SCIENCE & TECHNOLOGY
CENTER IN UKRAINE

AN INTERGOVERNMENTAL ORGANIZATION
ASSISTING FORMER WEAPONS SCIENTISTS'
TRANSITION TO PEACEFUL PROFITABLE
CONTRIBUTIONS TO GLOBAL R&D

NOLOGY NANOTECHNOLOGY NANOTECHNOLOGY NANOTECHNOLOGY NANOTECHNOLOGY NANOTE

International R&D Partnerships

Gateway to the Hi-Tech World of Former WMD Scientists

Business Security, Reliability and Stability

Over Ten Years of Successful Operations

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Azerbaijan | Canada | European Union | Georgia | Moldova | Ukraine | USA | Uzbekistan

The Science & Technology Center in Ukraine (STCU) provides Western companies with the services of highly skilled scientists from Azerbaijan, Georgia, Moldova, Ukraine and Uzbekistan as well as tax-free privileges, duty-free import of equipment and Western-style project monitoring. The STCU is an intergovernmental organization dedicated to the non-proliferation of weapons of mass destruction expertise. Since 1993, private companies and government agencies from Canada, the European Union and the United States have used the STCU to manage nearly 900 R&D projects, worth over US $120 million.

Background images courtesy of Accelrys, www.accelrys.com
Design by Natalia Pavlovskaya

Welcome from the STCU Executive Director

Andrew A. HOOD
STCU Executive Director

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 nonproliferation of WMD expertise, the STCU has compiled a treasure trove of experience and knowledge about the many highly talented scientists and technologists in Azerbaijan, Georgia, Moldova, Ukraine 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 900 research projects totaling over US $120 million, performed in close collaboration with the European and North American scientific communities;
- Over 100 private sector and governmental agencies which have joined the STCU's Partnership Program to finance their own, tailored S&T projects (totaling more than US $30 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 Azerbaijan, Georgia, Moldova, Ukraine 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 nonproliferation mission (which, actually, is a win for global security)!

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The New Structure of the STCU

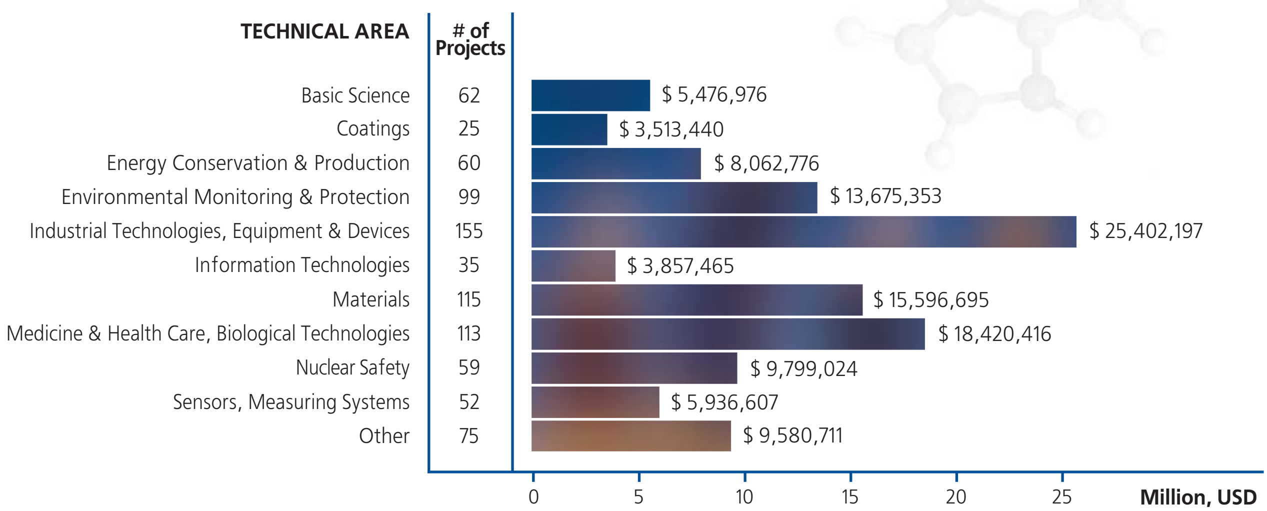
- **STCU Executive Director** (Andrew Hood, USA)
  - **Chief Financial Officer** (Curtis Bjelajac, USA)
  - **Chief Administrative Officer** (David Cleave, EU)
  - **Deputy Executive Director Science Excellence** (Esa Manninen, EU)
    1. Project Management: Nuclear Safety & Energy, Environment, Basic Sciences, Materials, Non-Nuclear Energy
    2. Proposal Processing
    3. Workshops/Seminars: Science Promotion, Competitive Research Support
    4. Regional Offices: Georgia, Moldova
  - **Deputy Executive Director Technology Advancement** (Landis Henry, Canada)
    1. Project Management: Biotechnology & Public Health, Industrial Technology & Safety, Instrumentation & Sensors, Information Technology
    2. Targeted R&D Initiatives
    3. Regional Offices: Dnipropetrovsk, Kharkiv, Lviv
  - **Deputy Executive Director Sustainability Promotion** (John Zimmerman, USA)
    1. Project Management: Partner Recruitment, Promotional Missions, Contacts/Networking Support
    2. Market Analysis
    3. Sustainability Development: Targeted Matchmaking, Institute Strategic Planning Support
    4. Patent/IPR Support
    5. Regional Offices: Azerbaijan, Uzbekistan
  - **Principal Deputy Executive Director Performance/Public Outreach** (Borys Atamanenko, Ukraine)
    1. Public Outreach: Promotional & Support Materials, Conference Support, Travel Grants
    2. Performance Measuring: Self-Sustainability, Program Effectiveness
    3. Targeted Training Program

The STCU's Matchmaking Initiative

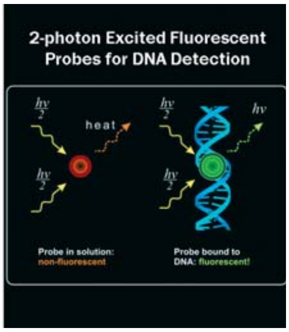
The goal of the Matchmaking initiative is to provide opportunities for information exchange, as well as matchmaking, between scientists and industries about their R&D potential and needs. Nanotechnology, an interdisciplinary field that includes the fields of physics, chemistry, applied sciences, engineering, biology and biomedical technology, is addressed in a number of proposals registered with the STCU along with over thirty STCU-funded projects. Knowledgeable researchers and trained personnel in this field; technologies for collaborative development, licensing, cooperative marketing and commercialization are all accessible through the STCU.

We kindly ask interested technology end-users (private firms, governmental bodies, educational institutions, etc.) to contact the STCU Governmental Partnerships Program (lyubov.taranenko@stcu.int) and Non-governmental Partnerships Program (boris.komarov@stcu.int) for assistance in matching your technology needs to the supply of excellent, knowledgeable expertise in Azerbaijan, Georgia, Moldova, Ukraine and Uzbekistan.

PROJECT FUNDING BY PRIMARY TECHNICAL AREA, 1996–2004



Two-Photon-Excited Fluorescent Probes for Biological Imaging



Fluorescent probes are widely used in biological and medical studies for detection and imaging of biological objects. The recently invented two-photon-exited (TPE) fluorescence technique enables noninvasive imaging of biological specimens in three dimensions with a high resolution. Two-photon excitation of fluorophores results from the simultaneous absorption of two photons. This excitation process has a number of unique advantages, such as reduced specimen photodamage and enhanced penetration depth. Powerful pica- and femtasecond sources are used for excitation. The working spectral region is near infrared, where the biological objects are transparent.

Dr. Yashchuk's team offers a new approach; the development of fluorescent probes for TPE technique on the basis of selected TPE-efficient molecules. These molecules are modified by so called "affinity-modifying groups" in order to enhance the affinity of the dye to various biological molecules. Using a new approach, the TPE fluorescent probes were developed on the basis of existing and newly synthesized dyes, which were accordingly modified. The developed probes demonstrate a high efficiency of two-photon excitation; they are photochemically safe and ideally suited for detecting bio molecules.

Potential medical applications include photodynamic therapy and pharmaceutical development.

Dr. Valeriy M. Yashchuk, National Taras Shevchenko University, Kyiv

Red and NIR Fluorescent Probes and Labels for Bio Applications

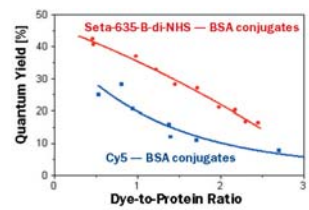
Fluorescence probes and labels excitable with red and blue diode lasers for use in biological research and biomedical assays have been developed on the basis of newly synthesized ring-substituted squaraines which are a subclass of polymethine dyes.

Unlike the widely used Cy5™ and Alexa™ dyes that are excitable only with red laser, the proposed tracers demonstrate:

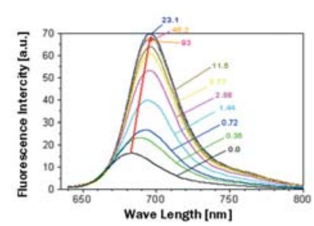
- higher photostability;
- lower tendency to aggregate in aqueous media;
- higher quantum yields when bound to proteins;
- increased brightness and five-fold longer FLTs when bound to proteins while allowing for low quantum yields and shorter fluorescence lifetimes (FLTs) in aqueous media;
- excitation with red and blue diode lasers.

These advantages make the developed tracers applicable in fluorescence-based technologies (intensity, polarization, Fluorescence Resonance Energy Transfer (FRET) and FLT). In addition these dyes can be used not only as reactive labels but also as non-covalent probes. The Radiative Decay Engineering approach (allocation of these dyes at certain distance onto the surface of nano-silver (8-10 nm) and nano-gold (~20 nm) particles prepared by sol-gel technology) can be used for additional improvement of the quantum yields, extinction coefficients, and photostability.

These novel fluorescence-based probes and labels, technologies for their production and protocols for their use in biological investigations and biomedical assays are available.



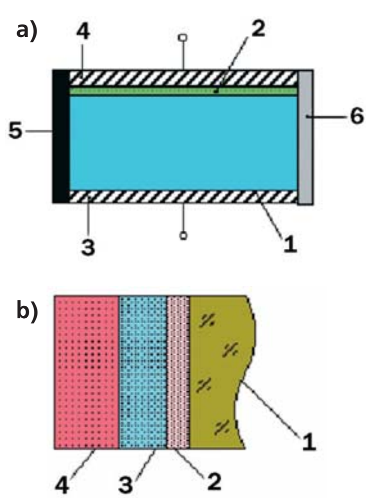
Developed amine-reactive fluorescent label **Seta-635-B-di-NHS** shows higher quantum yield as compared to Cy5™ when bound to protein (in phosphate buffer pH 7.4)



Developed **Square-670-di-carboxy** ($4.4x10^{-7}$ M) shows noticeable increase of fluorescence in presence of protein (BSA concentration from 0 to $93x10^{-6}$ M)

Dr. Leonid D. Patsenker, Institute for Single Crystals, Kharkiv
http://www.isc.kharkov.com/english/isma/structure/patsenker/index.htm

Optochemotronic Sensor for the Detection of Liquid Analytes



Schematic structure of **a)** optochemotronic sensor with working electrode modified with Langmuir-Blodgett film (1 – working solution, 2 – LB film on a working electrode, 3 – auxiliary electrode, 4 – working electrode contact layer, 5,6 – gasket) and **b)** working electrode (1 – glass substrate, 2 – ITO conducting layer, 3 – electroconductive organic subphase, 4 – LB layer doped with active molecules)

A liquid-phase electro-chemiluminescence phenomenon (ECL) allows creation of an optochemotronic sensor for the detection of analytes in bio liquids. The ECL phenomenon originates in the ordered thin/monomolecular film of the organic luminescer located on the electrode/solution interface.

Dr. Rozhit'skii's team designed a "Lab-on-a-chip" optochemotronic sensor and manufactured it by deposition of electro-chemiluminescent reactants onto the smooth surface of metal or optically-transparent semiconductor electrode using the Langmuir-Blodgett technology. The optochemotronic sensor enables the following improvements:

- wider assortment of compounds that can be detected in solutions;
- advanced selectivity and improved sensitivity approaching "molecular recognition";
- significant reduction in use of the most expensive component — electro-chemiluminescer, due to the sensor's miniature dimensions (micro or nano) and reusability;
- improved interference immunity and high processing speed due to the direct long-range transmission of the optical analytical signal by optical guides.

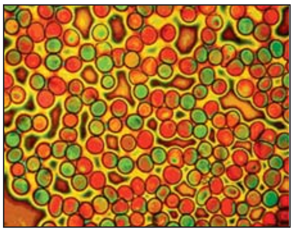
Optochemotronic sensors are expected to work in a variety of applications to detect analytes in biological liquids (blood, urine, milk, etc.) and organic toxic impurities in water ecosystems.

Dr. Mykola M. Rozhit'skii, Kharkiv National University of Radioelectronics, Kharkiv
http://www.kture.kharkov.ua/laboratory/electrohim/scientific.html

Noninvasive Color Visualization of Blood Cells

A new method for colour imaging of human blood cells using an ordinary optical microscope is offered. A specially designed part — a non-transparent thin-film reflector — was added to an optical system. A color interference pattern is generated by bio-specimen reflection and white light reflection from the specially designed reflector. Colour visualization of liquid specimens is obtained without any preliminary chemical or physical treatment of the tested substances and in so doing guarantees unchanged cells morphology.

Proposed technique is an inexpensive alternative to phase-contrast, interference, or luminescence microscopy. The method is also applicable for researching low-contrasting cells (salivary, lachrymal, exudative discharges, etc.) and cell cytoplasm.



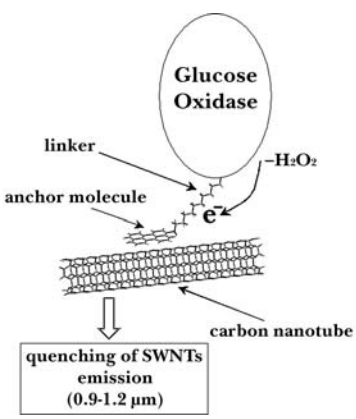
a)

b)

Human blood erythrocytes imaging using the developed technique **(a)** and ordinary microscopy **(b)**

Dr. Adkhamjon A. Paiziev, Institute of Electronics, Tashkent

Miniature Biosensor Based on Carbon Nanotubes



The unique physical and chemical properties of carbon nanotubes open possibilities for creating a new miniature chemical/biological sensor. This biosensor is under development. It will be based on semiconducting single-walled nanotubes. Using small-diameter (0.6-1.1 nm) nanotubes, NIR luminescence originates in the spectral range 0.9-1.2 mkm, which can be monitored by a conventional low-cost CCD matrix or photomultiplier. In this spectral range human tissues are optically transparent and a sensor can be implanted into the body.

The key element in creating such sensors is elaboration of interfaces between the nanotubes and the recognition biosystem, enzymes (glucose oxidase or lactate oxidase). To avoid the loss of intrinsic nanotube properties upon chemical modification aimed at efficient enzyme immobilization, a noncovalent nanotube functionalization will be applied, and the relevant chemical compounds will be synthesized.

The results of the team's current activities will be the development of a highly sensitive low-cost biosensor for glucose detection in blood and lactate in human saliva.

Dr. Victor A. Karachevtsev, Institute for Low Temperature Physics & Engineering, Kharkiv

Electronic Nose and Phosphorus–Containing Calixarenes

In their more than ten years of experience in working with phosphorus-containing calixarenes chemistry, the team has synthesized over 250 new calixarenes; more than twenty of which are now commercially available worldwide through the Acros Organics Company.

The kilo-scale setup for calixarenes manufacturing is owned and operated by the team.

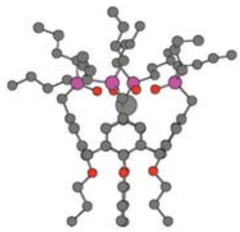
The calixarene based Electronic Nose was developed for monitoring hazardous pollutants in the environment; quality control in the food industry, automotive paintwork (control of organic solvent in air), agriculture, perfumes and beverages production as well as for the detection of drugs and explosives in the customer service sector.

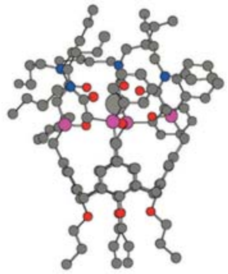
This technology can be used for applications in nanomedicine (drug delivery systems, diagnostics, scaffolds for drug design), nanotechnology, chemistry, material science including highly selective extractants, supramolecular catalysts, nanoparticles, nanocomposites, sensors and bioactive compounds.

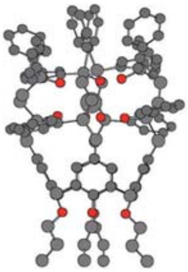
Calixarenes, macrocyclic compounds capable of assuming a basket (or 'calix') shaped conformation, due to such architecture are capable of recognizing, binding and separating anions, cations, neutral organic molecules (up to optical antipodes) and bio molecules, which are similar in properties and, in so doing, are hardly recognized by other means. This stipulates a wide diversity of applications for calixarenes.

Prof. Vitaly I. Kalchenko, Institute of Organic Chemistry, Kyiv

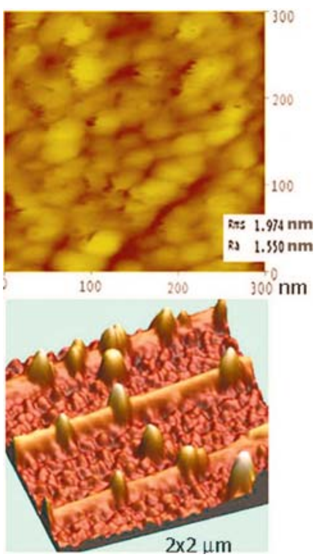
CALIXARENE — METAL CATION COMPLEXES


Calix-Phosphine Oxide


Calix-CMPO


Calix-Diphosphine Dioxide

Organic Nanocomposite Films for Nonlinear Optics



Relief of Teflon film and dye nanodots on it

Dr. Grytsenko's team manufactures the following product lines:

- Polymer films for use as low-k dielectric layers, barrier and protective layers;
- Nanocomposite dye-polymer films for integrated-optic devices, nonlinear optics, optoelectronics;
- Nanocomposite metal-dye-polymer films for photonic, plasmonic and sensor integrated-optic devices.

These materials are produced by gas phase deposition. The developed technology includes know-how and a unique device for the evaporation of dye and polymers, which principally differs from existing devices for evaporating inorganic materials.

Automated laboratory-scale installations and a prototype of an industrial installation are available and practically ready for commercialization.

Specific products include, but are not limited to:

- Teflon films as the best low-k dielectric for the next generation of microchips;
- Polyparaxylylene and polyparaphenylene sulfide films as a material with a high refractive index for waveguides;
- Polymer waveguides filled with asymmetric nonlinear or sensor dyes as active functional materials for integrated-optic devices, in particular, for creating fully-optical transistors and microchips;
- Teflon films filled with metal (Au) and dye nanoclusters for chemical catalysis, biochips and photonics devices;
- New asymmetric evaporable functional dyes for active components in integrated-optic devices.

Dr. Konstantin Grytsenko, Institute of Semiconductor Physics, Kyiv

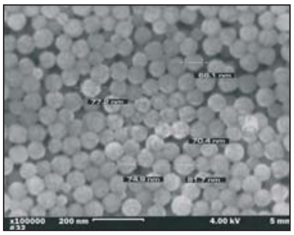
Polymeric, Inorganic, and Colloidal Nanoparticles

Surface-active oligoperoxides and oligoperoxide metal complexes have been developed and are being utilized for the production of the following functional nanoparticles:

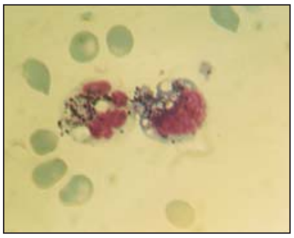
- Polymeric nanoparticles including fluorocontaining ones (40-100 nm), i.e. polystyrene and polyacrylate, with tailored particle size distribution, functionality and reactivity;
- Reactive functional nanoparticles with magnetic, conductive, resistive and dielectrical properties: ferric oxide based nanoparticles (8-12 nm), Ag (10-20 nm), Cu (500 nm), Ni (1-2 micrometres);
- Biocompatible colloidal particles capable of binding proteins and interaction with cell membrane, which are based on polymeric, ferric oxide, and Ni nanoparticles;
- Water-soluble oligomeric surfactants capable of improving the solubility of drugs and water based preparations;
- Luminescent oligomeric and colloidal cell markers.

Available production processes include, but are not limited to, radical polymerization and homogenous nucleation. Developed oligoperoxides and oligoperoxide metal complexes are of linear, block- and highly branched structures (including fluorocontaining chains or branches).

Possible applications are in microelectronics, biotechnology, surface modification in particular (water repellents, antimicrobial coatings, fillers, fibers and fabrics).



SEM of polyStr latex obtained in the presence of oligoperoxide metal complexes (OMC) which act as an initiator-stabilizer



The absorption of Ni colloids opsonizated by protein concanavaline A, neutrophile human blood cells. Two neutrophile cells, which are tightly packed up by colloids are shown in the picture

Prof. Alexander S. Zaichenko, Lviv Polytechnic National University, Lviv

Hybrid Nanocomposites

Hybrid nanocomposites

Hybrid Nanocomposites for Lithium Battery Cathodes

Developed ternary hybrid nanocomposites have a guest-host structure and include:

- inorganic nanoparticles i.e. layered vanadium oxide particles of around 10nm in size;
- electron-conducting polymer (polyaniline, polypyrrole), the macromolecules of which are mainly located inside the inorganic nanoparticles;
- ion-conducting polymer (poly(ethylene oxide)), whose chains are located both inside and outside of the inorganic nanoparticles.

The simultaneous presence of both electron-conducting and ion-conducting polymers inside the inorganic nanoparticles, in the form of a layer (0.5–0.6 nm thick), is a distinctive feature in comparison with known hybrids and provides for improved efficiency of charge-discharge cycling.

Can be used as an active component of the cathode in lithium batteries. Targeted discharge capacity is 200-250 mA*h/g which considerably exceeds the characteristics of presently used cathode materials.

Hybrid Nanocomposites for Light-Emitting Diodes

Hybrid nanocomposites based on organic semiconductors and inorganic matrices that are applicable in light-emitting diodes and displays.

Semiconducting conjugated polymer (MEH-PPV) and inorganic mesoporous silica (MCM-41) were used as the basis for the developed nanocomposite. The content of the organic component in the developed nanocomposite is 15wt% which well exceeds known international prototypes. Organic macromolecules are confined inside the channels of the mesoporous inorganic matrix that results in improved efficiency of electroluminescence and environmental stability.

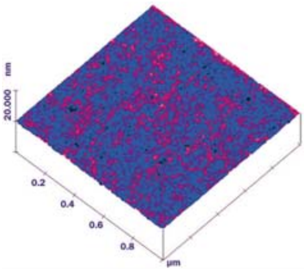
Dr. Oleg Y. Posudievsky, Institute of Physical Chemistry, Kyiv

Laser-Formed Ordered Nanostructures in Semiconductors

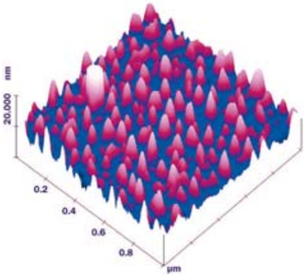
A laser irradiation technique is offered for the formation of ordered nanostructures in IV, II-VI, and III-V semiconductor crystals. The technique provides for the prescribed localization of nanostructures through the depth and surface of crystals.

For surface modification, crystals are irradiated by a single pulse of the Q-switched ruby laser with the duration of $2*10^{-8}$ s and a power density adjusted to be below the melting and damage threshold. It results in a generation of point defects. Upon attainment of the critical concentration of point defects on the crystal surface, ordered nanostructures occur. It results from a self-organizing process involving clusterisation of point defects under laser irradiation. Laser irradiation regimes are optimized in order to provide the homogeneous structure with a period of 100 nm, lateral sizes of ~19-50 nm, and a mean height of ~3.4-9.4 nm.

This technology and structures are applicable for the development of devices for solid-state lasers, IR radiation detection and imaging, converters of optical frequencies, and other photonic devices.



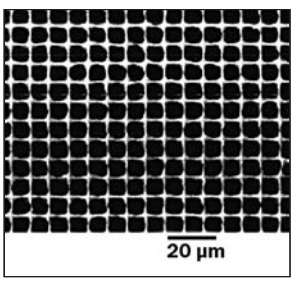
AFM image of the surface of a (111) p-CdTe crystal in its initial state



AFM image of the surface of a (111) p-CdTe crystal irradiated by ruby laser single pulse

Dr. Aliya Baydulayeva, Institute of Semiconductor Physics, Kyiv

Photonic Composite Macroporous Silicon



The two-dimensional macroporous silicon photonic structure with periodical macropore structure. The macropores have diameters of D_p = 3-6 µm, depths of about H = 250 µm, and a concentration of $N_p = 1{,}5.10^5$ cm^{-2}

Research into photonic crystals, a new class of composite materials, has been traditionally directed towards optical and microwave applications. The unique features of the two-dimensional macroporous silicon inspired research into a new application, light emitters based on Si photonic structures with surface nanocrystals, highly sensitive uncooled thermal and photo sensors manufacturing.

Macroporous silicon is created by light-assisted electrochemical etching of n-Si. The developed method is capable of electrochemically tuning the pore diameters and chemically modifying the surface. Produced material has cylindrical pores of 1-15 µm diameter and a high ratio of depth to diameter. The pores are located with strong periodicity. Conductive and isolating coatings are synthesized on the pore walls: silumine, boron silicide, silicon carbide, and silicon oxide nanolayers (100 nm).

With regards to integrated nanophotonic circuit applications based on two-dimensional photonic crystals, as well as medical and environmental monitoring applications, the following developments are in the process of being finalized:

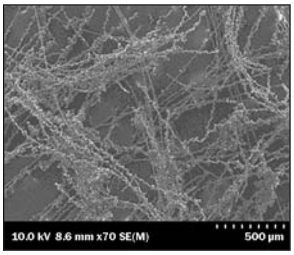
- light emitters for 0,65-0,75 micron operational range;
- uncooled thermal sensor (microbolometer);
- uncooled photo sensor for the 1-7 micron wave range.

Dr. Lyudmila A. Karachevtseva, Institute of Semiconductor Physics, Kyiv

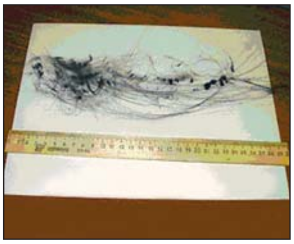
Lengthy Nanotubes for X–Ray Manipulation

An effective pyrolysis technology is used for production of carbon and copper nanotubes of specified dimensions. Process productivity reaches up to 12.5 mm/hour. Working temperatures exceed 600^{0}C. The working gas media for this technology is household natural gas or a butane-propane mixture. Gas flow is directed toward a special catalytic material (Ni, Fe, Co, cotton cloth, a special grid from selected cotton threads) or material with structural defects from which the nanomaterial is produced. Depending on the regimes, the proposed technology enables production of various products including defectless super-long nanotubes (up to 300 mm), nanotubes with maximal surface density, nanotubes with delta-type distribution of lengths, etc. Offered materials are applicable for:

- separation of soft X-rays from high-energy bremsstrahlung radiation;
- transportation of X-rays and density monitoring;
- effective absorbtion of X-rays.



a)



b)

Lengthy nanotubes (a, b)

Prof. Vasyl I. Maslov, Kharkiv Institute of Physics & Technology

Nanocomposites for Energy Generating Electrochemical Devices

Nanodispersed nanocomposites based on titanium and silica dioxides (TiO_2, TiO_2<C>, SiO_2<C>) were developed by using the fumed and sol-gel methods. Particles coagulation was averted with the help of carbon isolation. Laser irradiation was used for activation of materials at the stage preceding intercalation. Developed materials are applicable as cathode materials for production of electrochemical energy generating devices with Li-anode. Developed methods combining laser irradiation and intercalation allow achievement of a maximum specific capacity of up to 2000 mA•h/gr.

Perspectives of creation of a new class of electrochemical devices capable of accumulating "in-situ" regenerated sun energy was demonstrated for TiO_2 modified by various metal oxides.

Dr. Ivan I. Grygorchack, Precarpathian National University, Ivano-Frankivsk

Si–Ge Epitaxial Layers for Electronic Engineering

$Si_{1-x}Ge_x$, $0 \leq x \leq 0.3$

Technology for the production of diffusive diodes and photodiodes with improved stability and radiation hardness is offered. The ability of Ge atoms to be the center of annihilation for primary radiation defects encouraged research into the use of $Si_{1-x}Ge_x$ ($0.05 \leq x \leq 0.3$) solid solutions for manufacturing semiconductor devices. Diodes have been produced on the basis of relaxed $Si_{1-x}Ge_x$ layers, which were grown by the molecular beam epitaxy on Si substrates or $Si_{1-x}Ge_x$ single crystals. Testing of the electrical performances (current voltage, capacitance voltage, photocurrent) of diodes subjected to irradiation with 1 MeV electrons have shown that the diodes manufactured on the basis of $Si_{1-x}Ge_x$ demonstrate a reduced degradation rate (enhanced radiation hardness) in comparison with diodes made of Si. For example, the degradation rate at the same irradiation dose ($5 \cdot 10^{16}$ el$\cdot$cm^{-2}) for $Si_{1-x}Ge_x$-based diodes appeared to be 20% while it shows 62% for Si diodes.

Developed diodes are promising for long-term operation in a radiation environment as separate devices or as the components of large- and very-large-scale integrated circuits with enhanced radiation hardness.

Dr. Ludmila I. Khirunenko, Institute of Physics, Kyiv

Hard-Melting Composite Coatings on Light-Melting Metals

The developed technology of plasma electrolytic oxidation makes use of the electrolysis driven by a direct/alternative/pulse current and electrical breakdown voltage. Surface microplasma discharge promotes the crystallization of amorphous oxide film. Thus, the bulk of the underlying metal remains unheated and undistorted. This technology is of special importance for lightweight metals and alloys having numerous applications in the aircraft industry, mechanical engineering and instrumentation.

A new class of composite coatings results from this technology providing for:

- thickness variables from 20 to 300 mm;
- hardness of up to 25 GPa;
- variable coating colouration;
- high hardness, excellent adhesion, corrosion resistance, wear and friction performances, which are superior to both hard anodic films and plasma sprayed ceramics.

Cleaning, etching and polishing of surfaces can be also performed using this process.

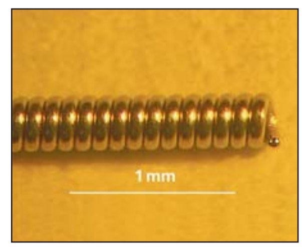
The technology is inexpensive and ecologically friendly.

This technology can be used in tribological applications, anticorrosion coatings, implants, electronic components.

Dr. Lyubov Snizhko, University for Chemical Engineering, Dnipropetrovsk

Nanostuctural Materials for Medical Applications

- Ultra-fine-grained tantalum, stainless steel replacement, in production of stents for cardiovascular surgery.
- Microsources and thin-walled shells for radioactive microsources applicable in angioplasty.
- Unique nanotitanium and yttrium β-sources for medical treatment of restenosis by the means of endovascular therapy of coronary vessels.
- Nanotitanium needles and applicators for radio-therapy of cancer in prostate, uterus and breasts.
- Biosoluble magnesium for endoprostheseses applicable in cardiology and bone surgery.



Medical radioactive β-source on the base of Ce-144

These products are based on the developed methods of simultaneous application of intensive plastic deformation and programmed thermal treatment that results in the formation of ultra fine-grained structures (d < 0,5 μm) and improved strength (by 1.5 times) and plasticity (by 2 to 4 times).

Prof. Igor I. Papirov, Kharkiv Institute of Physics and Technology, Kharkiv

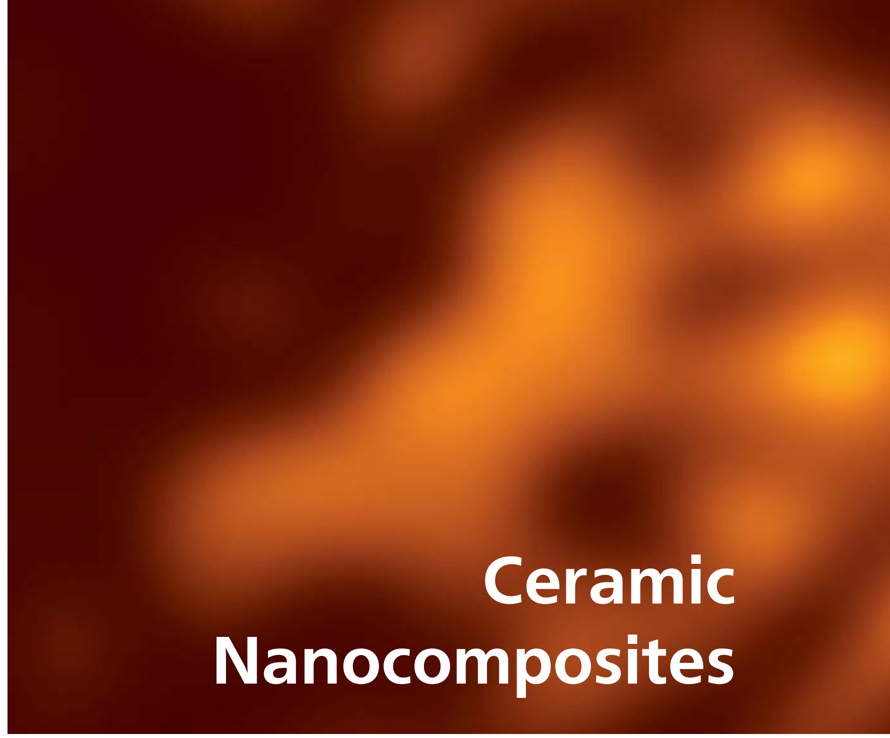
Nanograin Ceramics for Optoelectronics

Dense nanograin ceramics have been created by Dr. Glinchuk's team and produced from chemically synthesized nanopowders of K-Li-TaO_3, K-Ta-NbO_3 and Sr-Ba-TiO_3 solid solutions. The ceramics demonstrate advanced optoelectronic properties and high stability in severe conditions of ultraviolet radiation and cryogenic temperatures, in particular:

- high dielectric permittivity at cryogenic temperatures (up to 15,000 for Sr-TiO_3-based ceramic);
- extremely high values of electrostrictive and other electromechanical coefficients;
- high photoconductivity

These materials are promising for the development of electro-optical cells and solar batteries, miniature infrared and ultraviolet sensors, flow controllers for liquid fuels, precision positioning devices and transducers for ultrasonic monitoring of cryogenic liquids or structures.

Dr. Maya D. Glinchuk, Institute for Problems of Materials Science, Kyiv



Ceramic Nanocomposites

Ceramic nanocomposites which have a high melting temperature, hardness, chemical and thermal stability applicable for cutting tools, extra-fine finishing of metallic parts, wear resistive components, radiators for electronics, radiation resistive ceramic components.

SiC-C based nanocomposites are nanocrystalline (40-120 nm) beta-silicon carbide reinforced with diamond planar clusters built-in the lattice of SiC with the following properties:

- hardness around 40 GPa in pure poreless form and 24 GPa in nanocompostes with alumina;
- fracture toughness around 9 MPa $m^{1/2}$.

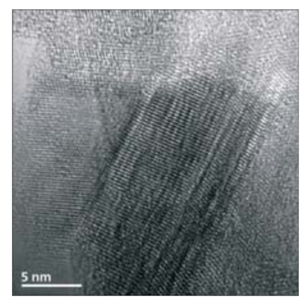
An equipped pilot shop for production of SiC-C nanopowder is available.

Developed materials were tested by Baker Hughes INTEQ GmbH.

Si_3N_4-TiN-TiB_2 based nanocomposites are nano-TiN reinforced with nano-TiB_2 and Si_3N_4 particles with the following properties:

- hardness around 20 GPs;
- fracture toughness of up to 8.5 MPa $m^{1/2}$;
- maintain high stability (grain size around 80 nm) of up to 800°C .

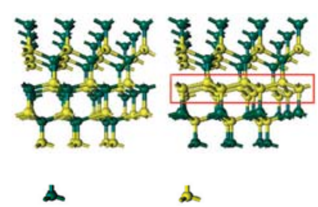
Developed materials were tested by the ALCON Concern, Ukraine.



HRTEM of the SiC-C solid solution

STRUCTURE MODELS

Silicon carbide (SiC)	Solid solution SiC-C (Diamond)

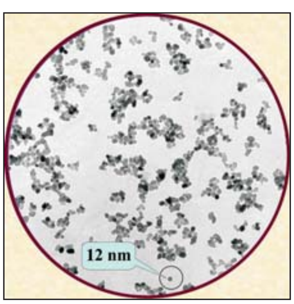


Silicon   Carbon

Prof. Andrey V. Ragulya, Institute for Problems in Material Science, Kyiv

Oxide Nanopowders for Ceramics Manufacturing

Pilot line for nanopowder manufacturing. Chemical zone.



Zirconium Dioxide nanopowder

Oxide nanopowders with a tailored particle size, chemical, phase, and granulometric composition for manufacturing ceramics, producing materials for nanoelectronics, as well as creating nanocomposites and nano-porous materials.

A production technology has been developed for ZrO_2 powders and is being tested for TiO_2, $(La,Sr)MnO_3$, $LaBGeO_5$, Al_2O_3-MgO, and other powders.

The technology is based on chemical methods combined with highly effective physical impacts — ultrasound, MWR radiation, pulse magnetic field, high hydrostatic pressure and heat treatment.

The technology provides for:

- narrow particle size distribution;
- low degree of agglomeration;
- predetermined particle sizes in the range of 5 to 50 nm;
- homogenious component distribution;
- low synthesis temperature (400-500° C);
- eliminating the mechanical grinding stage;
- high performance of ceramics and polymer matrix nanocomposites including homogeneity, stability and durability;
- production of precise articles and films;
- low cost, environmentally friendly.

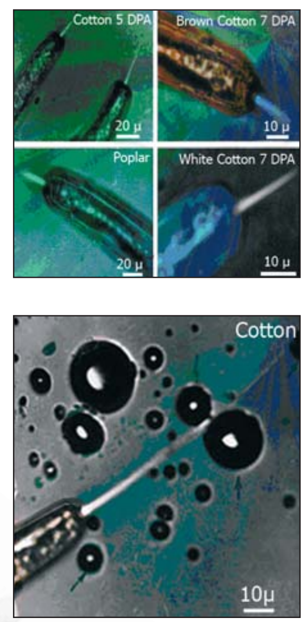
Prof. Tatjana E. Konstantinova, Donetsk Physics and Technology Institute, Donetsk

Super–Weak Photon Emission from Biological Cells

A new method for detection and visualization of a super-weak emission of UV photons ($\lambda<200$ нм) from a live plant cell has been developed. Due to radiolysis, UV cellular radiation produces tracks in the gelatine- and polymetilmetacrilate-based emulsions. These tracks are observed via an optical microscope. In contrary to the known method of detecting cellular radiation with the help of an electron photomultiplier, the developed method allows for the detection of short wavelength ($\lambda<200$ нм) radiation; it is sensitive enough to detect radiation from a separate cell.

Using the developed method, UV radiation from the apical point of a live cotton cell was studied. The distribution of radiation from the cell is found to be directed, not isotropic, and has a conical shape as shown in the pictures. These findings broaden the traditional view of isotropic radiation distribution from biological cells.

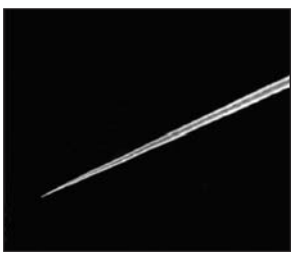
This method could be instrumental for biological objects processing (cells, molecules) in nanobiology and nanomedicine. It opens perspectives for the development of super-weak UV dosimetry and soft X-Ray visualization.



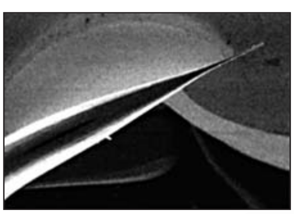
Superweak photon emission from biological cells

Dr. Adkhamjon A. Paiziev, Institute of Electronics, Tashkent

Nanoscale Instruments



Fiber-optic nanoneedle



Deposited carbonic nanostructure on fiber-optic nanoneedle

A new method of generating the massif of quantum dots, carbon and others, on the surface of nanosized optical elements is offered. Using the "near field optics" approach this method enables reactions which were impossible through traditional photochemical resonance transformations. The method is based on the phenomenon of non-resonance breakdown of molecules under the influence of nonlinear electric fields.

These findings encourage creation of an instrumental technique which can affect biological tissues at a cell level in order to research intracellular processes, biotransformations and execute local phototransformations. Nanoscale needles and pipettes with tailored geometry and relief can be made of standard optic silica fibres. These instruments will be applicable for:

- dosing and targeted introduction of physiologically-active substances and drugs into cells and other biological objects;
- non-scaring cellular surgery;
- targeted exposure of biological objects to electromagnetic fields.

A feasibility study on potential applications for photocatalytic cell destruction, cell nanotherapy and nanodevice development is under way.

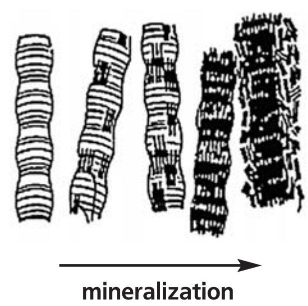
Dr. Volodymyr M. Ogenko, Institute of General and Inorganic Chemistry, Kyiv

Nanoscale Inorganic Particles Localized in Biological Tissues

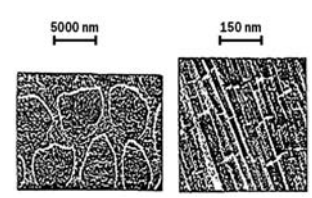
Engineering of Synthetic Analogues Based on the Principle of Biological System Functioning

New phenomena connected with the functioning of nanoscale inorganic particles localized in biological tissues were discovered. Biological tissues, which include neurons (rat brain, etc.) and intercellular matter of bone tissue, were studied by electron paramagnetic resonance. Mineral particles, such as akahaneit [β-FeO(OH)] and carbonate bioapatite, were revealed in brain and bone tissues accordingly. The particles are generated by physiological biomineralization and demonstrate various structural and magnetic modes. Bioapatite particles include impurities of crystal phases of different types. Akahaneit has an anomalous resonance signal that demonstrates unique dynamical parameters and macroscopic quantum oscillation. The experimental data lead to suggestions that (1) impurities of crystal phases are the indicators of bone demineralization and assimilation of implants by living bones; and (2) akahaneit localized in the brain plays an important role in the storage and processing of information.

These findings open perspectives for the creation of synthetic analogues of the physiologically generated particles. Synthetic analogues of bioapatite could be used for the creation of artificial bone. Akaganeit's synthetic analogous would be a promising material for the development of systems for storing and processing information on the principle of brain functioning. Macroscopic quantum oscillations observed in akahaneit give reason to believe in the development of quantum computers based on synthetic analogues of the material.



The collagen fibrils of bone tissue with hydroxylapatite nanocrystals. The cross size of the collagen fibrils is equal to approximately 100 nm



The internal structure of tooth enamel: enamel prisms and nanocrystals of hydroxylapatite

Prof. Aleksandr B. Brik, Institute of Geochemistry and Mineralogy, Kyiv

Lasing by Nanosystems Based on Dispersive Polymers

This recently discovered phenomenon of lasing by dispersive polymer based nanosystems creates conditions for light confinement. Due to multiple light scattering (MLS) and amplification, some photons may stray within a local spatial domain without dumping. Several processes condition this effect. When the multiple light scattering volume becomes equal to the amplifying volume and the external cavity stops supporting the resonance feedback, the non-resonance feedback, which is conditioned by MLS, appears due to random photon walks in diffusion transport mode. This phenomenon could be observed in the following media:

- Polymer matrix containing laser dyes and nanosized particles of fumed silica, sapphire, cerium or titanium oxides;
- Vesicular polymer films containing dyes and micro- and nanosized blebs;
- Mesomorphic liquid crystal matrix with dyes where domains act as light dispersers and enable control over the scattering diagram by electric field.

This principle would work in a variety of applications including development of optoelectronic chips for optical computers; generators and amplifiers for optical fibre communication and multicolour laser displays. There is a hope that the same mode of light generation in biological tissues could contribute to tumour destruction.

Dr. Eugene A. Tikhonov, Institute of Physics, Kyiv

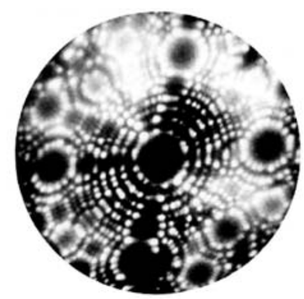
High-Field Nanoprocessing for Smoothing Metal Surfaces at the Atomic Level

This developed nanotechnology is used for the treatment of nano-scaled objects, including curved objects, provides for surface modification into an atomically smooth state (surface with zero roughness) and is applicable for production of:

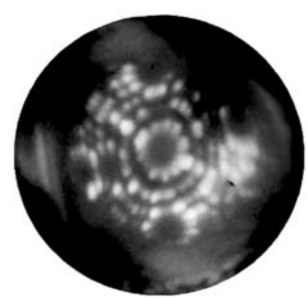
- ultra-sharp atraumatic ophthalmologic microsurgical instruments;
- ultra-fine microprobes for high-resolution scanning tunneling microscopes and for nanotechnological devices based on such microscopes;
- field emitters with localized emission surface for nanoelectronics.

The technology is based on the discovered phenomenon of evaporation of metals in high electric fields in the presence of dielectric liquids at low temperatures. The previously known method, which was based on evaporation in super-high electric fields, faced a serious technological problem caused by the destruction of objects under the impact of mechanical stress generated by super-high electric fields. This method resolves this problem.

Joint patents with Dr. N. Wanderka, Hahn-Meitner-Institute, Berlin, Germany, and Dr. R. Forbes, University of Surrey School of Electronics, UK.



a

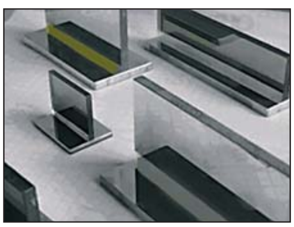


b

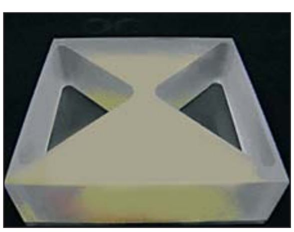
Field ion microscopic images of STM probe before **(a)** and after **(b)** high-field processing

Prof. Igor M. Mikhailovskij, Kharkiv Institute of Physics and Technology, Kharkiv

Glue–Free Bonding of Glass Ceramics Using Nanolayers



Samples of a mirror prism with external reflection and 90° angle



Sample of a light-weight mirror fragment

This developed technology of Solid-Phase Bonding of Polished Parts (SBPP) joins parts that are made of Zerodur glass ceramics and provides for:

- the accuracy of a joined optical construction (angular positions) is close (within 1 angular second) to the accuracy of high-precision components manufacturing;
- the accuracy of a joined optical construction is stable under temperature changes ($+400^{0}$C to -196^{0}C) and mechanical double impact (by 100 g followed by 300 g);
- durability and stability of joined optical constructions remain at the monolith level;
- the size of parts that can be joined is extremely high, up to 8 m.

In SBPP, connective nanolayers include silicon oxide based substance and different metal oxides in combination with aluminum. The layers are vacuum deposited.

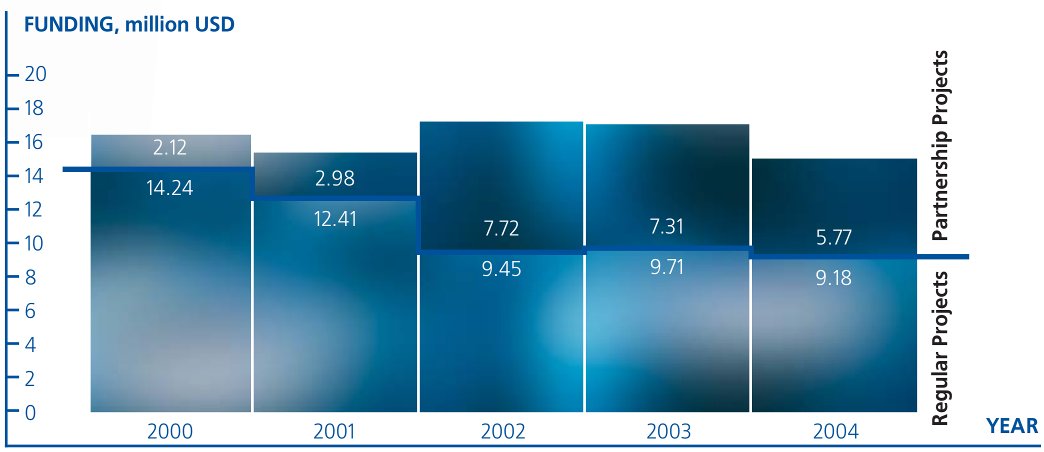
Can be used for applications in serial optical manufacturing (laser gyroscope, light-weight mirrors, mirror prisms, etc.).

Collaboration with Schott AG, Germany, exclusive producer of Zerodur.

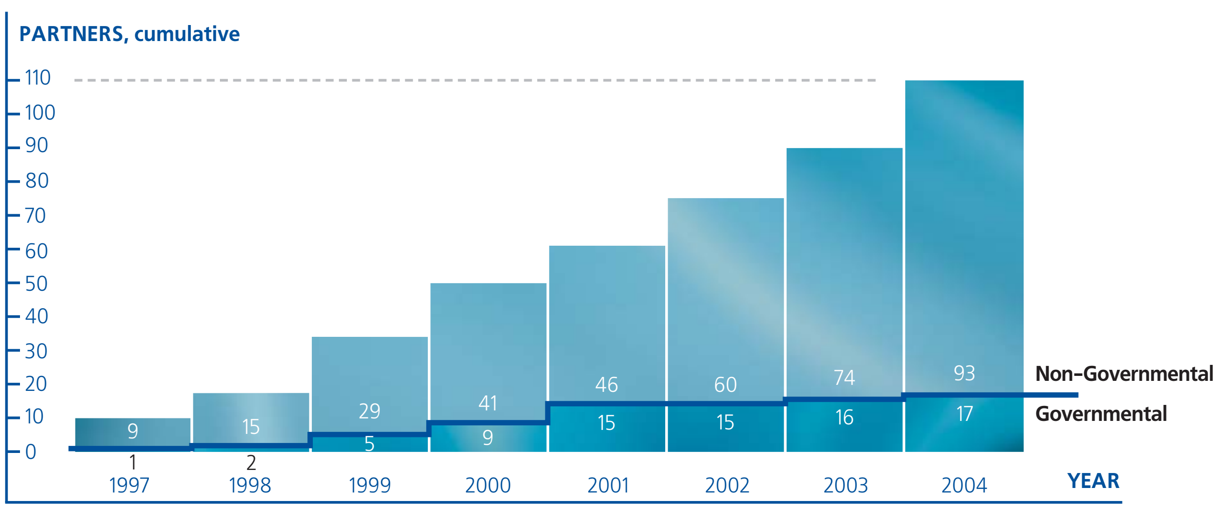
Dr. Vladimir Maslov, Institute of Semiconductor Physics, Kyiv

STCU Financial Activity

STCU PROJECT ACTIVITY, 2000–2004



STCU PARTNERS, 1997–2004



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STCU–funded projects cover a wide range of disciplines, including over thirty on–going nanotechnology projects. For forward–looking nanotech organizations, the STCU offers a great opportunity to examine the many products and services available at our member institutes.