

Meeting of Consultative Scientific Council “Skolkovo”

May 17-18, 2012



Novosibirsk

SIBERIAN BRANCH OF RUSSIAN ACADEMY OF SCIENCES: STATUS, RESEARCH AND DEVELOPMENT

**Academician A.L. Aseev
Chair of Siberian Branch of RAS**

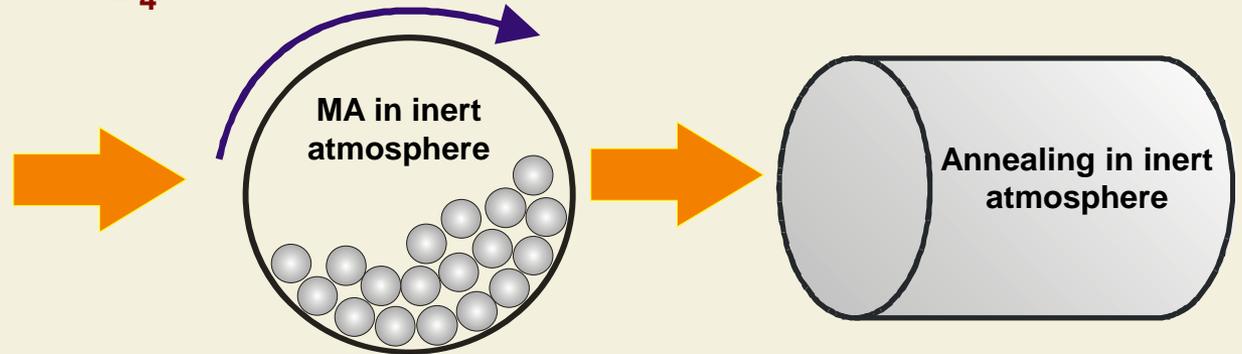
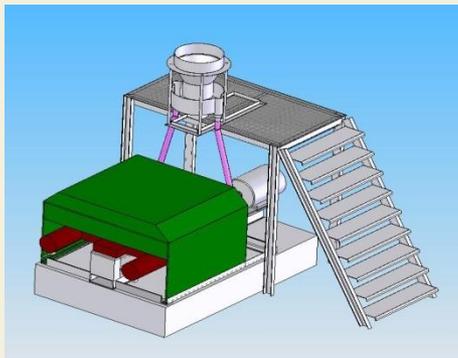


DEVELOPMENT AND INNOVATION ACTIVITY

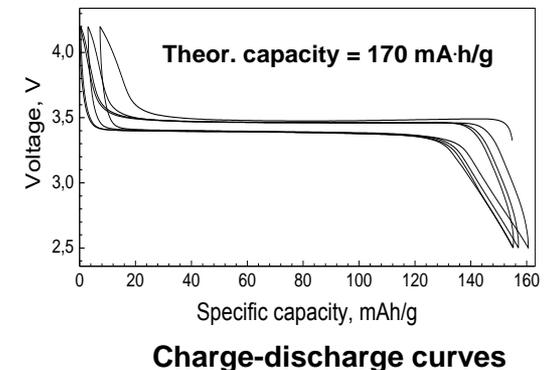
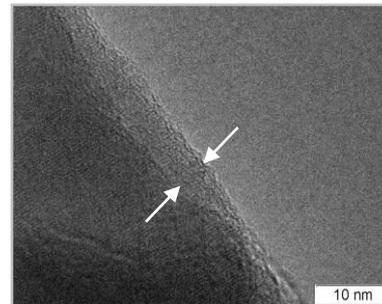
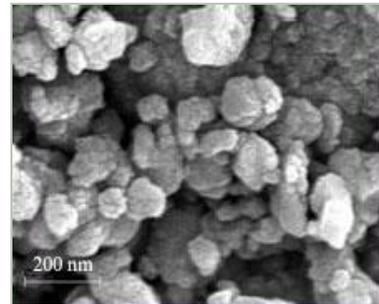
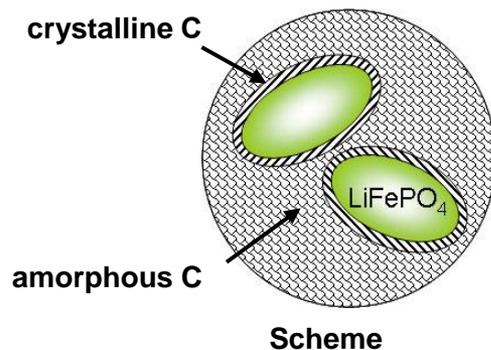
LiFePO₄ – a new perspective cathode material

Nanocomposite prepared by mechanical activation (MA) - the grains of LiFePO₄, surface-modified by crystalline carbon embedded into the matrix of amorphous carbon – overcomes the main disadvantage of LiFePO₄ – low electronic conductivity (10⁻⁹ S/cm) and ensures high-rate capability and high discharge capacity 150-160 mA·h/g, close to the theoretical one.

Method of synthesis LiFePO₄/C:



Characteristics of mechanonanocomposite LiFePO₄/C:



The project of the State Corporation «Rusnano» on the production of lithium ion rechargeable batteries together with the Chinese company «Thunder Sky Group Limited»

- ❖ Amount of investment into the project – **13,8** billion roubles.
- ❖ Plant is launched into operation in 2011.
- ❖ Productivity – **12 000** batteries per year, 4 lines.
- ❖ Accrued taxes paid – about **5** billion roubles.

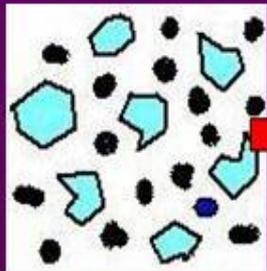
State Corporation «Rusnano» accepted the project of the production of special materials for manufacturing the cathodes of lithium ion rechargeable batteries *together with Chemical Corporation, Novosibirsk*

Cathodes made of the nanocomposite material based on lithium ferrophosphate developed by researchers from the Institute of Solid State Chemistry and Mechanochemistry SB RAS possess the best electron and ion conductivity and will be used in the joint Russian-Chinese project that has already been launched by RUSNANO for the production of lithium ion rechargeable batteries together with the “Thunder Sky” company.

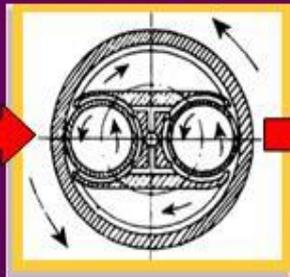
State Corporation “Rusnano” and the Government of Novosibirsk Oblast support the project “Industrial production of goods from nanostructured ceramics based in Holding JSC NEVZ-Soyuz” with participation of SB RAS Institute of Theoretical and Applied Mechanics and SB RAS Institute of Solid State Chemistry and Mechanochemistry

Combined plasma-mechanochemical synthesis of nano- and submicrostructured powders of metals, intermetallic compounds, and construction ceramics

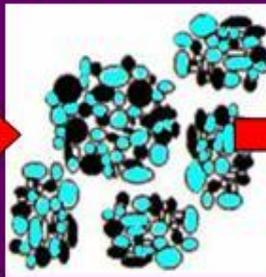
Исходная смесь порошков



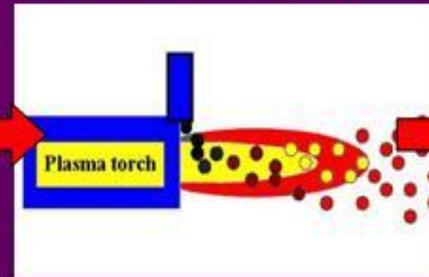
Мехактивация порошковой смеси



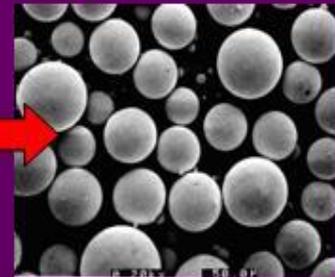
Агломерированный порошок



Плазменная микрометаллургия в частицах



Закалка порошкового продукта



Near surface electromagnetic frequency induction sounding (NEMFIS) for shallow (up to 10 m) subsurface survey

The NEMFIS is intended for shallow-depth (up to 10 m) subsurface investigations. Essential experience is gathered at the following applications:

- Archaeological targets search and examination;
- Ground water flows mapping;
- Subsurface communications tracing;
- Subsurface pipe leakage determination;
- Ground water contamination study.

The main features of current NEMFIS are:

Device dimensions: 2.75 x 0.3 x 0.15 m

Device weight 8 kg

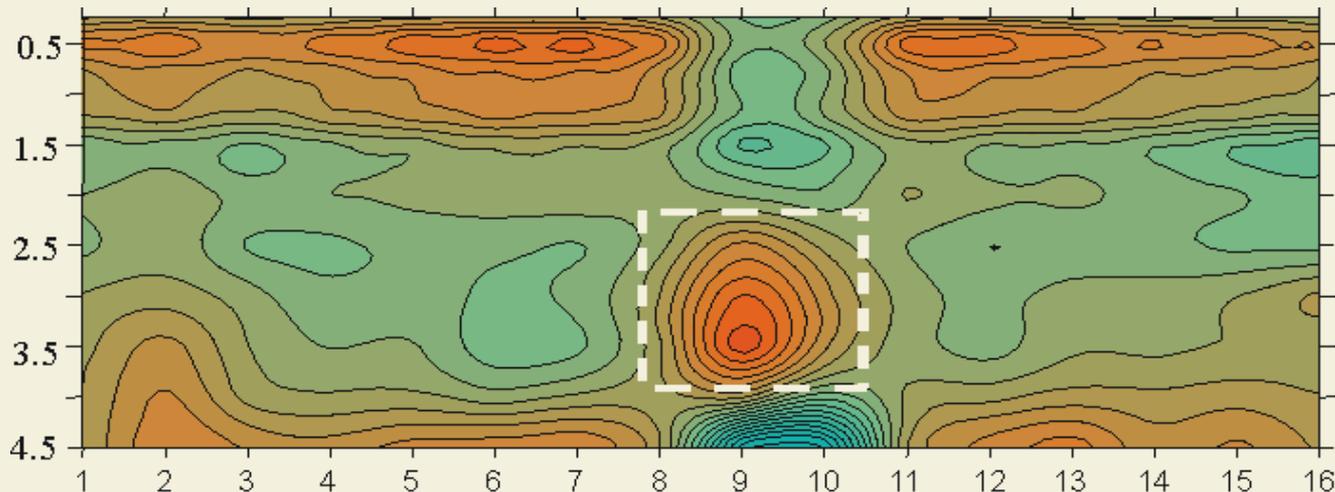
Frequency range 2.5 – 200 kHz

Number of frequencies 1-14

14-frequencies sounding time 2 sec



NEMFIS at operation

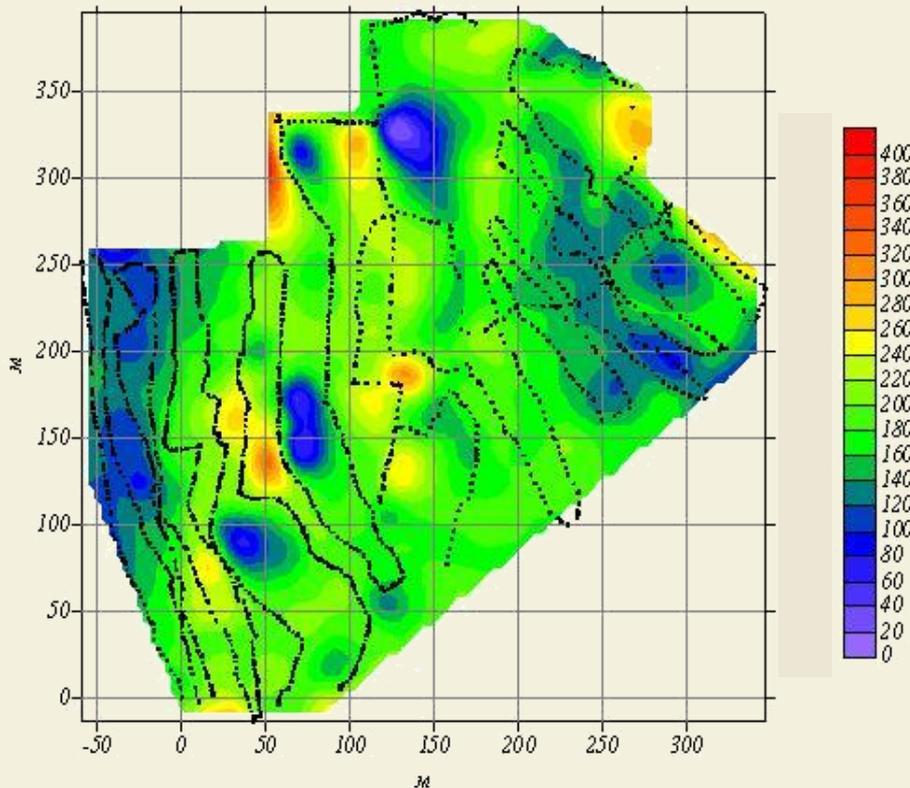


Cross-section across metal subsurface pipeline. The pipe (marked by dotted line), trench and non-conductive isolator can be seen.

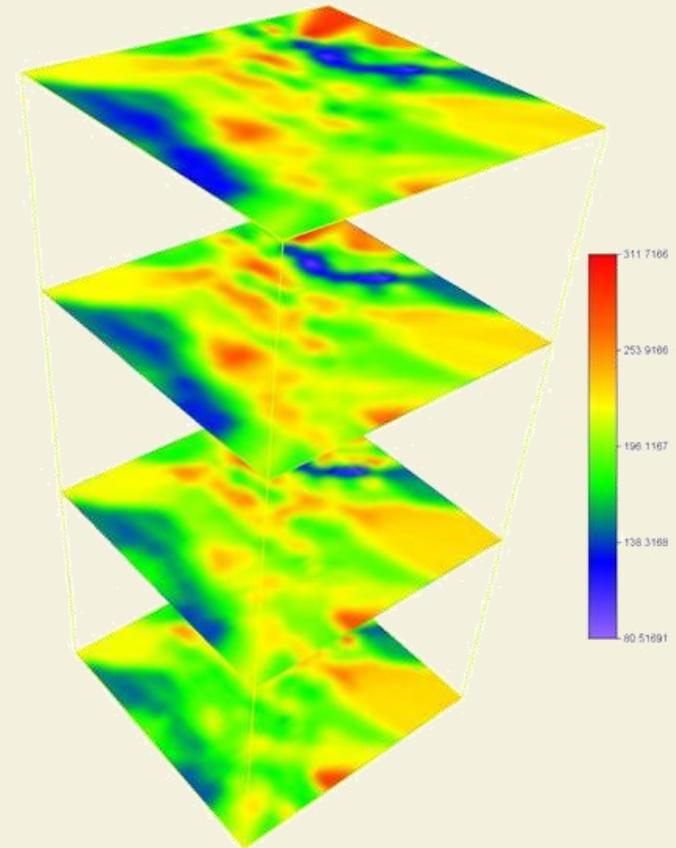
Ob river bridge construction site survey

The 125000 sq m of the Ob river right coast was explored using NEMFIS in GPS data binding mode to explore the shallow depth boundary of ledge rocks. The number of records is 1470. The map of electric resistivity distribution at the depth of 1 m (62.5 kHz) with data reading points shows few spots of high resistivity that corresponds to the ledge rocks. The four maps of lower frequencies corresponds to 3-7 m of depths depict the shape of ledge rocks in quazi-3D visualization.

Field works takes 4 hour, data processing, 40 min.



2D electric resistivity distribution.
Frequency 62.5 kHz



Pseudo-3D electric resistivity distribution.
Frequencies: 40, 20, 12, and 4 kHz

PROJECT

Prototyping center for the bio- and nanoelectronics products

Organization of silicon mini-factory within the Technopark of Novosibirsk Akademgorodok using the technologies developed in the institutes of SB RAS joint with Silicon Valley Technology Center и B-Global Partners, USA

Novosibirsk, Russia – San Jose, USA
2011

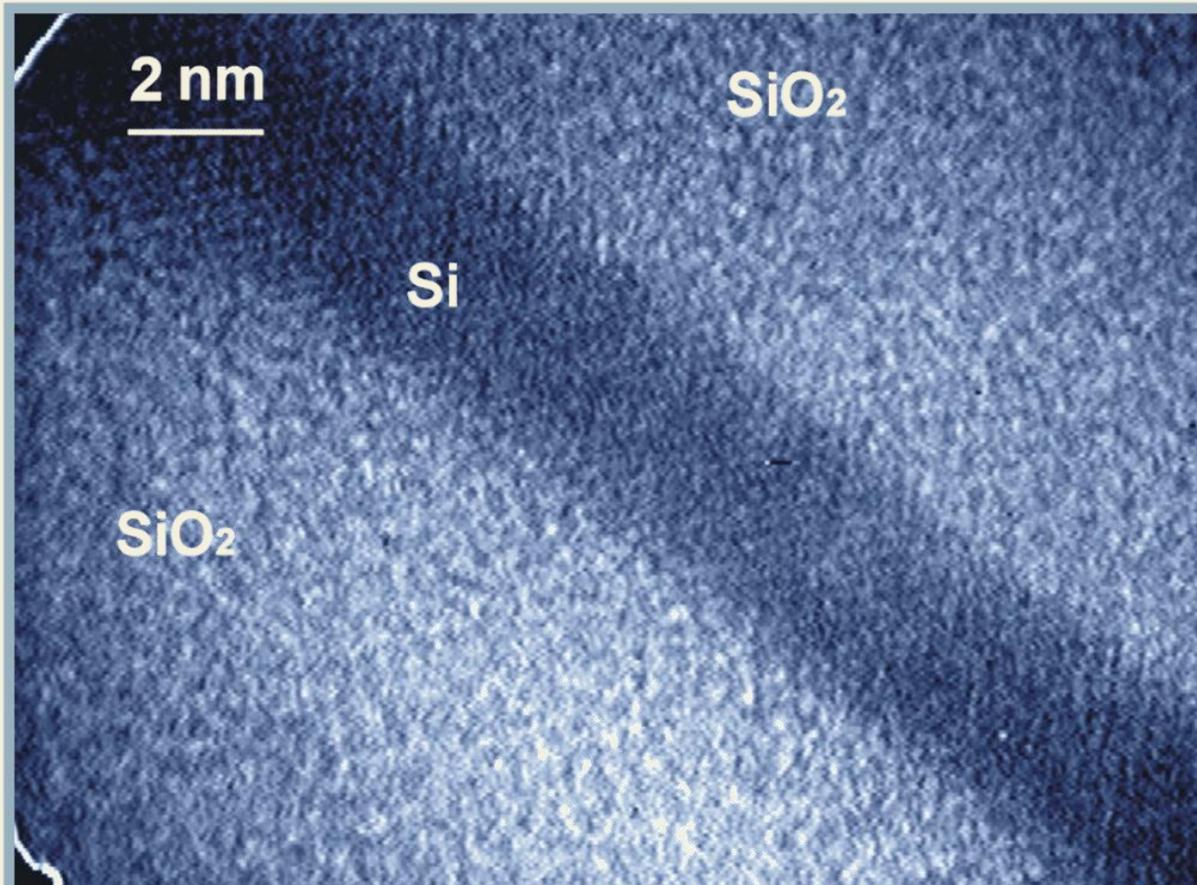
The aim of the project is to develop and produce small series of fundamentally new products based on the technologies of silicon nanoelectronics, including:

- ❖ Silicon labs-in-package (LIP) based on nano-, bio-, gas and electromechanical sensors;
- ❖ Elements based on epitaxial structures silicon-germanium, silicon-crystals III-V, silicon-diamond, and structures with quantum points for nanoelectronics of the nearest future, including the microwave elements for telecommunication systems of new generation, systems of quantum cryptography, and quantum computing;
- ❖ New types of elements of T-bit memory.

We suppose to introduce the developed products for the large-scale production to JSC “Mikron” (Zelenograd), JSC “Vostok”, JSC “Novosibirsk Plant of Semiconductor Devices and Special Design Office” (Novosibirsk), SVTC, Intel, Samsung Electronics, etc.

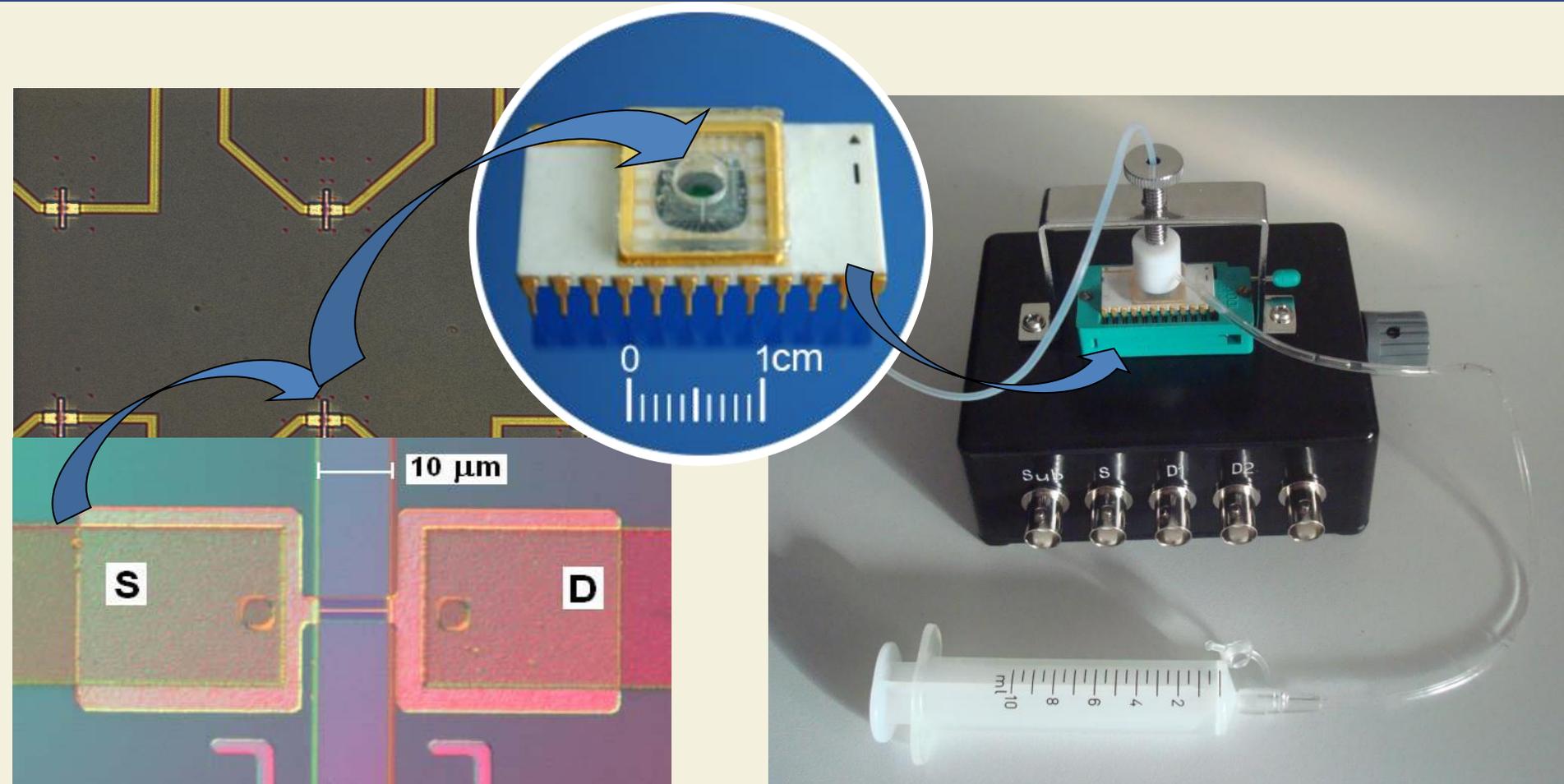


Silicon-on-Isolator (SOI) ultra-thin structure



Electron microphotography with atomic resolution of cross-section of mono-crystalline ultra-thin cut-off 3 nm silicon layer between upper oxide and buried dielectric of SOI-structure

SOI Open-Channel Nanotransistors for Biomedicine

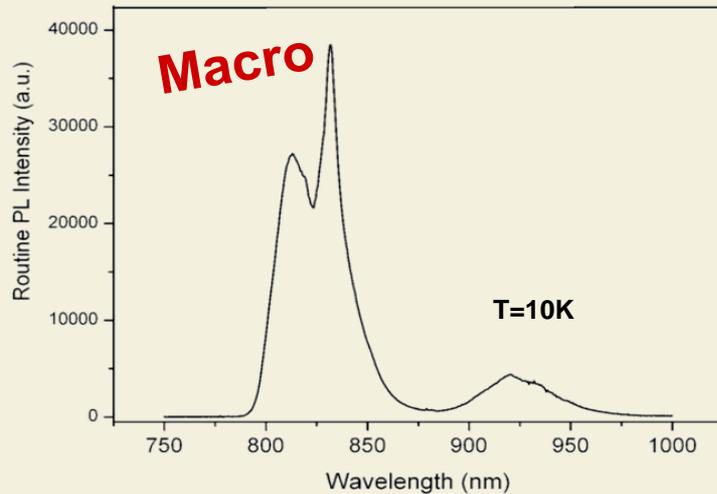


- *the thickness of SOI (w_{NW}) (10 – 40) nm;*
- *the width of NWs: (50 – 100) nm;*
- *the length – 10 μm*
- *the number on chip – 20*
- *the diameter of the chip sensitive area - 2 mm*

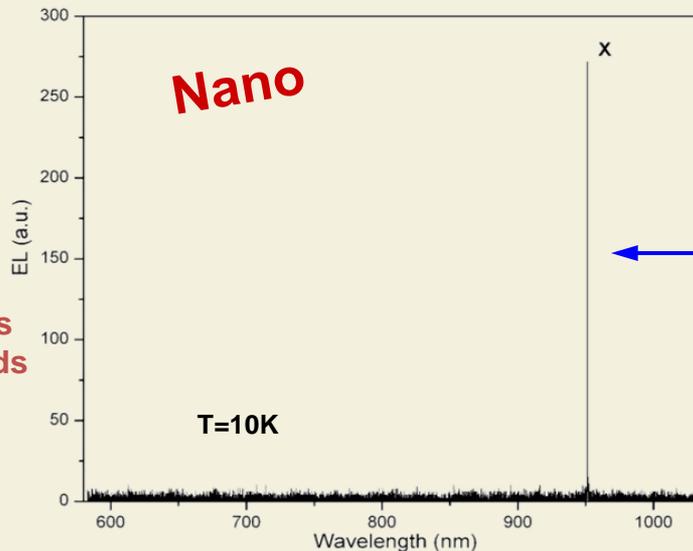
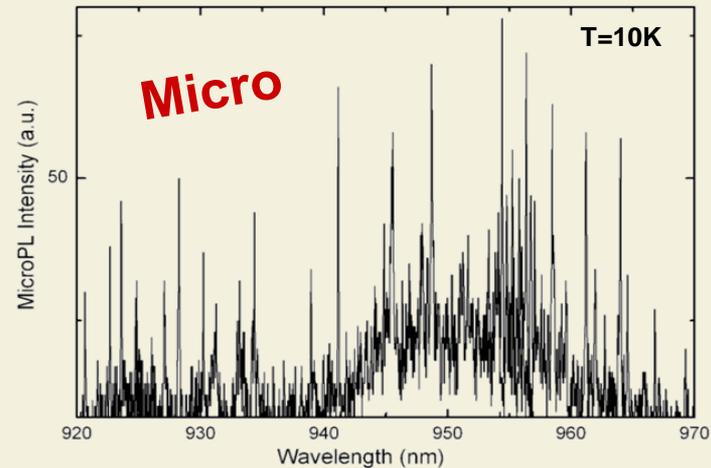
*Test module with fluid cell and packaged biochip
Sensitivity BSA ~10 aM (10^{-17} M)*

The comparison of PL spectra of InAs QDs ensemble with electroluminescence spectrum of developed nano-LED.

Macro-PL spectrum, laser spot diameter $\sim 100 \mu\text{m}$



Micro-PL spectrum, laser spot diameter $\sim 2 \mu\text{m}$



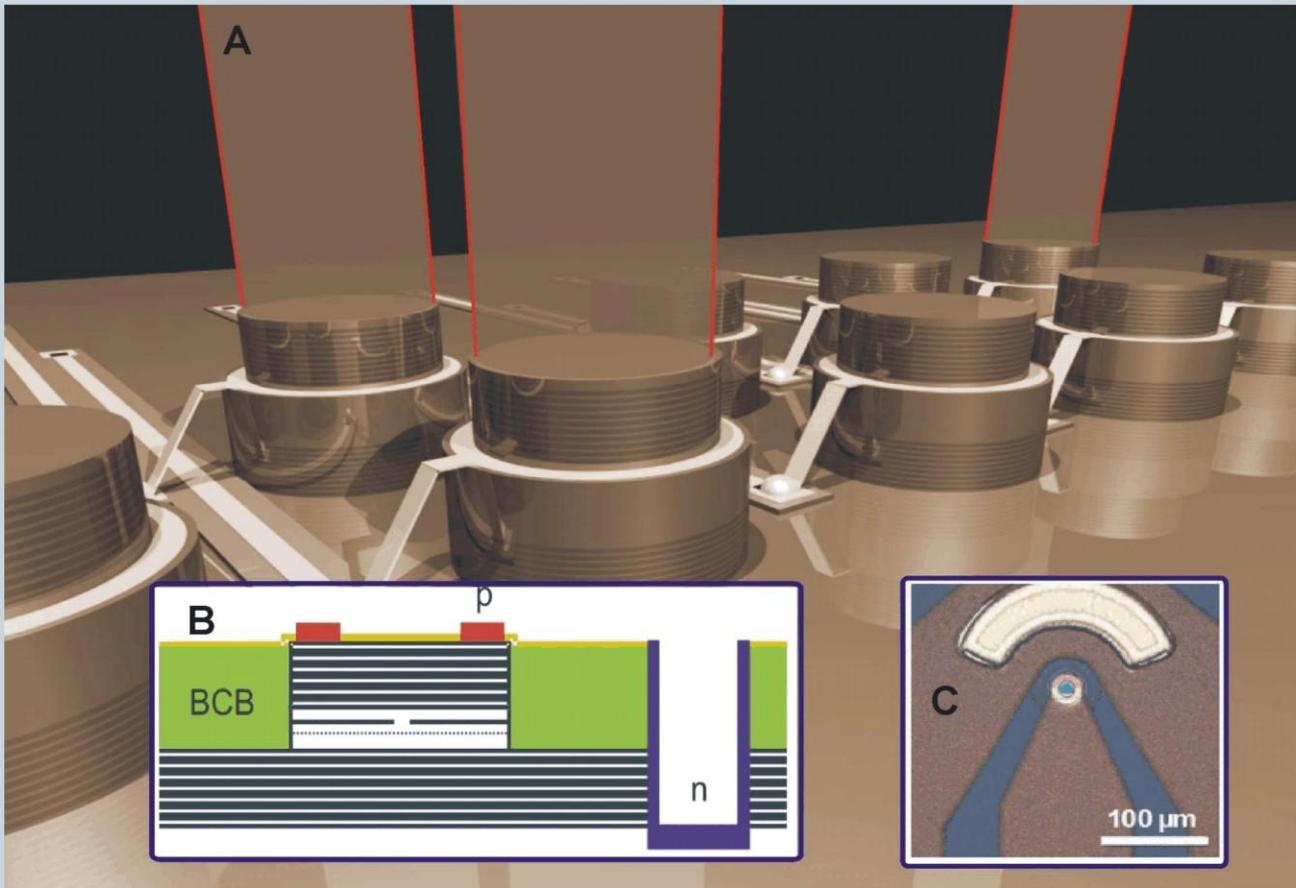
Electroluminescence spectrum with subnanoampere current excitation through submicron oxide aperture.

Confident addressing to single quantum dot.

Record-breaking high injection efficiency ~ 0.2
(1 photon per 5 electrons)

Application:
Quantum cryptography
Precise spectroscopic systems
Precise optical power standards

High frequency semiconductor vertical-cavity surface-emitting lasers

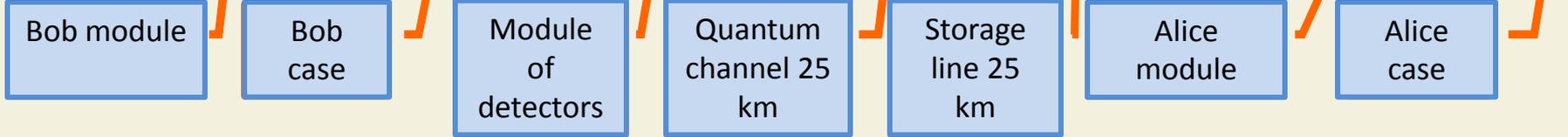
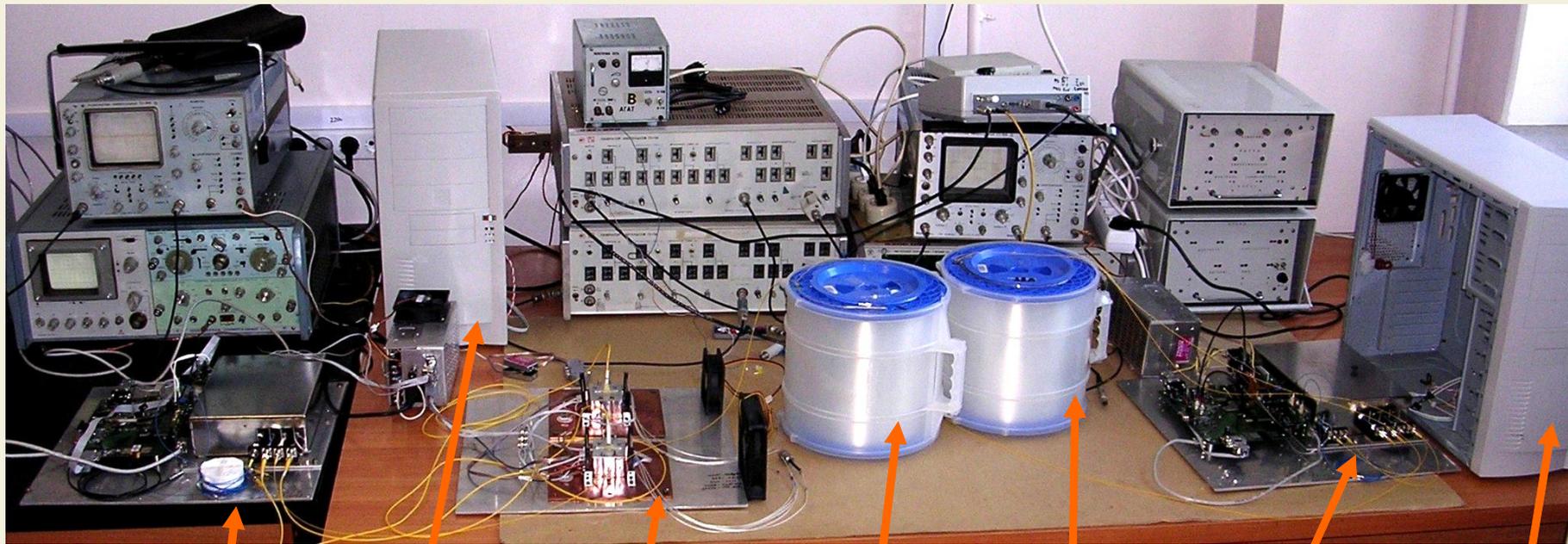


Schematic sketch of parallel short-distance optical networks based on high frequency semiconductor vertical-cavity surface-emitting lasers (A). Device layout (B) and microscope image (C) of the developed VCSEL with 20 Gb/s Error-Free Operation.

Arrays of such VCSELs offer the challenge for 1Tb/s optical network

Institute of Semiconductor Physics, Novosibirsk, Ioffe Physicotechnical Institute, St.-Petersburg, Institut für Festkörperphysik and Center of NanoPhotonics, Technische Universität Berlin, Fraunhofer Institut für Nachrichtentechnik, Heinrich-Hertz-Institut Berlin, NL-Nanosemiconductor GmbH, Dortmund, Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany

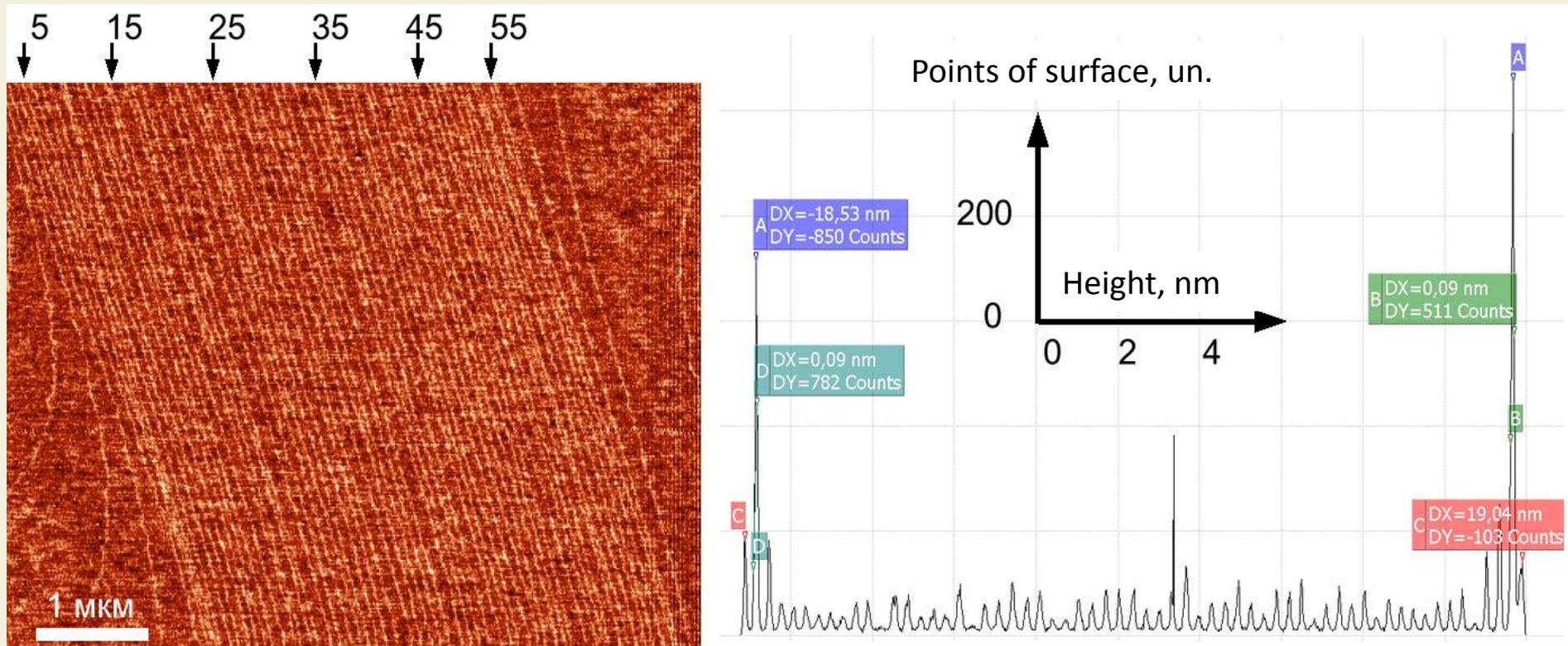
Experimental system for quantum key generation in fiber-optic line of communication (Institute of Semiconductor Physics of SB RAS design)



Optical line length	25-50 km (up to 100 km at perspective)
Laser impulse frequency	5 - 20 MHz
Average number of photons in impulse	0,1 - 0,3
Quantum efficiency	10 - 20%
Key generation rate	1-10 kbit/s



Certificate of ROSSTANDART RU.C.27.007A №44289 from 16.11.2011 y.



Phase-shift AFM-image of the area of standard set with gage 18,53 nm (left).

Height spectra (right) demonstrates peaks, which corresponds to atomically flat terraces separated by monoatomic steps, - height difference between maximal peaks was measured as 18,53 0,05 nm, corresponds the 59 monoatomic steps height on the (111) silicon crystal orientation.

SB RAS PARTICIPATION IN TECHNOLOGICAL PLATFORMS

1. **MEDICINE OF THE FUTURE** – Siberian State Medical University (Tomsk). SB RAS – Institute of Chemical Biology and Fundamental Medicine, Institute of Cytology and Genetics, Institute of Strength Physics and Materials Science, etc.
 4. **NATIONAL SUPERCOMPUTER TECHNOLOGICAL PLATFORM** – RAS Program Systems Institute. SB RAS – Institute of Computer Mathematics and Mathematical Geophysics a.o.
 5. **INNOVATION LASER, OPTICAL AND OPTOELECTRONIC TECHNOLOGIES - PHOTONICS** – “Laser Association”. SB RAS – Institute of Laser Physics, Institute of Automation and Electrometry, Zuev Institute of Atmospheric Optics, Institute of High Current Electronics, Institute of Theoretical and Applied Mechanics.
 9. **NATIONAL INFORMATION SATELLITE SYSTEM** – JSC “Information Satellite Systems” Reshetnev Company”. SB RAS – Institute of Physics, Institute of Computer Modelling a.o.
 11. **CONTROLLED FUSION** – State Corporation “Rosatom”. SB RAS – Budker Institute of Nuclear Physics.
 14. **HIGH PERFORMANCE CLEAN HEAT ENERGY** – JSC “All-Russian Heat Engineering Institute”. SB RAS participation – Kutateladze Institute of Thermophysics, Boreskov Institute of Catalysis.
 23. **ADVANCED PROCESSING OF HYDROCARBON RESOURCES** – Gubkin Russian State University of Oil and Gas. SB RAS – Boreskov Institute of Catalysis, Institute for Problems of Carbohydrates Processing, Trofimuk Institute of Petroleum Geology and Geophysics a.o.
 25. **MICROWAVE TECHNOLOGIES** – JSC “Roselektronika”. SB RAS – Institute of High Current Electronics, Rzhanov Institute of Semiconductor Physics, Kirensky Institute of Physics.
 27. **BIOENERGETICS** – National Research Center “Kurchatov Institute”. SB RAS – Boreskov Institute of Catalysis, Institute of Cytology and Genetics, Institute for Problems of Chemical and Energetic Technologies.
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DIRECTIONS OF INNOVATION DEVELOPMENT OF SIBERIAN BRANCH OF RAS

- **DEVELOPMENT OF MINERAL RESOURCES BASE, DEVELOPING AND PROCESSING OF MINERAL FIELDS;**
- **TECHNOLOGIES OF ADVANCED PROCESSING OF CARBOHYDRATES;**
- **WASTE-FREE PRODUCTION OF HEAT AND ELECTRIC POWER, COKE, HYDROGEN AND NEW CARBONIC MATERIALS FROM BROWN COAL;**
- **MECHANICAL ENGINEERING AND POWER ELECTRONICS;**
- **NANOTECHNOLOGIES AND NANOMATERIALS;**
- **INFORMATION TECHNOLOGIES AND INSTRUMENT MAKING;**
- **NEW TECHNOLOGIES IN MEDICINE AND BIOTECHNOLOGIES;**
- **OPTIC AND LASER TECHNOLOGIES;**
- **BASIC RESEARCH FOR DEFENSE AND SAFETY.**

Economical effect is estimated by Institute of Economics of SB RAS in value above 3 Trln. Rub.

NANOTECHNOLOGIES AND NANOMATERIALS

- For more than 30 years the institutes of Siberian Branch of RAS research nanotechnologies and nanomaterials on the world level. The most important results include the detonation technology of nanodiamonds manufacturing; development of technologies of nanosized catalysts and new carbonic materials manufacturing, including graphene; manufacturing, studying and practical use of semiconductor and magnetic nanostructures with quantum properties; manufacturing of nanoparticles of oxides and metals; nanoceramics; nanoconstruction in chemistry and biology. The infrastructure of nanotechnologies and nanodiagnostics has been created.
- The principal partners are JSC “Rusnano”, “Nitol” Ltd., JSC “Ugleplastik”, “Konnektor Optiks” Ltd., JSC “Novosibirsk Chemical Concentrates Plant”, “Liotekh” Ltd., Holding JSC NEVZ-Soyuz, etc.
- Today the SB RAS institutes are involved into realization of seven projects of JSC “Rusnano” with the total budget of more than 30 billion roubles.
- Within the framework of the joint investment project of JSC “Rusnano”, JSC “Sigma” and JSC “Technopark of Novosibirsk Akademgorodok” the organization of nanofactory (“Nanofab”) is planned for manufacturing the nanosized catalysts, nanostructured materials, medicines, and nanoelectronic devices with the volume of commercialization up to 50 billion roubles.