today.

**Fig. 1. The shape of gold-bearing probiotic drug "*Okarin-Au*"**

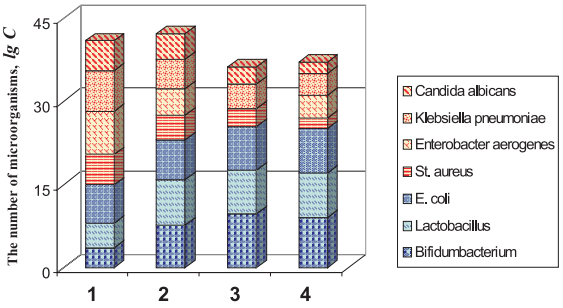


**Fig. 2. Results of the clinical testing of the bacteriological concentrate "*Okarin-Au*": 1 – the state of the microbiocenosis of gastrointestinal tract of children on I–III disbacteriosis stages; 2 – treatment by primary pathogenetic therapy; 3 – treatment by the same pathogenetic therapy along with the gold-bearing probiotic drug "Okarin-Au"; 4 – normal state of the digestive tract: bacteria that form the normal flora of humans GIT are marked blue when the conditionally pathogenic species are marked red**

## *Areas of Application*

"***Okarin-Au***" can be used for prophylaxis and treatment of disbacteriosis of wide etiology including healing of oncological patients in the postchemotherapeutical period.

## *Stage of Development*

Laboratory prescription for production of bacteriological concentrated product "***Okarin-Au***" has been developed. Preparation has also passed preclinical and clinical tests (result of clinical trials are shown on Fig. 2).

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# DYNAMIC CELL MONITORING USING A NEW FRACTAL MICROSCOPE SYSTEM

## *Description*

A new Fractal Microscope System (FMS) for continuous monitoring of the tiniest changes of an object's optical density is developed. FMS provides a quantitative view of virus-cell interactions in a time-series of frames at any stage of the interaction. The FMS is useful in life sciences and drug design, in agriculture and veterinary sciences, in physics of liquid crystals and surface phenomena, in polymer and colloid chemistry.

## *Innovative Aspect and Main Advantages*

The FMS is based on the fractal structural properties of an object's organization. The computerized fractal microscope could take frames of any nano-scale process, monitoring it in real time. The FMS has numerous benefits as compared to standard techniques, such as the direct infected cells' luminescent microscopic counting:

It is a better and simpler way of providing a quantitative description;

It provides an objective quantitative numeric measurement;

It allows in-line quick monitoring of virus-cell interaction could be realized at any stage.

## *What does a Fractal image tell you?*

A fractal image after processing makes it possible to estimate the size of minimal cluster composed by the units under consideration (e.g. cells, nuclei or viruses) and the fractal dimension D of the cluster itself which demonstrates the level of the space filling.

In one example, we have shown that the intraspinal brain fluid has liquid crystalline properties and forms a fractal cluster. The cluster's fractal dimension was changed as a result of brain trauma and the recovery process was accompanied by the changes of the fractal dimension. The treatment of the trauma enhanced the rate of the fractal dimension changes.

In another experiment a fractal microscope was used for leukemia blood serum samples study. The normal serum had distinctively other values of the fractal dimension than that taken from the leukemia patient. The treatment of the leukemia case demonstrated the changes in fractal dimension towards normal values of this system parameter.

## *Areas of Application*

Applications of FMS in life sciences and drug design:

- For antiviral applications FMS provides a quantitative view of the virus-cell interaction in a time-series of frames at any stage of the interaction,
- For detecting viral infections of the animal semen during artificial insemination,

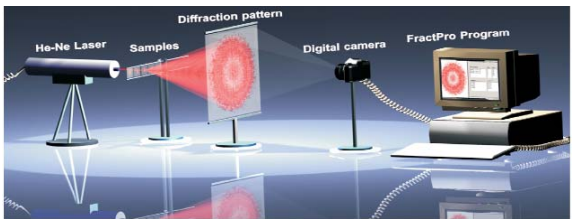


**Fig. 1 Functional view of Fractal Microscope**

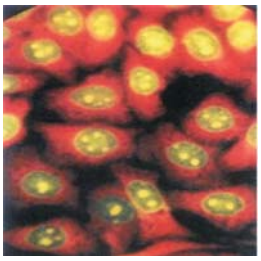

**Fig. 2 Image of herpes infected Hep-2 cells obtained by luminescent microscope**

**Fig. 3 The fractal image of the same cells specimen**

- For drug design process acceleration.

Applications in agriculture and veterinary sciences:

- Food and drug quality monitoring,
- Viral infection transfer monitoring in domestic animals and wild nature.

Applications in surface science phenomena:

- For organic materials water dissolution limits establishment,
- For chain polymerization process monitoring and for production of polymers,
- For problems of surface and interface exchange in physics and physical chemistry,
- Self-organization and clusterization control in nanotechnologies.

## *Stage of Development*

A prototype of the FMS has been assembled and tested. International patent applications are anticipated.

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# CANCER AUTOVACCINE (CAV) – NEW SPECIFIC ACTIVE ANTITUMOR AGENT

## Description

***Mechanism of action***. Cancer Autovaccine prevents further development of relapses and metastasis in the patients, who were radically operated concerning various tumors. Has a wide spectrum of action causing activation of immune response: raises cytophagous activity of neutrophils, strengthens their digesting function, stimulates antitumor cytotoxic activity of natural killer cells and T-lymphocytes.

***Indications for the use***. Secondary (functional) immunodeficit, depression of cytophagous and cytolitic function. It is recommended as independent immunorecriative agent in the postoperative period, and also for immunocorrection after postoperative chemotherapy and radiotherapy. CAV renders antitumor effect, improves an acceptability of hard courses chemotherapy and radiotherapy, allows to overcome development of cytopenia. It has antirelapse and antimetastatic action practically at all nosological forms of malignant neoplasms. There are no contraindications to the use of CAV.

## Innovative Aspect and Main Advantages

***Preparation***. CAV is repared from autologous tumor by its processing with products of synthesis of a saprophytic microorganism B.subtilis B-7025.

The proteases and antibiotic contained in a filtrate, cause lysis and complete destruction of tumor cells. Thus, the recognition of membranous antigens is increased. They stimulate activity of effector cells, antitumor immunity, immune answer of macrophages, T- and B-lymphocytes, neutrophils, natural killers.

Absence of living cells and viruses in CAV are guaranteed.

***Way of introduction***. A single dose at hypodermic injection contains 1,5 mg of protein. The complete course consists of 3 injections with 7 day's interval. The revaccination should be carried out after 1 and 6 months.

The vaccine is not toxic, has no anaphiloctogenic properties, does not give local reactions. As a side effect in some patients the insignificant pyrogenic transitional reaction observed with rise of temperature on 1–2 °C which completely passes in 8–12 hours.

***Combination to other methods of therapy***. After radical operation (early stages of disease, the absence of metastasis) on assignment of the physician an effective utilization CAV without chemo- or radiotherapy is possible. If carrying out courses of chemo- or the radiotherapies is necessary immunotherapy by CAV may be started in 18–21 days after their end.

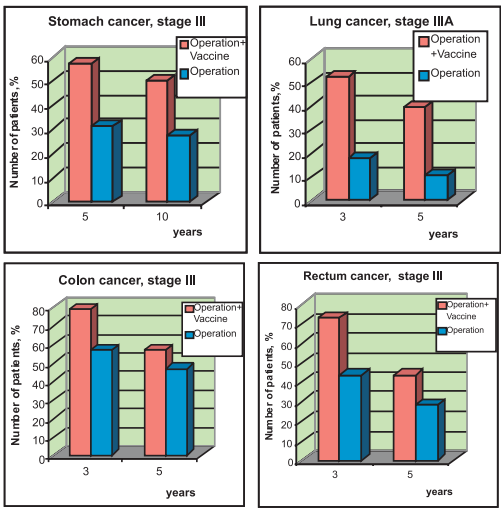


**Fig. 1. Efficacy of anticancer autovaccine during complex therapy of cancer patients (overall survival)**

## Areas of Application

Oncology

## Stage of Development

Certificate for clinical application in Ukraine is obtained.

***Clinical trials***. The clinical trials of CAV were carried out during 30 years on the base of various research institute of Ukraine and Russia. As a result of control randomize trials the data about survival of the patients who were radically operated are received. So, the five years' survival rate at a carcinoma of the stomach stage III in patients with CAV was 57,1 % (control group without CAV – 30,4 %); at a cancer colon and rectum stage $T_{3-4}$ $N_{1-3}$ Mo – 63 % and 57 % (in the control 29 % and 33 % accordingly); at a lung cancer stage IIIA – 39,9 % (in the control – 10,6 %); at a breast cancer stage III – 64,2 % (in the control – 40 %).

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# ULTRASONIC VISUALIZATION OF VISCO-ELASTIC PROPERTIES OF SOFT TISSUES FOR DIAGNOSIS OF PATHOLOGIES

## *Description*

The improved method of visualization of soft tissues visco-elasticity is based on ARFI (Acoustic Radiation Force Imaging) and SWEI (Shear Wave Elasticity Imaging) modalities. This method uses generation of local shear deformation of soft tissues with ultrasound radiation force. The proposed approach provides for diagnostics of neoplasms and other pathological conditions of soft tissues on very early stages where standard methods of ultrasound visualization do not work. Experimentally confirmed possibility of determination of pathologies less than 5 mm, while standard methods determine only sizes of 15–20 mm. Moreover, the proposed methods could be used for control of destruction process of pathological tissues. This was confirmed by studies of visco-elastic properties of soft tissues. Both in phantoms and in samples of soft tissues (in particular, samples of muscles and fragments of cow liver) we've obtained the similar dependences of amplitude of displacement growth at the increase of temperature. Thus, it confirms that the control of amplitudes of displacement of tissue with the help of Doppler method could be used for the temperature control during destruction of pathological tissues by powerful ultrasonic radiation.

## *Innovative Aspect and Main Advantages*

- unigue algorithm of calibration of ARFI and SWEI methods for ***simultaneous*** estimation of visco-elastic modulus of tissues;·
- noninvasive 2D visualization of elasticity and viscosity properties of soft tissues;·
- early diagnostics of malignant neoplasms and other pathologies;·
- real time noninvasive control of temperature de-struction margins of soft tissues pathological areas by powerfull ultrasound;·
- real time Doppler technology.

## *Areas of Application*

Ultrasonic visualization of visco-elastic properties of soft tissues could be used in medicine for health care

- Measurement of hardness and viscosity in local points in human body during medical checkup (oncology, different pathology);
- Measurement of fluids inclusion in human body;
- Measurement of muscle strain during athletes training;
- Noninvasive monitoring of process of ultrasonic thermal tissue destruction in real time.

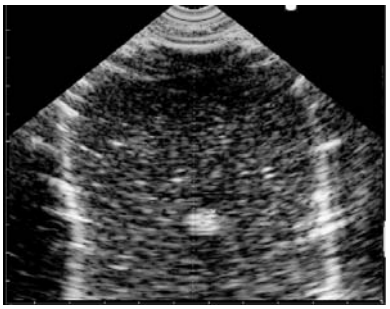

**Fig. 1. Visualization of model pathology with adding contrast matter $Al_2O_3$ (it is impossible to visualize such pathology without such contrast matter by standard ultrasound visualization methods)**

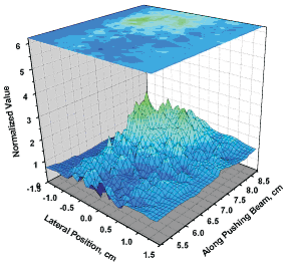


**Fig. 2. Determination of the same pathology without any contrast matter by the method of acoustic remote palpation (ARP). This pathology is registered by the skeqness of standardbell-shaped signal shown on the Fig. 3**

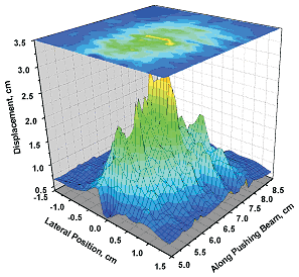


**Fig. 3. Standard bell-shaped signal obtained from the homogeneous model medium**

## *Stage of Development*

SWEI system with ultrasound Doppler signal processing is available for demonstration. This system is validated by the use of phantom based on gelatine and muscle tissues.

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# SUPER-SENSITIVE MAGNETO-CARDIOGRAPHIC SYSTEM FOR EARLY RECOGNITION, PRECISE DIAGNOSTICS AND MONITORING OF HEART DISEASES

## *Description*

Magneto-Cardio-Graphy (MCG) as a contact-free measurement method is an excellent tool to perform studies for early recognition, precise diagnostics and monitoring of heart diseases.

The electrophysiological behavior of the heart may be altered in disease and drug intervention, presumably by changes in individual ion currents or disease-induced increased ion channel density. During myocardial activation and recovery there is a flow of ions, which creates changes of electrical and magnetic field around the heart. The hearts magnetic field is exquisitely sensitive to anisotropy ratios in the cardiac tissue. Therefore, magnetic imaging of cardiac action currents is an ideally suited technique for testing the heterogeneity, thus elucidating the effects of anisotropy in spread of action currents.

## *Innovative Aspect and Main Advantages*

MCG is modern imaging and quantitative analysis technique for detection abnormal difference in electrophysiological cardiac phenomena.

MCG is non-invasive and informative methods which could be effectively used a variety spectrum of clinical setting.

It is a useful tool for screening diagnostics and may be used in unshielded environment.

## *Areas of Application*

MCG can be used for non-invasive diagnosis of cardiac events related to :

- coronary artery disease (CAD),
- safety of all medical drugs with respect to the drugs potential to cause heart arrhythmia,
- early detection of graft rejection after cardiac transplantation,
- pathophysiological role and therapeutic potential of stem cells.

**Fig. 1 Supersensitive MCG-system (CardioMagScan)**

## *Stage of Development*

System is ready for application.

We look forward to international collaboration for clinical trials and for production.

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# ENDOPROSTHESIS WITH A SAPPHIRE HEAD FOR HIP JOINT TREATMENT

## *Description*

Different artificial joints with metal, ceramic, metal-polymer and ceramic polymer trybological pairs which correspond to the natural biomechanical joint "head-acetabulum" are widely used for the hip joint arthroplasty at present time. Along with positive qualities of modern ceramic, polymer and metal constructions, they have some disadvantages, such as: insufficient biological inactivity and superfluous abrasion of the components. These factors lead to short life of the implant. Moreover, accumulation of toxic and carcinogenic substances in the soft tissue due to abrasion of the implant causes serious complications in up to 30 %–40 % cases.

We developed endoprosthesis with sapphire head for treatment of diseases and damages of the hip join.

## *Innovative Aspect and Main Advantages*

Endoprosthesis consists of a metal stem, sapphire head and lowmolecular polyethylene intermediate layer. Sapphire heads manufactured from pure material storage-oxide, which was synthesized in the temperature > 2000 °C.

Sapphire head has the following characteristics and advantages:

- does not resolve and its qualities do not-change during the patient's life; has high level of biological compatibility;
- has constant effect of the friction ($f$ = 0,05–0,10) with defined crystallography of the contacted sapphire trybilogical situations;
- has high durability;
- may bear 50 kN;
- may be polished to high degree of the purity (higher then in metal and ceramic analogs).

In comparison with metal heads, allergic reactions are excluded. In comparison with corundum ceramic heads, single-crystal head is more durable because the sapphire is homogeneous and does not have bloc's borders, that results in high wearproofness of material.

## *Areas of Application*

Orthopedics and traumatology.

## *Stage of Development*

Endoprosthesis with sapphire head is developed. Pro-totype samples are made and studied in experiments. Animal trials of the samples and clinical approbation in 5 patients are done.

**Fig. 1. General view of the hip joint endoprosthesis with sapphire head**

*a* *b*

**Fig. 2. X-ray photograph of the patient before operation (a) and after operation (b)**

## *Contact Details*

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# FLUORESCENT PROBES AND LABELS FOR BIOMEDICAL APPLICATIONS

## *Description*

Proprietary fluorescent probes and labels of **Square** and **Seta** dyes series are used in biological and biomedical research, clinical diagnostics and high-throughput screening. These materials include: a) **Reactive Red and near-infrared (NIR) Fluorescent Labels** for covalent attachment to biomolecules (proteins, amino-acids, peptides, amino-modified oligonucleotides, DNA, RNA, etc.); b) **Fluorescent Probes** for proteins, lipids and cells; c) **Dark quenchers** for Fluorescence Resonance Energy Transfer (FRET) Applications; d) **Classification Dyes** (hydrophobic fluorophores) for single or multiple encoding of microspheres used in High-throughput Screening (HTS).

## *Innovative Aspect and Main Advantages*

- ***Spectral properties***. The **Square** and **Seta** dyes series absorb and emit in the 500–900 nm spectral range. Unlike the **Cy** and **Alexa** series, these red and NIR emitting markers can be excited not only with the red, 635-nm and 670-nm diode lasers but also with the blue, 370-nm or 405-nm lasers or light emitting diodes (LEDs).
- ***Brightness***. The red and NIR **Square** and **Seta** dyes have high extinction coefficients (up to 265,000 $M^{-1}cm^{-1}$) and protein conjugates of these labels are extremely bright (quantum yields up to 70 %).
- ***Photostability***. **Square** and **Seta** dyes are in general more photostable compared to **Cy** or **Alexa** dyes.·
- ***Fluorescence Lifetimes***. **Square** and **Seta** dyes are perfect tracers for lifetime (FLT) based assays. The microenvironment sensitive lifetimes of these dyes are in the range of 500 ps to 3 ns. We are currently also developing lifetime labels that have lifetimes in the order of 10 ns.
- ***Sensitivity towards the microenvironment***. Selected **Square** and **Seta** probes exhibit high affinity for proteins, biomembranes and lipoproteins and can be used to detect and quantitate these species.·
- ***Reactive Dark Quenchers***. The newly developed reactive Dark Quenchers that absorb in the 600–800 nm spectral range have several times higher extinction coefficients as Black Hole Quenchers, do not exhibit any residual fluorescence and are perfectly suited for covalent labeling of proteins, peptides and oligonucleotides for use in FRET and real-time PCR based applications.

## *Areas of Application*

**Seta** and **Square** dyes are utilized in fluorescent applications using intensity, polarization, Fluorescence Resonance Energy Transfer (FRET), or Fluorescence Lifetime (FLT) as a read-out parameter. These products are used in life sciences (**biology**, **medicine** and **pharmacology**), more specific areas include Biological Imaging, Cytology, Immunology, Drug Screening, Cellular and Molecular Biology, Proteomics, Genomics, High-throughput Screening, Photodynamic Therapy, Clinical Diagnostics.

**Fig. 1. Seta and Square dyes fluoresce in a wide spectral region from the ultra-violet (UV) to the near-infrared (NIR)**

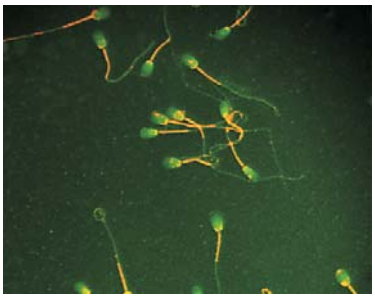

**Fig. 2. Biological Imaging. Dog spermatozoa stained with a mixture of fluorescent probes K35 and Square–635**

## *Stage of Development*

These fluorescence products are already commercially available from SETA BioMedicals, LLC,
http://www.setabiomedicals.com

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# E-BEAM PRODUCTION OF CARBON-BASED MATERIALS WITH AMORPHOUS, NANO-STRUCTURES FOR INDUSTY AND MEDICINE

## *Description*

Technology is based on the method of electron beam evaporation of carbon (graphite) using a liquid pool of tungsten and subsequent condensation of the vapour flow, which was suggested by us and patented in Ukraine and the USA (US Patent #5296274, cl. B05D 1/00 Movchan B. A. and others. "Method of producing carbon-containing materials by electron beam vacuum evaporation of graphite and subsequent condensation"). Evaporation is performed as follows: a plano-cylindrical tungsten tablet 5–10 mm high is placed on the end face of a cylindrical graphite block of 50–100 mm diameter and specified length. The tablet is melted by the electron beam and forms a "hot pool". A continuous transport process of carbon dissolution in the liquid pool volume, subsequent evaporation from the pool surface and formation of an intensive vapour flow of carbon atoms (clusters) is established. Tungsten practically does not evaporate.

Located near the above-mentioned carbon evaporation source is the second independent traditional source of electron beam evaporation of metallic and non-metallic materials, which are added to the main vapour flow of carbon by evaporation, if required (The third evaporation source can also be used).

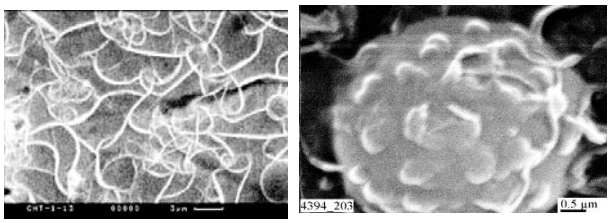
This method has been recently improved by applying the technique of reflection of the vapour flow of carbon (or carbon plus additives) from surfaces (mirrors) heated up to high temperatures (1000–1800 °C), to form in space vapour flows of a specified orientation and particles which would be more uniform in terms of composition, structure and energy. This improvement is required at subsequent deposition of the vapor flow and "engineering" of the specified coating structure. Vapour flow ionization and bleeding gases into the vacuum chamber can be used as additional technological parameters for controlling the deposition process and condensate structure. Temperature of the deposition surface is one of the main technological parameters, controlling the condensate structure.

Rate of evaporation of a graphite block of 70 mm diameter is equal to 1.0–1.1 kg/h.

## *Innovative Aspect and Main Advantages*

Electron beam technology differs from the currently available methods of arc and laser evaporation of carbon by availability of many parameters for fine adjustment of the main stages of the evaporation process, vapour flow formation and its condensation, namely:

1. Area, average values of evaporation rate and temperature of atoms (molecules) evaporated from the tungsten "hot pool".




*a* *b*

**Fig. 1. Examples of special structures of carbon condensates: nanotubes (a) and spheres (b).**

2. Temperature, composition and molecular structure of the vapour flow after reflection from the heated surfaces, vapour flow ionization, bleeding gases and using additives of inorganic and organic substances, including catalysts of the growth of macromolecular structures of the type of nanotubes and fullerenes. Temperature of the condensation surface of an oriented vapour flow in the range from room temperature to 1000–1200 °C and respective structures
3. From amorphous to nano- and micro-sized. Possibility of producing macromolecular (fullerenes, nanotubes) and diamondlike structures, carbides and composite materials (coatings) on their base is shown. A pilot production electron beam unit of up to 250 kW power adapted to the above technology variants is available. Areas of Application:Electronics and optoelectronics, medicine, chemical technology, instrument and mechanical engineering.

## *Stage of Development*

Technology and equipment have been patented, experimental facilities are available, and a demonstration can be done.

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# DIAMOND POLYCRYSTAL NANO-COMPOSITES FOR INDUSTRY

## *Description*

At present one of the most important directions in solving the problem of of superhard materials development with qualitatively and quantitatively new complex of physico-mechanical properties is the use of nanodispersed materials as the initial ones. Under adequate conditions a unique complex of mechanical properties, e. g., a combination of very high hardness and fracture toughness, can be realized in a nanodispersed polycrystal.

In development of production technologies of novel superhard materials using initial nanomaterials, retention of the material nanodispersed state in the course of sintering is an important problem. In addition, one should remember that mechanical properties are highly structure-sensitive, which is particularly distinct in using nanomaterials.

Conditions of preparative treatment of diamond nanopowders, and their effective compacting, before a sintering including at heightened temperature, have been developed. Effect of prior compacting conditions on process of obtaining of qualitative polycrystals by sintering has been studied. Thermobaric conditions of production of polycrystal materials based on diamond powders of nanometric range have been investigated and optimized. The obtained results have allowed to develop optimum conditions of tool materials based on the diamond nanopowders production.

## *Innovative Aspect and Main Advantages*

It is experimentally proved that the most efficient approach to improvement of physico-mechanical properties of diamond polycrystals produced from nanopowders is to find optimal conditions for sintering of mixtures containing additions acting as solvents for carbon (Co, Ni, Fe, alloys of them, etc.) and as inhibiters of the grain growth. The mixture should be mechanically activated.

The use of high-pressure technique in combination with purification and vacuum degassing for sintering of statically synthesized diamond nanopowders with an initial particle size of about 100 nm favors the formation of nanostructure elements of 10 to 50 nm in size in a polycrystal due to fragmentation of coarser initial grains (supported by TEM studies). Preactivation of the initial statically synthesized diamond nanopowders using cold isostatic pressing has allowed the production of polycrystals with a density of 3,31 g/cm$^3$, Vickers hardness of 35 GPa ($P$ = 9.8 N) and fracture toughness $K_{1c}$ = 10–14 MPa·m$^{1/2}$.

## *Areas of Application*

Tools made of the composites of statically synthesized diamond nanopowder can successfully compete with single-crystal natural diamond tools. The composites may be used for making cutting, deforming or measuring tools for various purposes. Due to high fracture toughness, they may be also used as inserts in drilling tools. Now the samples of the instrument are being tested in construction.

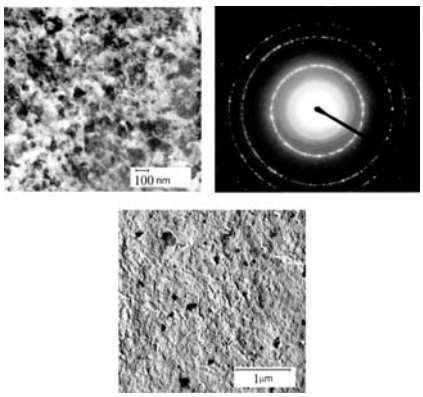


**Fig. 1. The typical electron-microscopic image particle structures of the polycrystal from nanodiamond by static syntheses**

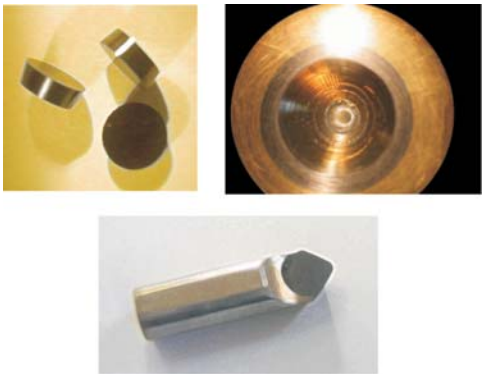

**Fig. 2. Cutting plates, drawing die and cutting tool**

## *Stage of Development*

Prototype available for testing.

## *Contact Details*

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# NEW FILMCOATINGS FOR OPTICS AND OPTO-ELECTRONICS

## *Description*

Creation of novel film forming materials is carried out on the basis of developed by us concept of adjustable stabilisation of valence state of metal due to donor-acceptor interaction between components – binary compounds. Valence state is stabilised both during synthesis of the film forming material, and during its thermal evaporation in deep vacuum. It makes receiving coatings with a high degree of perfection – both chemical, and structural – possible. In turn, it positively reveals both in optical (refractive index, factors of scattering and absorption, width of range of an optical transparency) and operational (mechanical and beam durability, stability to a damp atmosphere etc.) properties of coatings received from the materials.

Film forming materials on the basis of complex fluorides of s-metals and lanthanides, in particular systems $MgF_2$-$LnF_3$ (Ln-Nd, Lu) and $LnF_3$-$Ln'F_3$ (Ln-Eu, Yb, Ln'-Ce, Tb), for interference optical coatings with a low refractive index are developed. The materials are obtained through the fluoridation of metal oxides with further melting in an inert atmosphere. The use of the materials resulted in essential increase in reliability in operation and simplification of technology for modelling of interference coatings for laser optics, spectral divisors, optical filters and other products.

## *Innovative Aspect and Main Advantages*

Proposed film forming materials by their optical loss (less than 0.01 %) in the coatings are competitive with the widely used ones, namely thorium fluoride ($ThF_4$). Additionally, proposed materials are higher in mechanical durability (0 group) as compared to $ThF_4$, they also have no radioactivity.

## *Areas of Application*

Film forming materials have wide applications in several industrial sectors:

- optical industry;
- optoelectronics.

New more effective materials were developed for interference optics of technological and eximer lasers used in:

- mechanical engineering;
- lithography;
- medicine.

## *Stage of Development*

- Prototype is available for testing;
- License agreements and cooperation for further development are sought.

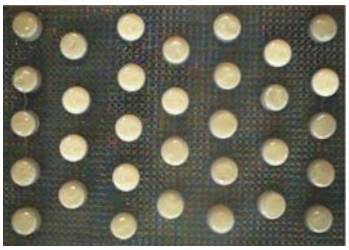

**Fig. 1. Experimental samples of film forming material on the base of $MgF_2$-$LuF_3$ composite**

**Fig. 2. Experimental specimens of the optical elements for the IR spectrum divisor with the multilayered coatings on the base of $MgF_2$-$LuF_3$ and ZnS-GdS composites (CDO "Arsenal")**

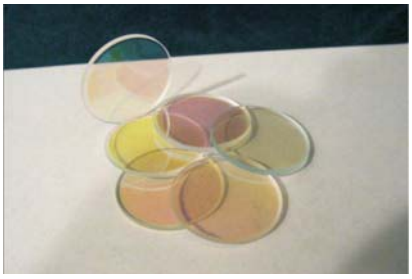

**Fig. 3. Experimental specimens of the optical elements for the IR narrow-band filter with the multilayered coatings on the base of $MgF_2$-$LuF_3$ and ZnS-GdS composites (CDO "Arsenal")**

## *Contact Details*

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# ATOMICALLY SMOOTH METAL SURFACES

## *Description*

Various modifications of the method of evaporation in high electric fields are the most promising methods of forming surface of different nanometer-scale objects. However, the main obstacle to the use of this method is a super high electric field on a surface of a processed object. In such fields there are serious technological problems connected with destruction of objects under the influence of mechanical stress generated by the fields. We propose to use phenomenon of high-field evaporation of metals in dielectric liquids at low temperatures. This phenomenon was revealed and studied by our team together with University of Surrey School of Electronic (Surrey, UK) and Hahn-Meitner-Institute (Berlin, Germany). This phenomenon and process of field evaporation in active gases could be used for controlled forming of metal objects with sizes in a nanometer range. The magnitude of electric fields below the level of field evaporation in high vacuum is required for realization of high-field evaporation of metals in dielectric liquids. This opens up technological prospects for practical use of this phenomenon.

## *Innovative Aspect and Main Advantages*

- formation of surface with a zero-level roughness (atomically smooth metal surface);
- high degree of localization of field emission;
- atomic sharpness of STM probes;
- reducing traumatic effects of microsurgical instruments.

## *Areas of Application*

- field emitters;
- probes for scanning tunneling microscopy and nanotechnology;
- microsurgical instruments with qualitative changes of roughness level.

## *Stage of Development*

Patents received:

- Method of fabrication of tip objects, Patent of Ukraine, UA 6607 U, 16.05.2005, Velikodnaya O. A., Ksenofontov V. A., Mikhailovskij I. M., Sadanov E. V.

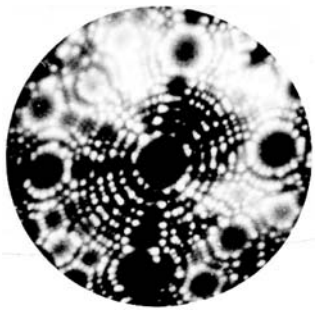

**Fig. 1. Field ion microscopic images of STM probe before high-field sharpening**

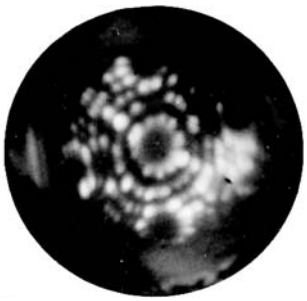

**Fig. 2. Field ion microscopic images of STM probe after high-field sharpering**

- Method of fabrication of tip objects, Patent of Ukraine, UA 8336 U, 15.07.2005, Velikodnaya O. A., Ksenofontov V. A., Mikhailovskij I. M., Sadanov E. V.

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# OXIDE NANO-POWDERS FOR ADVANCED MEDICAL AND INDUSTRIAL APPLICATIONS

## *Description*

Technology of obtaining oxide nanopowders with speci-fied chemical, phase and granulometric composition is based on wet-chemicals methods with the use MW radiation, pulse magnetic field and ultrasonic for agglomeration prevention.

We obtain $ZrO_2$ (0–8 % $Y_2O_3$) powders with predetermined particle size in the range from 5 to 30 nm, narrow size distribution and specific surface area 140–20 $m^2/g$, respectively with soft agglomerates for ceramics, compos-ites and SOFC applications.

We obtained $TiO_2$ (anatase) powders with predetermined particle size in the range from 5 to 25 nm, narrow size distribution, specific surface area from 150 to 50 $m^2/g$ and soft agglomerates for catalyst and UV-protects and $TiO_2$ (rutile) powders with particle size 30–50 nm.

We obtained $LaSrMnO_3$ powders with narrow size distribution (12–15 nm) and bimodal size distribution (40,200 nm) for magnetic sensors and SOFC cathodes, and other oxide powders (PZT, $Al_2O_3$ based, for example).

We have a pilot line for nanopowders obtaining.

We also obtain zirconia and/or alumina ceramics with small grains for wear-resistant, structural, instrumental and functional applications. Porous ceramics obtained can be used in medicine, catalysts, filters and SOFC electrodes. We can obtain nanocomposites with metal, ceramics and polymer matrix.

We obtain PZT ceramics.

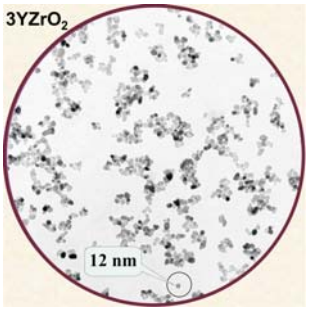


**Fig. 1. Structure of 3Y $ZrO_2$ powders**


**Fig. 2. Ceramic details**

## *Innovative Aspect and Main Advantages*

The main advantages of our technology are:

- more narrow particle size distribution;
- lower degree of agglomeration;
- predetermined particle sizes in the range of 5 to 50 nm;
- high homogenious component distribution;
- low synthesis temperature (400–700 °C);
- eliminating the mechanical grinding stage;
- easy scale-up in manufacturing;
- low sintering temperature (1250–1350 °C)
- high performance of ceramics including homogenity, stability and durability;
- lifetime of ceramics mine pump plunger from zirconia nanopowders is 15–20 times longer than usually
- production of precise articles and films;
- lower cost, environmentally friendly;
- lower energy consumption.

## *Areas of Application*

**Power Engineering** – SOFC, thermal stable coatings for turbine blades;

**Mining Industry** – rods, plungers, injectors;

**Chemical Industry** – parts of pumps (breechblocks, valves, plungers) injectors, milling balls, catalysts, sorbents;

**Metallurgy** – refractory structural elements, cutting tools, guides, crucibles;

**Medicine** – prosthetic appliances, filters, ion-exchangers, UV-protect, capsules.

## *Stage of Development*

Tested, available for demonstration, field tested.

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# NANO-CERAMIC COMPOSITES FOR WEAR-RESISTIVE APPLICATIONS

## *Description*

We present technologies for development of ceramic nanocomposites based on SiC-C and $Si_3N_4$-TiN-$TiB_2$ systems for using in novel generation of ceramic cutting tools, wear resistive components, radiation resistive ceramic components and for other potential applications. Such properties as high melting temperatures, hardness, chemical and thermal stability and other are successfully combined in them. Formula SiC-C means nanocrystalline (40–120 nm) beta-silicon carbide reinforced with diamond planar clusters built-into the lattice of SiC. This unique structural property provides for 40 GPa hardness in pure poreless ceramics. We found hardness of 24 GPa in nanocompostes with alumina, which also show fracture toughness around 9 MPa $m^{1/2}$. As a result of NATO SfP project we have built the pilot unit for production of 20 kg of SiC-C nanopowder a day. Here we propose the technology development of the nanocomposites based on SiC-C nanopowders.

Another group of nanocomposites based on nano-TiN reinforced with nano $TiB_2$ and $Si_3N_4$ particles was obtained by sintering, high-pressure sintering and spark-plasma sintering. Prototypes of cutting tools (unresharpable tools) were tested both at room and elevated temperatures. These composites are promising tools for extra-fine finishing of metallic parts. Such parameters as hardness around 20 GPs, fracture toughness up to 8.5 MPa $m^{1/2}$, show high stability (grain size around 80 nm) up to 800 C which looks attractive. The best combination of properties: hardness 24 GPa, bend strength > 500 MPa, and fracture toughness of 7 MPa $m^{1/2}$ was revealed for the TiN-25 %$Si_3N_4$ nanocomposite. With sintering process without pressure near fully dense (98.5 %) ceramics can be achieved and therefore, such process is promising for mass production of tools. At present we propose development of technology for ceramic cutting tools based on TiN-$Si_3N_4$ ceramic nanocomposites.

## *Innovative Aspect and Main Advantages*

A very good combination of hardness and fracture toughness at room and elevated temperatures looks attractive for cutting tool application.

Technological operations are not expensive: for instance, synthesis of SiC-C is comparable with analogues by costs, pressureless sintering at moderate temperatures is used instead of hot pressing etc.

Refinement of grains is a desirable property for finishing treatment of alloyed steels and viscous metals and alloys. Stability of properties at high temperatures is promising for dry cutting operations.

We have a patent of Russian Federation concerning technology of SiC-C nanopowder synthesis, pending patents of Ukraine and know-how in technologies of TiN-$TiB_2$ and TiN-$Si_3N_4$ nanocomposites.

## *Areas of Application*

Cutting tools, ceramic bearings, wear resistive components.

Cutting tools made from $Si_3N_4$-TiN nanoceramics were tested in ALCON (Kiev, Ukraine). Wear resistive components based on SiC-C ceramics were examined in Baker Hughes INTEQ GmbH.


**Fig. 1. SiC-C nanopowders**

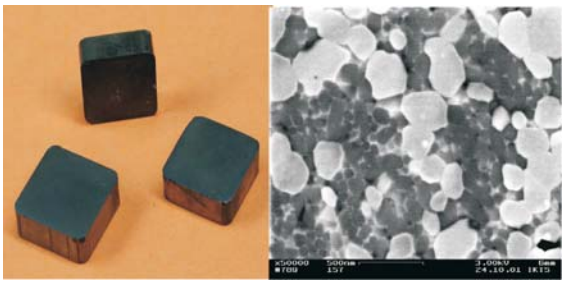

**Fig. 2. TiN-$Si_3N_4$ multilayer cutting plates (50 % $Si_3N_4$ 50 % TiN)**

## *Stage of Development*

The pilot unit for SiC-C nanopowder synthesis is under operation. The pilot batch of cutting tools made from $Si_3N_4$-TiN nanoceramics has been prepared. Technical documentation is under preparation.

We have a patent of Russian Federation concerning technology of SiC-C nanopowder synthesis, pending patents of Ukraine and know-how in technologies of TiN-$TiB_2$ and TiN-$Si_3N_4$ nanocomposites.

We would prefer joint development of ceramic nanocomposite products with foreign partner. Licensing of technologies or development of start-up company or joint venture would be also appropriate.

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Ragulya@ipms.kiev.ua

# SURERCONDUCTING NANO-MATERIALS FOR CRYOGENIC ELECTRICAL MACHINES

## *Description*

The aim of presented project is formation of magnesium diboride based superconducting nanostructural materials with high level of critical current density, $j_c$, field of irreversibility, $H_{irr}$, trapped magnetic field, $B$, microhardness, $H_v$, fracture toughness, $k_{1c}$, Young modulus, $E$, and density close to the theoretical one. Such materials will be effective for application in the cryogenic electrical machines (electric motors, pumps) working at the liquid hydrogen temperature (20 K). The increase of $j_c$ and $B$ we plan to reach using high pressure-high temperature synthesis and alloying. In the frame of the project an electromotor will be constructed based on the best of developed materials and its efficiency will be estimated. The magnesium diboride based superconductive blocks for the elements of the electromotor rotor will be produced by high pressure-high temperature synthesis.

Modern technological progress is aimed at substitution of fuel for aircrafts and combustion engines of autotransport and watertransport (submarines) by hydrogen, at the development of electrical power networks (first of all on the territory of the USA) by which the electrical power should be transmitted to big distances through the superconductive cables at the liquid hydrogen temperature and using liquid hydrogen as cooling agent. These directions caused great interest to electric machines working at the liquid hydrogen temperature. Superconductive electromotors and pumps for liquid hydrogen pumping will be in great demand when new technologies utilizing liquid hydrogen are introduced: they are more effective than traditional ones due to essentially smaller weight, considerably higher speed of operation in the reversion regime and higher specific output power on the rotor surface.

## *Innovative Aspect and Main Advantages*

Scientific and technological approach to development of bulk materials using magnesium diboride is based on synthesis in high pressure conditions. Improved magnetic properties are to be obtained due to high material density, nano-dimensional defects and chemical doping. Special attention will be paid to technological basis of synthesis of bulk blocks with typical dimensions up to 50 mm and further selection of samples with equal parameters by frozen magnetic field estimation and measuring of the levitation force. Developed magnesium diboride based superconducting nanostructural materials should have high level of critical current density at 20 $K_{jc} \geq 1000–100$ kA/cm$^2$ in the fields 3–4 T, field of irreversibility, $H_{irr} \geq 8$ T, trapped magnetic field, $B \geq 2$ T for the samples 30–50 mm in diameter, microhardness, $H_v \geq 15$ GPa at $P = 4{,}9\ N$, fracture toughness, $\kappa_{1c} \geq 7$ MPa×m$^{1/2}$, Young modulus, E ≥ 220 GPa and density close to the theoretical one.

One of the advantages of superconductive motors, generators and pumps is high power density due to a small size of rotor that allows an essential decrease in size (by 5–8 times) and weight, as well as achieving of high dynamics: a high angle acceleration which is especially important when a device operates under the conditions of high reverse frequency. The use of superconductive electrical machines

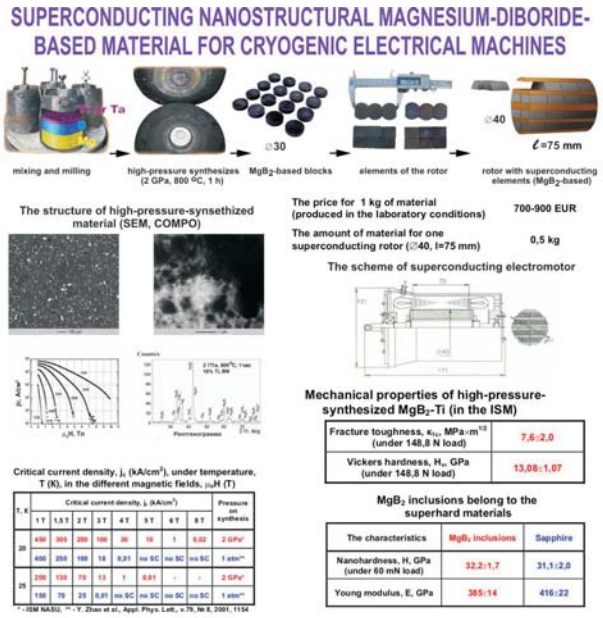


**Fig. 1. Superconducting nanostructural magnesium-diboride-based material for cryogenic electrical machines**

saves energy resources. Advancement in applications of the second-type superconductors in electrical machines is closely related to materials improvement, because in operation they should provide high currents in magnetic field and should withstand stresses induced by magnetic fields and temperature variations during heating-cooling processes.

## *Areas of Application*

Electroengineering (electromotors, generators and pumps for liquid gases pumping, fault current limiters), magnetic transport (MAGLEV), fly-wheel energy storage systems

## *Stage of Development*

National patents, know-how Development phase - laboratory tested

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# BOREHOLE SITING TECHNIQUE FOR GEOLOGICAL REPOSITORIES OF RADIOACTIVE WASTE

## *Description*

The purpose of siting repositories is to reveal those most promising for the development of deep geological repository (DGR) for radioactive wastes. The technique of siting borehole DGRs is described as follows.

This technique takes into account IAEA recom-mendations and requirements with respect to DGR siting, national regulatory requirements as well as preliminary requirements and other considerations identified by the designers for a stage-by-stage siting.

The proposed technique is based on the application of the following methodological package:

- Analysis of literature and data of geological and hydrogeological structures and rock properties over the area to be studied as well as data reinterpretation according to new objectives;
- Aerospace image decoding (revealing areas minimally dislocated by tectonics);
- Field seismic studies (identification of sedimentary patterns, detection of dislocations in crystal-line rocks);·
- Field magnetic and gravimetric studies (revealing blocks composed of minimal types of crystalline rocks with minimal density gradient);
- Indicator studies (gas surveys) for groundbased verification of aerospace image data decoding;
- Siting of exploration boreholes, borehole drilling with detailed sampling and testing (to obtain data for an assessment of radioactive waste disposal safety);·
- Processing and interpretation of drilling and test studies data with subsequent verification of groundwater flow and transport models;
- Development of refined groundwater flow and transport models as well as simulation tests;
- Assessment of the longterm safety of radioactive waste disposal systems using data obtained to plan further studies.

## *Innovative Aspect and Main Advantages*

In contrast to a mined geological repository, the degree of safety of waste disposal in borehole repositories is assured primarily by natural barriers (depth of waste package allocation, stagnant water exchange and lengthy pathways of radionuclide migration towards biosphere) rather than by engineered safeguards. Up to now the practical experience of siting waste repository has been obtained only for the case of mined repositories.

Basic advantages include:

- The proposed technique makes it possible to decrease costs and speed-up selection of promising sites by discriminating areas of a few dozen km$^2$ out of larger regions tens of thousands km$^2$.
- This technique enables selection of promising sites within crystalline rocks even in the presence of thick sedimentary covers;
- The technique is based on the application of remote methods.

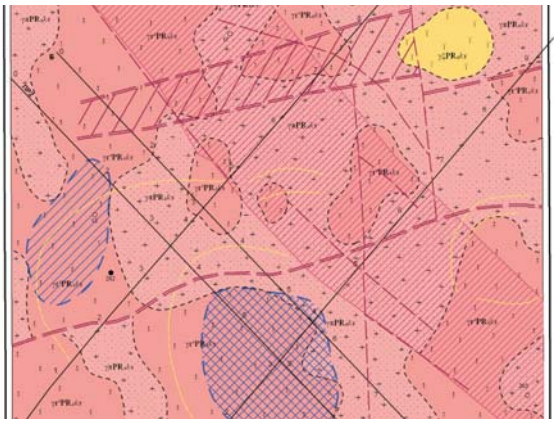

**Fig. 1. Promising areas of the Veresnia study site (marked by blue hash lines) as revealed by the technique presented here**

## *Areas of Application*

This technique has been developed for early-stage DGR borehole siting. The DGR boreholes may be utilized for the disposal of the highly-hazardous radio-active wastes: spent nuclear fuel, vitrified high-level wastes, and long-lived intermediate-level wastes.

## *Stage of Development*

The first stages of this technique (i.e., without drilling) have been utilized to ascertain the geological conditions of the northern areas of the "Ukrainian Shield" within the Korostensky pluton as well as within the 30-km Chornobyl Exclusion Zone.

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# NEUTRON SOURCE FOF NEUTRON CAPTURE THERAPY OF CANCER TISSUES AT KYIV RESEARCH REACTOR (KRR)

## *Description*

Neutron Capture Therapy (NCT) is a promising form of radiation therapy characterized by two interrelated features: (1) the infusion or delivery of a capture compound which preferentially concentrates in the tumor, followed by (2) the irradiation of the tumor site with neutrons. Inasmuch as the boron isotope $_5B^{10}$ is often used as a neutron capture agent in compounds, this form of therapy is thus termed Boron Neutron Capture Therapy (BNCT).

The large thermal neutron capture cross section of $_5B^{10}$ greatly increases the probability of the resulting $_5B^{11}$ nucleus to split into He and Li. As the ionization potential of He and Li ions is high as they slow down in the biological material along relatively short distances, the affected cells enriched by boron are destroyed while normal, healthy cells are damaged to a much lesser extent. However, as the penetrating capability of thermal neutrons is low, to reach cancerous tumor cells localized at depths of several centimeters, epithermal neutrons are more suitable to the task. Such epithermal neutrons have a lower neutron capture rate in hydrogen, which results in a lower skin dose burden while the moderation of epithermal neutrons within the head would give rise to a thermal neutron peak at the cancerous tumor site. The most suitable neutrons for BNCT are those with energies in the range of 1 eV to 10 keV because their KERMA factor (and hence direct tissue damage) is less than for thermal or fast neutrons.

Such epithermal neutron beams may be provided by nuclear research reactors. The concept behind providing such a source the a modification of the reactor such that the emergent beam is slowed to the epithermal range. Such modifications of research reactors are usually relatively straightforward and not cost prohibitive – especially when compared to constructing new reactors dedicated to BNCT. Of course, any modification to a reactor should be justified with careful design work taking into account all specifics of a given specific reactor system.

## *Innovative Aspect and Main Advantages:*

- Existing nuclear research reactors may be readily modified to provide the proposed epithermal neutron beam-precluding any need to design and construct a dedicated reactor;
- Uses a Ni-60 neutron filter for essential improvement in therapeutic source parameters;
- Destroy tumors by avoiding highly traumatic surgical techniques;
- High radiation doses are applied directly to malignant cells while the impact on healthy cells is minimized.

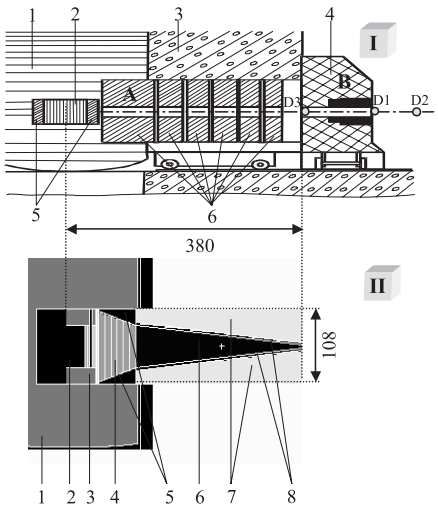


**Fig. 1. KRR Thermal Column (dimensions in cm):**
**I – TC (untill reconstruction): A – the first block, B – the second block. 1 – water, 2 – core, 3 – concrete, 4 – paraffin, 5 – beryllium reflector, 6 – graphite. D1, D2, D3 – detector positions in the MCNP calculations.**
**II – Geometry for MCNP calculations (vertical cross section through the core center): 1 – water, 2 – core, 3 – beryllium reflector (source), 4 – moderator, 5 – reflector (natural nickel), 6 – air, 7 – borated polyethylene, 8 – natural nickel layer.**

## *Areas of Applications:*

- Cancer treatment, in particular of brain tumors,
- Veterinary medicine.

## *Stage of Development:*

We have demonstrated analytically that an epithermal neutron source meeting the requirements of BNCT may be constructed at the nuclear research reactor in Kyiv. The modification to the reactor may be achieved by altering the design of the thermal column and replacing the Beryllium reflector with one based on Aluminum.

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# NEUTRON FILTERED BEAM TECHNIQUE AT THE KYIV RESEARCH REACTOR (KRR)

## *Description*

The neutron filter technique is characterized by the transmission of neutron beams emanating from nuclear research reactors through relatively thick (up to 2–2.5 m) layers of materials with deep interference minimums in the total neutron cross sections. As a result of passing through these interference minimums, narrow energy range "filtered" neutrons emerge as quasi-monochromatic beams. Figure 1 below provides a cross-sectional view of the proposed neutron filer as located in the reactor's horizontal experimental channel.

Quasi-monochromatic neutron beams emerge from the filters with the following energies and half-widths: $E_n$(keV) = 1.86 (1.46), 3.57 (1.68), 7.5 (0.1), 12.67 (1.2), 24.34 (1.8), 56.37 (0.55); 58.8 (2.7), 133.3 (2.8), 148.3 (14.8).

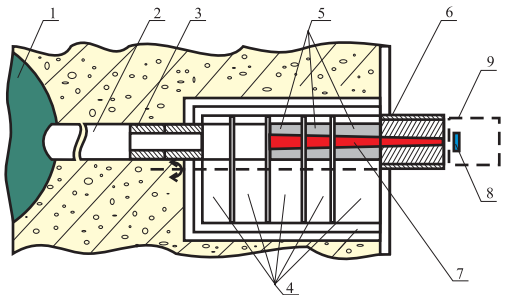


**Fig. 1. Schematic of neutron filtered beam facility (1 – beryllium reflector; 2 – horizontal channel tube; 3 – preliminary collimator; 4 – beam shutter disks; 5 – filter-collimator assembly; 6 – outer collimator; 7 – filter components; 8 – research samples; 9 – device for samples removing.)**

## *Innovative Aspect and Main Advantages*

The KRR has specialized in neutron filters for more than 20 years, with a very significant amount of knowledge and experience accumulated-characterized by the following:

- The filtered neutron beams emerging are of among the highest flux values in the world for the kiloelectron volt energy range: 105–108 neutrons/sec·cm$^2$. This provides an opportunity to conduct unique and very precise measurements.
- Large quantities of highly enriched (stable) iso-tope (such as $^{52}$Cr, $^{54,56,57}$Fe, $^{58,60}$Ni, etc) are available at the KRR facilities for designing and constructing specific energy-range filters which provide very high neutron fluxes within narrow (i.e., "clean") energy bands.

## *Areas of Applications*

1. High precision measurements (0.1–0.01 %) of total and partial cross sections for fundamental neutron-nuclear investigations.
2. Precise measurements (to 1 %) of neutron cross sections to obtain averaged nuclear parameters ($\sigma_t$, $\sigma_s$, $\sigma_\gamma$, $\sigma_f$, $S_o$, $S_1$, $S_2$, $R_o$, $R_1$, $D$, $<\Gamma_\gamma>$).
3. Measurements of neutron capture gamma-spectra.
4. Measurements of $\sigma_{inel}$ for the first exited levels of heavy nuclides.
5. Measurements of activation cross sections.
6. Isomeric ratio investigations.
7. Doppler-Effect Investigations.
8. Time-of-flight method used for precise cross section measurements of $\sigma_t$, $\sigma_\gamma$, $\sigma_{inel}$.
9. Research of radiation damage energy dependence in materials.
10. Neutron radiography and tomography.
11. Biomedical investigations.
12. Neutron and Boron-neutron capture therapy.
13. Measurements of the average energy loss $W(E)$ for ion-pair generation.
14. Prompt Gamma-ray Activation Analysis (PGAA).
15. Development of standard fluxes for neutron-dosimetry.
16. Energy calibration of proton recoil counters.

*(1–8 refer to scientific research areas, while 9–16 pertain to technological applications)*

## *Stage of Development*

Naturally-occurring and enriched isotopes used in the development of neutron filters include:

Natural: Si, Al, V, Sc, S, Mn, Fe, B, Ti, Mg, Co, Ce, Rh, Cd, LiF.

Enriched: $^{52}$Cr (99.3), $^{54}$Fe (99.92), $^{56}$Fe (99.5), $^{57}$Fe (99.1), $^{58}$Ni (99.3), $^{60}$Ni (92.8–99.8), $^{62}$Ni (98.04), $^{80}$Se (99.2), $^{10}$B (85), $^{7}$Li (90).

Three horizontal channels at the KRR are currently equipped with such neutron filters and with experimental installations for the precise measurement of total, scattering and capture cross sections. There is also the possibility to study capture gamma ray spectra with a Ge spectrometer characterized by its high resolution and angle distribution of scattered neutrons. Each of the filters is easily replaced by another to meet beam characteristic requirements, and the development of new filters is currently in progress for producing neutron energies up to 1000 keV.

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# NEUTRON TUBES HTГ-2, HTГ-3

## *Description*

The neutron tube HTГ-2 is comprised of a cermet (glass-metal) body housing a Penning-type ion source with incandescent or cold cathode, a system of forming and accelerating electrodes, and a neutron-generating target. The distance between the active target surface and the tube face is 25 mm. In the glass-metal version this distance is 1 mm.

The neutron tube HTГ-3 is made of cermet (glass-metal) body housing an orbitron ion source. A cylindrical neutron-generating target is arranged on the inner lateral surface of the tube body.

These tubes generate neutrons with an acceleration of mixed deuterium-tritium beams of energies up to 100–120 KeV, which bombard the neutron-generating target saturated with a deuterium-tritium mixture.

## *Innovative Aspects and Main Advantages*

| Main Characteristics | HTГ-2 | HTГ-3 |
|---|---|---|
| Max neutron yield, (n/s) | 3×108 | 2×108 |
| Max avg target current (mA) | 0,4 | 0,5 |
| Radiation pulse repetition frequency (kHz) | 0.05–20 | 0.02–30 |
| Min radiation pulse duration (μs) | 5 | 3 |
| Operating life (hr) | 200 | 200 |
| Overall dimensions (mm) | | |
| Diameter (without magnet) | 35 | 60 |
| Length | 250 | 300 |

The above neutron yield values were obtained at an accelerating voltage of 110 kV.

The recommended value of the magnetic field induction for the neutron tube HTГ-2 is not less than 20 mT.

## *Areas of Application*

These tubes are intended to generate neutrons at energies of 14 MeV. Such neutron generators are used for monitoring oil wells and ore holes, as well as in mobile or stationary neutron generators.Stage of Development:The neutron tubes NTG-2 and NTG-3 are at the stage of serial production. Note other types of neutron tubes are available as well.

**Fig. 1. Neutron Tubes HTГ-2, HTГ-3**

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# SEMICONDUCTOR DETECTORS FOR NUCLEAR RADIATION SPECTROMETRY

## *Description*

Semiconductor detectors are among the most important devices employed for the spectral analysis of nuclear radiation, although the type of semiconductor detector to be used depends on the specific problem to be resolved. The Department of Radiation Physics at the Kyiv Institute for Nuclear Research has devel-oped the following types of detectors:

1. Surface-barrier detectors of total absorption (E-detectors) based on high-ohmic silicon n- and p- type semiconductors for nuclear radiation spectrometry.
2. Charged-particle energy-loss (dE/dx) detectors used in telescopes for the determination charged particles masses in composite nuclear reactions.
3. Drift silicon-lithium detectors (Si (Li)-detectors) based on silicon compensated to lithium used for the spectral analysis of charged particles.

## *Innovative Aspect and Main Advantages*

The developed semiconductor detectors will be for nuclear measurements in charged particle accelerators. These detectors are characterized by a high energy resolution and high sensitivity over a wide range of energies.

## *Areas of Application*

The detectors will be utilized for the spectrometry of nuclear radiation.

## *Stage of Development*

The detectors are developed are produced based on anticipated performance parameters different nuclear problems.

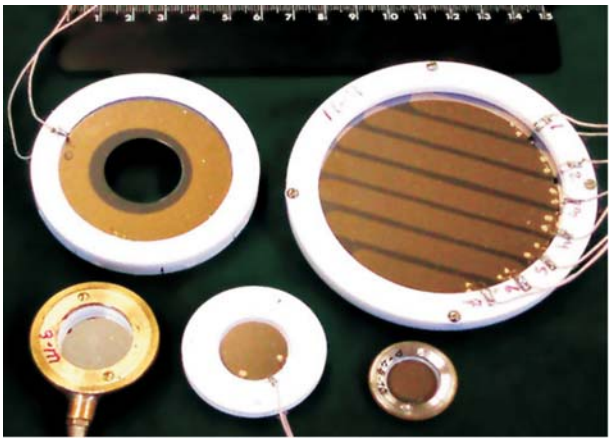

**Fig. 1. KINR Semiconductor Detector Elements**

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# TRITIUM STATIC ELIMINATORS (TSET)

## *Description*

Tritium sources for generating soft beta-radiation (BITr-M) are at the heart of the static eliminators developed by physicists at the Kyiv Institute for Nuclear Research. The sources themselves are comprised of a thin film (0,5 μm) of titanium metal impregnated with tritium deposited on molybdenum backing material. The working surface of the source is covered with a protective film made of either silicon monoxide or dioxide.

Tritium used in BITr-M is a pure beta-radiator which emits the lowest maximum energy (18,6 keV) among all known isotopes. It permits and essentially unlimited use of these static eliminators in production facilities without having to employ special radiation protection measures where, in some cases, there is no option other than the use of these static eliminators.

These static eliminators operate under the principle that air flowing past the working material is ionized by the beta radiation (electrons) which is then able to attract and neutralize latent charges (of opposite polarity) accumulated in the working environment. The ionization current produced by the BITr-M is $1{,}5 \cdot 10^{-8}$ A/cm$^2$.

Based on client needs, these eliminators may be constructed to match the specific working environment. In one example, the sources are set in proximity (1–3 cm) to electrifiable material while an ionization current is maintained due to the electrostatic charge. The required ionization current from the working surface is provided by the choice of BITr-M sources. As such, static eliminators may be produced to meet the specific needs of the client.

The static eliminator service life is no less than 8 year.

## *Innovative Aspect and Vain Advantages*

- high efficiency and complete autonomy;·
- compactness, simplicity and convenience in service;·
- reliability and durability;
- operation of these eliminators is possible even in explosion and firehazard conditions;
- operate independently of power sources;
- may be used in a wide variety of industrial needs;
- inexpensive;
- ecological hazards are essentially nonexistent.

This product is designed to eliminate electrostatic charges that arise during the treatment of materials highly susceptible to electrification. As such, these eliminators help to reduce unforeseen outages and external interference in process such as material sealing, material crushing, photomaterial exposure, etc., to increase worker safety by decreasing the probability of occurrence of fires and explosions connected to spark formation, and to minimize electrostatic field effects on workers and the working environment.

**Fig. 1. Tritium static Elemina Tors TSET**

## *Areas of Application*

These static eliminators may be employed in the chemical, textile, printing and other industries including the manufacture and treatment of film, sheet and powder materials which are susceptible to static electrification.

## *Stage of Development*

Preparations are underway to create facilities for the serial production of the static eliminators in industries that work with dielectric and other static-susceptible materials.

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# TRITIUM-CONTAINING TARGETS FOR NEUTRON GENERATORS

## *Description*

These targets are intended for generating neutron fluxes with energies of up to 14 MeV for the d (T, n) reaction and 25 MeV for the d (D, n) reaction. These targets provide stable neutron fluxes of the required intensity. The designed lifetimes compare favorably with the best in the world.

## *Innovative Aspect and Main Advantages*

| | |
|---|---|
| Neutron flux (n/s) | 108 to 1013 |
| Target diameter (mm) | 11.6 to 432 |
| Substrates | Cu, Mo |
| $_1T^3$ and $_1D^2$ sorbents | Ti, Zr, SC |
| Mass surface density of sorbents (mg/cm$^2$) | 0,5 to 3 |
| $_1T^3$ and $_1D^2$ atoms per sorbent atom | 1,5 |
| Number of standardized sizes | 10 |

Modification of the target at the request of the client is possible.

## *Areas of Application*

They Are Intended for use in booster of the particles.

## *Stage of Development*

First Stage: a technical process has been established for the serial production of Tritium-containing targets for neutron generators.


**Fig. 1.Tritium-Containing Targets for Neutron Generators**

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# ADVANCED ONE-STAGE EB-PVD COATINGS FOR AEROSPACE AND GAS-TURBINE APPLICATIONS

## *Description*

Electron beam technology and equipment are developed for one-stage deposition of functional graded coatings with the use of a composite ceramic ingot for evaporation. This technology allows replacing the flat interface between metal and ceramic layers with a graded transition zone and achieving good adhesion of the coating to the substrate.

The composite ingot incorporates the program of evaporation and deposition of a graded coating, embodied in composition, shapes and sizes, of the respective inserts, number of them, and also in arrangement of them inside of the basic ingot. Inserts determine composition, structure, and properties of a graded coating at all levels including transition zones and coating layers.

## *Innovative Aspect and Main Advantages*

As compared to traditional multi-stages technologies of protective coating deposition, this technology allows to achieve higher reproducibility level of composition, structure, and lifetime of the functional graded coatings.

Due to using only one EB-PVD unit and reducing number of stages, total cost of one-stage EB-PVD deposition process is at least 2 times smaller than that of traditional multistage technological processes of protective coating deposition.

Graded thermal-barrier coatings (NiAl/YSZ, NiCoCrAlY/AlCr/YSZ) with about 250 μm thickness allow to increase gas turbine engine gas temperature up to 100 °C maintaining the same temperature of the cooling blade surface. Outer ceramic YSZ layer has low level of thermal conductivity of about 1.2 W/m·K and reliable adhesion strength with bond coat (more than 100 MPa). Thermal-cyclic lifetime of graded TBC is about 1.8–2 times higher in comparison with traditional TBC.

Graded hard erosion-resistant coatings (TiN-based, TiC-based) of 15–25 μm thickness that deposited with high deposition rate (up to 1 μm/min) can increase the erosion resistance up to 15–30 times as compared to steel substrate.

Graded hard damping coatings (Sn-Cr-MgO) with thickness of about 25–50 μm allow to increase by several times the damping capability and erosion resistance of Ti-based articles with 25 % improvementI wI of fatigue resistance.

## *Areas of Application*

- Gas turbine blades and vanes;
- Hot parts of aerospace technique;
- Compressor steel and titanium blades.

**Fig. 1. Composite ceramic ingot**

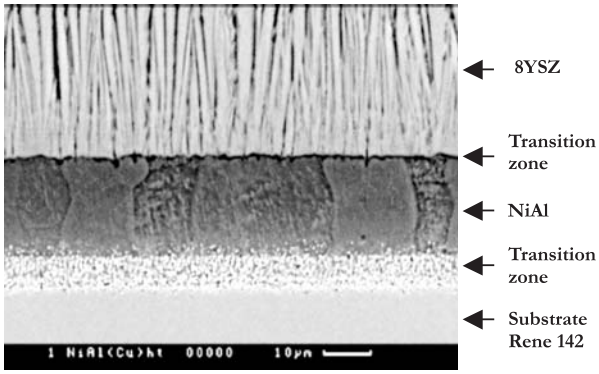


**Fig. 2. Graded thermal barrier coating NiAl/YSZ microstructure**

## *Stage of Development*

Patented and tested, available for demonstration.

## *Contact Details*

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# NANOSATELLITE FOR ELECTROMAGNETIC MEASUREMENTS

## *Description*

Nanosatellite is a new super-inexpensive mobile instrument for electromagnetic environment study near International Space Station (ISS). The instrument is capable to measure, store and transmit to the base station data about the following parameters:·

- three components of the constant magnetic field in the range ± 65 000 nT;·
- variations of magnetic field in the frequency range 0.1...40 000 Hz;
  electric potential in the frequency range DC...40 000 Hz;
- the current density in the frequency range 0.1 ... 40 000 Hz;
- kinetic plasma parameters – temperature, concentration and velocity of the charged and neutral particles.

## *Innovative Aspect and Main Advantages*

Carefully developed conception of the instrument based on the cheap industrial single-board computer PC-104 with open operational system LINUX and low-power sensors with high metrological character-istics provides for:·

- low cost;·
- low power consumption;·
- low physical dimensions and weight;·
- possibility of the rapid modernization.

## *Areas of Application*

Equipping the ISS for monitoring of its surface electric potential and electromagnetic environment. With minor modernization the nanosatellite could be used as a fully autonomous measuring system for both space and ground applications.

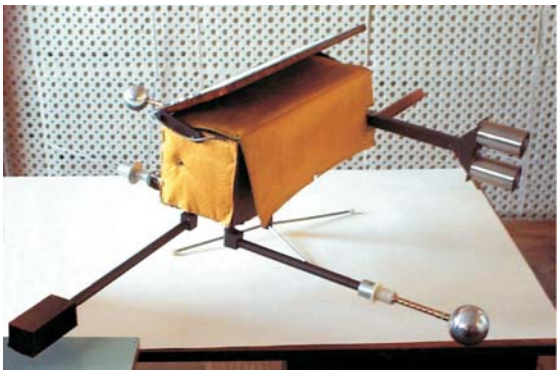

**Fig. 1. Nanosatellite for electromagnetic measurements**

## *Stage of Development*

The engineering model was tested at laboratory conditions. A group of sensors passed the tests in the plasma-dynamic vacuum chamber under conditions close to operation requirements.

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# UNMANNED TRANSPORT REUSABLE AIRBORNE-SPACE VEHICLE

## *Description*

Unmanned transport reusable airborne-space vehicle (ASV) "Sura" is designed for launching into near Earth orbit and as a reentry vehicle for satellites and other payloads.

It is a two-staged vehicle. Full weight is 48–50 tons, full thrust of air feed and liquid propellant jet engines (LPJE) is 61.1–70 tons, length – 17 m, wings span – 14 m, height – 6.6 m.

The first stage can be used in autonomous mode as a cargo sub-orbital plane. The second stage – as a space ship, i. e. for inter-planet flights and also for flights in the atmosphere of Solar system planets. The second stage contains a cargo module. Body of the module can be moved for launching and reentry of Earth satellites.

For further flight in the atmosphere the body is moved back to its place.

During reentry with cosmic speeds and flights on a chosen trajectory, the thermal protection shields prevent overheating.

Unmanned maximal quick-responsive option allows reducing transitive processes time up to minutes, seconds and microseconds.

Application of produced serially air-feed engines and LPJE makes it possible to reduce time of development by three times, as compared to analogues, and to cut cost of development by two times (for example, in comparison with Russian project TU-2000).

## *Innovative Aspect and Main Advantages*

Special constructional features of ASV construction are the following:

- plane stages have modular construction;
- there are no aerodynamic control elements;
- flight control is realized by LPJE;
- an advantage of the atmosphere is used (wing lifting force and oxidizer – oxygen);
- the principle of a "mortar" launching for staging and orbiting the payload is applied.

ASV construction features allow reducing spacelaunching cost.

**Fig. 1. Picture of the dimensional model of two-staged airborne-space vehicle**

Expected specific cost index of launching for 300 km height and 300 kg cargo weight is $ 1000 per one kg.

## *Areas of Application*

- launching of commercial communication satellites to the near Earth orbit;
- space research and remote Earth sounding.

## *Stage of Development*

Conceptual development at the stage of construction patenting in Ukraine.

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# FILTERED VACUUM-ARC PLASMA SOURCE FOR HIGH QUALITY COATINGS

## *Description*

Developed a cathodic vacuum arc plasma source with a magnetic filter that turns the plasma stream 90°. T-shaped plasma duct with a system of intercepting screens and fins provides a significantlly higher degree of absorption of macroparticles when compared to conventional "torroidal" filters (more than an order of magnitude). A small ratio of curvature radius of the plasma duct to its inner radius, a large diameter of the plasma guiding channel (200 mm), and an optimal geometry of transporting magnetic fields ensure a high throughput of the filter – up to 55 %. Filtered plasma source proposed may be used in new vacuum-arc industrial setups for the ion plasma processing of mate-rials including deposition of high quality coatings.

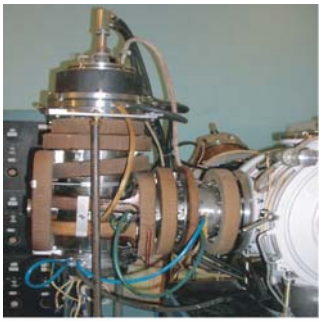

**Fig. 1. T-shaped filtered vacuum-arc plasma source for diamond-like coating (DLC) deposition. Coating deposition rate is 6 μm/h at the diameter 20 cm**

## *Innovative Aspect and Main Advantages*

Efficiency of the main versions of known systems and our results

| Type of filters | Knee shaped [Falabela] | Toroidal (45°) [Martin] | Rectangular [Gorokhovsky] | Dome type [Sanders] | **Wide aperture (our results)** |
|---|---|---|---|---|---|
| Efficiency $I_i$/Id ×100,% | 3,0 | 2,5 | 2,5 | 2,5 | **about 5** |

The ratio of the total ion flow at the channel exit to the discharge current ($I_i/I_d$) – the system efficiency coefficient – is commonly assumed to be the criterion of plasma passage efficiency through the system as a whole (generator + filter).

**Fig. 2. Elements of the gas dynamic bearing with DLC coatings (convex hemispheres) and with TiN coatings (concave hemispheres)**

## *Areas of Application*

Filtered vacuum-arc plasma source described can be used for the following coating deposition: DLC, metals (Ti, Cr, Nb, Mo, Cu, Al, etc.), alloys, nitrides, oxides, carbides, composites, multilayers.

Such coatings can be used as:

- wear-resistant coatings at surfaces of fine mechanic elements (hydrodynamic and electrostatic supports of gyroscopes and centrifuges, pistons of fuel pumps, etc.);
- decorative coatings;
- hard protective coatings on magnetic and optic devices;
- transparent conducting oxide films in solar sells;
- low-e films on architectonic glass;
- protective biologically indifferent coatings;
- "back-end" metal layers in ultra large scale integrated circuits.

Above mentioned filtered plasma source may be used:

- in new vacuum-arc industrial equipment for the ion plasma processing of materials including deposition of high quality micro- and nanostructural coatings;·
- when upgrading of existent vacuum-arc equipment for widening their technological potentiality; ·
- for high quality coatings deposition processes in machine building, fine mechanics, microelectronics, optics, automobile industries, etc.

## *Stage of Development*

Prototype available for testing; patented in USA.

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# MICROMODULES FOR LOW-POWER THERMOELECTRIC GENERATORS WITH RADIOISOTOPE HEAT SOURCE FOR INTERPLANETARY SPACE EQUIPMENT

## *Description*

The operating principle of thermoelectric micromod-ules is based on the use of thermoelectromotive forces arising in semiconductor thermocouples. A large num-ber of legs in thermopiles (from hundreds to tens of thousands) allows to obtain the necessary electric volt-ages at relatively small temperatures differences (~ 10–100°).

**Temperature modes of micromodules**

| | |
|---|---|
| Maximum operating temperature of hot side | + 230 °C; |
| Admissible overheat of hot side | +250 °C; |
| Maximum operating temperature of cold side | + 120 °C; |
| Admissible overheat of cold side | +150 °C; |
| Minimum operating temperature of cold side | – 50 °C. |

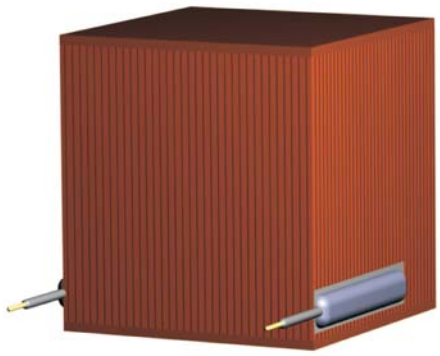

**Fig. 1. A micromodule**

## *Innovative Aspect and Main Advantages*

Special attention is paid to micromodules reliability. It was provided by special technology preventing degradation of legs in manufacturing and highly reliable technologies of legs connection to antidiffusion layers. Particularly reliable modules of IR series utilize special redundancy systems improving considerably their service life. The use of redundancy provides operating capacity of modules even at complete degradation of some legs. At degradation of one leg the electric power generated by module is reduced only by 1–3 %. The probability of failure-free work of module with redundancy during 10 years is increased by two-five orders.

## *Areas of Application*

Micromodules are intended for use in low-power thermoelectric generators of space or terrestrial purpose. Sources of heat can include radioactive isotopes (for example, $Pu^{238}$), thermal flows in soils, heat released by organisms, including human, thermal flows through the walls of buildings and heat from various heated objects, waste heat from industrial and house-hold devices, microcatalytic sources using flameless combustion of combustible gases or liquids (petrol, kerosene) etc. Micromodules open up opportunities for wide application of low-power thermoelectric generators for power supply to space equipment.

The use of a large number of such generators on space objects radically improves the reliability of electric power sources, provides for their convenient location, serves as alternative to solar thermopiles on the orbits distant from the Sun. Terrestrial applications open up new opportunities of using thermoelectricity for power supply to medi-cal equipment (heart pacemakers), heat meters, alarm and guard systems, portable electric devices, etc. Based on micromodules, compact long-action sources can be created having specific characteristics higher than those of chemical power sources (storage batteries, chemical batteries).

## *Stage of Development*

License agreements and cooperation for further development are sought.

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# SPACE ENVIRONMENT SIMULATOR

## *Description*

Cryogenic and aerospace equipment is exploited in complicated and unfavorable environmental conditions caused by Solar irradiation, high-power flux of corpuscular irradiation from radiation belts of Earth, vacuum, zero-gravity, low temperatures, significant cyclic gradient thermal loading, notable static, dynamic and reciprocal cyclic loadings, vibration etc. Each of the mentioned factors influences alteration of mechanical, optical, electric, thermo-physical, tribotechnical and other properties of materials used in the equipment, whereas cumulative impact of all these factors is not additive.

Today, therefore, the main tasks of cryogenic and aerospace materials science are: determination of serviceabil-ity, reliability and lifetime of existing materials as well ascreation of novel materials with enhanced characteristics. Such factors as non-uniformity of in-flight heating of different portions of Space vehicle (SV), time-dependent alteration of adsorption coefficients and degree of darkness for outer surfaces of SV, with account of inner energy dissipation – require special and sometimes very intricate experimental studies. It is expedient that the experiments are run at on-ground elaboration of spacecraft and involve special facilities simulating Space environment conditions.

In order to solve the abovementioned problems, experts of Special Research and Development Bureau (CRDB) for Cryogenic Technologies of B. Verkin Institute for Low Temperature Physics and Engineering at National Academy of Sciences of Ukraine (SRDB) have elaborated methods, equipment and technologies for creation of special-purpose simulators series .

Specialists of the SRDB have a great experience in development of simulation equipment. Earlier they built more than 10 complete sets of Simulators (Fig. 1, Fig. 2) for commercial purposes, as well as for researches in the field of materials science and SV testing in Germany, China, for National Space Agency of Ukraine, "Yuzhnoye" Design Bureau, Ukraine, etc.

**Fig. 1. The complex outer-Space environmental factors simulation unit**

**Fig. 2. General view of the stand-facility for thermo-vacuum testing of Space-vehicles**

Personnel of the SRDB includes, particularly, a team of experts capable of solving a wide range of materials science tasks, specialists in the area of design and technology engineering, a group of young scientists and experts.

## *Innovative Aspect and Main Advantages*

We are seeking collaboration for development of a cooling machine which would be installed in the cooling equipment of Simulators. Such modification of Simulators would allow to use them without cryogenic liquid and to expand, therefore, application in the aerospace industry.

## *Areas of Application*

The complex simulation equipment is intended for simulation of space vacuum, cold Space environment, fluxes of protons and electrons, electromagnetic radiation by the Sun and Earth, and Earth-albedo with the purpose to study the influence of these factors on thermal regime of hardware and instruments of SV, as well as to determine serviceability, reliability and lifetime of cryogenic and other materials used in aerospace.

## *Stage of Development*

Patented (Ukraine Patent 52338, "Cryogenic-vacuum camera") and already on the market.

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# ADVANCED MATERIALS AND STRUCTURES FOR LONG-TERM SPACE OPERATIONS

## *Description*

A new technology has been introduced for development of materials and structures with special properties for a long-term operation in orbit as well as for modification of existing materials by unique properties providing resistance to the space environment factors, such as radiation, vacuum ultraviolet, electromagnetic radiation, thermal cycles and atomic oxygen.

Special unique equipment is available which allows to ascertain the materials resistance on the ground.

## *Innovative Aspect and Main Advantages*

Usually resistance to space environment factors is determined by the influence of one or two factors. In this case an effect of synergism is not taken into account. In Ukraine a unique installation has been developed – CSSF – that allows testing of materials under simultaneous influence of protons, electrons, ultraviolet, Sun's light radiation, vacuum and cyclic change of temperature.

With the use of this installation materials testing allows reliable estimation of their protective properties and development of materials with special properties and optimal mass characteristics.

## *Areas of Application*

Aerospace industry

## *Stage of Development*

The CSSF installation is created and ready to use.

Materials and structures are developed or modified at availability of Customer's initial data.

**Fig. 1. Complex Simulator of Space Factors (CSSF)**

## *Contact Details*

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# УКРАЇНСЬКИЙ НАУКОВО-ТЕХНОЛОГІЧНИЙ ЦЕНТР (УНТЦ)

SCIENCE & TECHNOLOGY CENTER IN UKRAINE

The STCU is a multilateral organization involving Ukraine, Canada, the European Union, and the United States, and includes in its membership the countries of Azerbaijan, Georgia, Moldova, and Uzbekistan. The STCU has operated for 11 years in Ukraine and is proud to have sponsored over 900 science research projects between former Soviet military scientists and institutes in Ukraine and the scientific communities of Canada, the United States, and the European Union. The governments of Canada, the European Union, and the United States have financed over USD 90 million and EUR 17,4 million in cooperative science research in Ukraine. Further, the STCU has connected Ukrainian scientists to commercial customers throughout North America and Europe, bringing over USD 14 million and EUR 366 037 in valuable research funds from these companies into Ukraine and creating the basis for future successful commercial technology development in Ukraine.

The STCU continues to seek opportunities to integrate its Weapons of Mass Destruction (WMD) nonproliferation mission with national, regional, and international needs so as to successfully transition former WMD scientists and institutes into self-sustaining, peaceful research work that brings social and economic benefits. In matching STCU's nonproliferation objectives with the development objectives of Ukraine, Azerbaijan, Georgia, Moldova, and Uzbekistan, the STCU hopes to be seen as a valuable asset to both its donor and beneficiary member countries.

The STCU has served as a bridge between Ukraine's science community and the science communities in Europe, the United States, Canada, as well as Ukraine's regional partners: Georgia, Azerbaijan, Moldova, and Uzbekistan.

Український науково-технологічний центр - це багатостороння організація, що діє на основі угоди між урядом України, Канади, Європейського Союзу та США, а також Азербайджану, Грузії, Молдови та Узбекистану. Український науково-технологічний центр працює в Україні протягом 11 років. За цей час УНТЦ профінансував понад 900 науково-дослідних проектів між колишніми Радянськими військовими вченими і інститутами в Україні та науковими співтовариствами Канади, США та Європейського Союзу. Уряд Канади, Європейського Союзу та США виступили спонсорами наукових досліджень в Україні на суму більш ніж 90 мільйонів доларів США та 17,4 мільйонів євро. Також УНТЦ слугує ключовою ланкою між українськими вченими та комерційними замовниками Північної Америки та Європи, залучивши більш ніж 14 мільйонів доларів США та 366 037 євро до України і створивши основу для майбутнього успішного розвитку комерційної технології в Україні.

УНТЦ продовжує процес пошуку можливостей для об'єднання місії компанії по нерозповсюдженню зброї масового знищення з національними, регіональними та міжнародними потребами щодо успішного переходу колишніх науковців ВПК до мирної, самоокупної діяльності, яка сприятиме соціальному та економічному зростанню країни. Збігання цілей УНТЦ по нерозповсюдженню зброї масового знищення та національних цілей України, Азербайджану, Грузії, Молдови та Узбекистану робить УНТЦ цінним інструментом як для країн-донорів, так і для країн-реципієнтів.

УНТЦ слугує сполучною ланкою між українськими науковими співтовариствами та науковими співтовариствами Європи, США, Канади, а також регіональними партнерами України: Грузії, Азербайджану, Молдови та Узбекистану.

# ІНФОРМАЦІЯ ДЛЯ АВТОРІВ ЖУРНАЛУ "НАУКА ТА ІННОВАЦІЇ"

В журналі "Наука та інновації" друкуються статті та короткі повідомлення, що містять відомості про наукові дослідження, технічні розробки, перспективні бізнес- та інноваційні проекти, ноу-хау з таких напрямків:

1. Загальні питання сучасної науково-технічної та інноваційної політики
   1.1. Законодавчі та методологічні основи
   1.2. Економічні аспекти
   1.3. Дискусійна трибуна
2. Наукові основи інноваційної діяльності
   2.1. Приладобудування
   2.2. Телекомунікації, зв'язок і навігація
   2.3. Нанотехнології та функціональні матеріали
   2.4. Транспортні і будівельні технології
   2.5. Сільськогосподарські і аграрні технології
   2.6. Екологічні технології і біотехнології
   2.7. Енерго- і ресурсозбереження
3. Світ інновацій
   3.1. Ноу-хау і трансфер технологій
   3.2. Інноваційні структури
   3.3. Мовою цифр
   3.4. Оперативна інформація науково-інноваційної сфери

В журналі також друкуються науково-технічні та тематичні матеріали, повідомлення про конференції, вихід з друку наукових видань за вказаною тематикою, про профільні та спеціалізовані виставки.

**Рукопис статті** подається автором у двох екземплярах українською, російською або англійською мовами.

**До рукопису додається**:

**Компакт-диск** або **дискета** з текстовим файлом та файлами рисунків (електронна копія матеріалів може бути направлена до редакції за допомогою електронної пошти).

**Направлення** – офіційний лист, підписаний керівником установи, де виконувалась робота.

**Експертний висновок** – висновок експертної комісії про можливість відкритого публікування представленої роботи.

**Угода** про передачу авторського права на друк статті редакції журналу, для того, щоб сприяти широкому розповсюдженню наукової інформації. Форму угоди можна отримати в редакції журналу.

**Правила оформлення рукопису статті:**

***Титульна сторінка*** подається обов'язково українською, російською та англійською мовами:

1. Назва статті, прізвище(а) та ініціали автора(ів).
2. Назва установи, повна поштова адреса, номер телефону, номер факсу, адреса електронної пошти всіх автора(ів).
3. Анотація – 100 слів максимум.
4. Ключові слова – не більше восьми слів.

***Текст*** друкується шрифтом 12 пунктів через два інтервали на білому папері формату А4. Назва статті, а також заголовки підрозділів друкуються прописними буквами та виділяються напівжирним шрифтом.

***Формули*** необхідно набирати у відповідних редакторах. Статті із вписаними від руки формулами до друку не приймаються. Необхідно давати визначення величин, які використовуються в тексті вперше.

***Таблиці*** подаються на окремих сторінках. Повинні бути виконані у відповідних табличних редакторах або представлені в текстовому вигляді з використанням текстових роздільників (крапка, кома, кома з крапкою, знак табуляції). Використання символів псевдографіки для оформлення таблиць не припускається.

***Список літератури*** друкується через два інтервали та нумерується послідовно у порядку їх появи в тексті статті. Неприпустимі посилання на неопубліковані та незавершені роботи.

Бібліографічний опис повинен відповідати титульній сторінці видання. Назви статей, а також монографій, збірників, праць нарад, тезисів доповідей, авторефератів дисертацій та препринтів вказуються повністю. Для статей обов'язково вказуються назва статті, назва видання, рік, том, номер, початкова та кінцева сторінки, для

монографій – назва, місце видання (місто), видавництво, рік видання, загальна кількість сторінок.

***Підписи до рисунків і таблиць*** друкуються в рукопису після літературних посилань через два інтервали.

***Примітки***. Припускається використання текстових приміток тільки у випадку необхідності.

***Ілюстрації***. Приймаються до друку тільки високоякісні ілюстрації. Підписи та символи повинні бути надруковані. Не приймаються до друку негативи, слайди. Не рекомендується використання напівтонів – важливо представляти ілюстрації з максимальним чорно-білим контрастом.

***Рисунки***. Кожен друкується на окремій сторінці. Повинні мати розмір відповідний формату журналу: не більше 160 × 200 мм. Текст на рисунках повинен бути виконаний шрифтом 10 пунктів. На графіках одиниці виміру вказуються через кому (а не в дужках). Усі рисунки (ілюстрації) нумеруються в порядку їх розташування в тексті. Частини рисунків нумеруються літерами: (а), (б), ... . Не припускається внесення номера та підпису до рисунка безпосередньо в рисунок. На зворотній стороні рисунка олівцем пишеться назва статті, автор (автори), номер рисунка. "Верхні" частини рисунків повинні бути позначені стрілкою.

***Фотографії*** повинні бути надруковані на глянцевому білому папері. Фотографії, які вже є растрованими (у напівтонах), будуть розглядатися як рисунки.

Загальний об'єм тез – до 2 стор. (кількість ілюстрацій – до 2), загальний об'єм коротких повідомлень – до 5 стор. (кількість ілюстрацій – до 5), загальний об'єм статей – до 20 стор. (кількість ілюстрацій – до 10).

**Вимоги до електронної копії статті:**

1. Електронна копія (дискета – 3,5, CD-R або CD-RW) матеріалу подається одночасно з наданням твердої копії статті, рисунків.
2. Для тексту слід використовувати такі формати: MS Word 6.0 (або новіші версії) (doc).
3. Рисунки приймаються у форматах EPS і TIFF (кольорова палітра CMYK) з роздільною здатністю 300 dpi. Рисунки, які виконані за допомогою програмних пакетів математичної та статистичної обробки, повинні бути конвертовані у вищевказані графічні формати.
4. Фотографії приймаються у форматі TIFF (кольорова палітра CMYK) з роздільною здатністю 300 dpi.
5. Надписи та тексти в графічних файлах повинні бути переведені в криві.

Відповідальність за достовірність інформації в матеріалах, надрукованих журналом, несе автор або замовник матеріалу.

Для отримання необхідної Вам додаткової інформації контактуйте з відповідальним секретарем редакції.