NATIONAL RESEARCH UNIVERSITY

St. Petersburg State Polytechnical University

Founded in 1899

St. Petersburg State
POLYTECHNICAL UNIVERSITY

HISTORY



Founded by

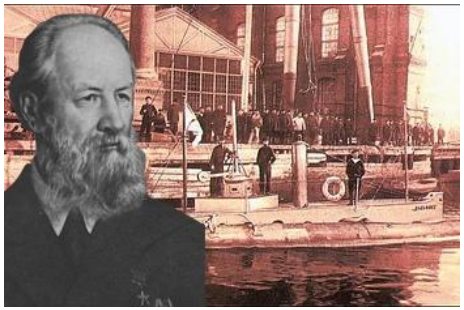
- **Sergey Yu. Vitte** - the Prime Minister of Russia (1903-1906), initiated the idea of setting up Polytechnic institutes in St.Petersburg, Warsaw, Kiev
- **Andrey G. Gagarin** - the first Director of the Institute

Founders

- **Dmitry I. Mendeleev** - Chemistry

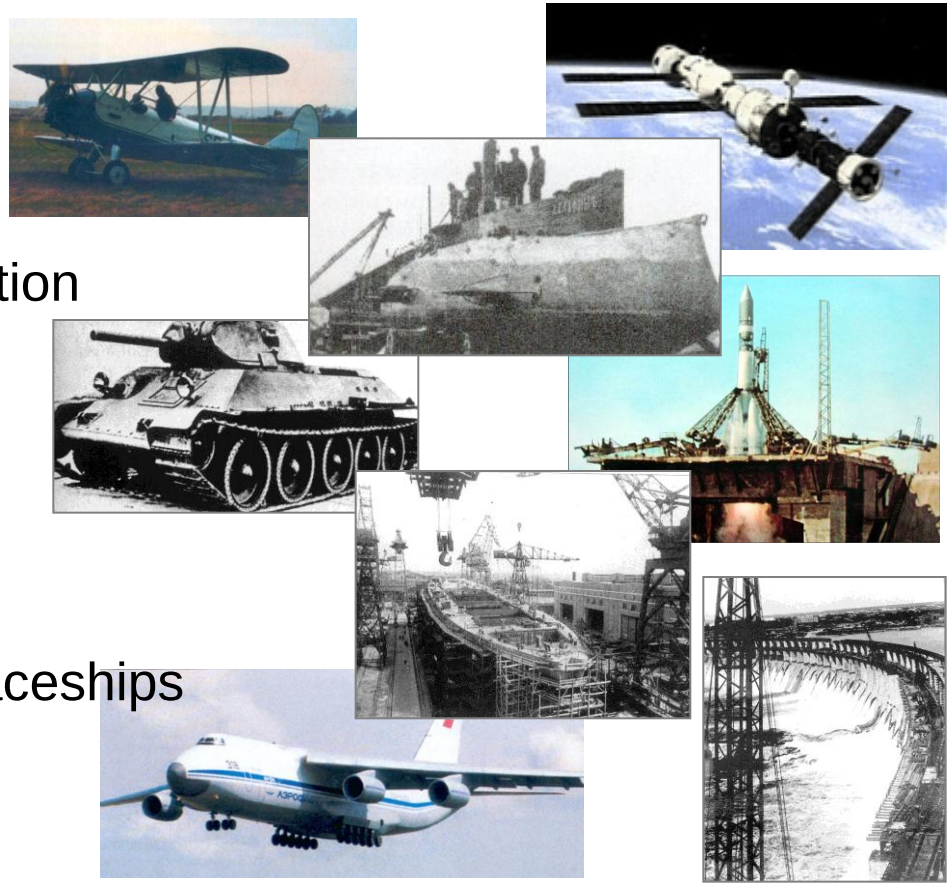
- **Alexander S. Popov** - Radio Engineering

- **Alexey N. Krylov** - Shipbuilding



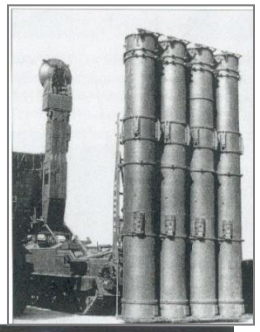
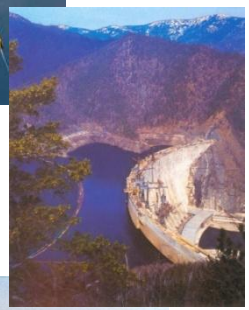
Famous Scientific Developments

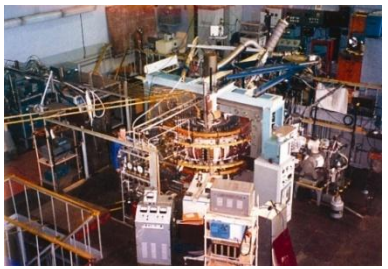
- Submarine “Dolphin”, **1904**
- Plane “Po-2”, **1928**
- Implementation of State Electrification program, **1926-1935**
- Tank T-34, **1939**
- Nuclear Ice-breaker “Lenin”, **1954**
- Automated control systems on spaceships “Vostok”, **1961**
- Plane “Antey”, **1965**



Famous Scientific Developments

- Space developments, **1966-1970**
- Radio telescope RATAN-600, **1968-1974**
- Construction of biggest Hydroelectric and Nuclear power stations, **1977**
- Launching thermonuclear synthesis device “TOCAMAC-16”, **1988**
- Spacecrafts of RSC “Energia”, **2000-s**
- Engines for “MIG” aircraft, helicopter “Black Shark”, **2000-s**
- Bioenergetics and hydrogen energy, **2000-s**

Nobel Prize Winners

- Nicolay N.Semenov (Chemistry, **1956**)
- Pyotr L. Kapitsa (Physics, **1978**)
- Zhores I. Alferov (Physics, **2000**), Dean of the Faculty of Physics and Technology



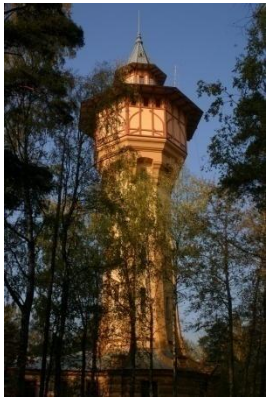
St. Petersburg State
POLYTECHNICAL UNIVERSITY

UNIVERSITY TODAY



General Information

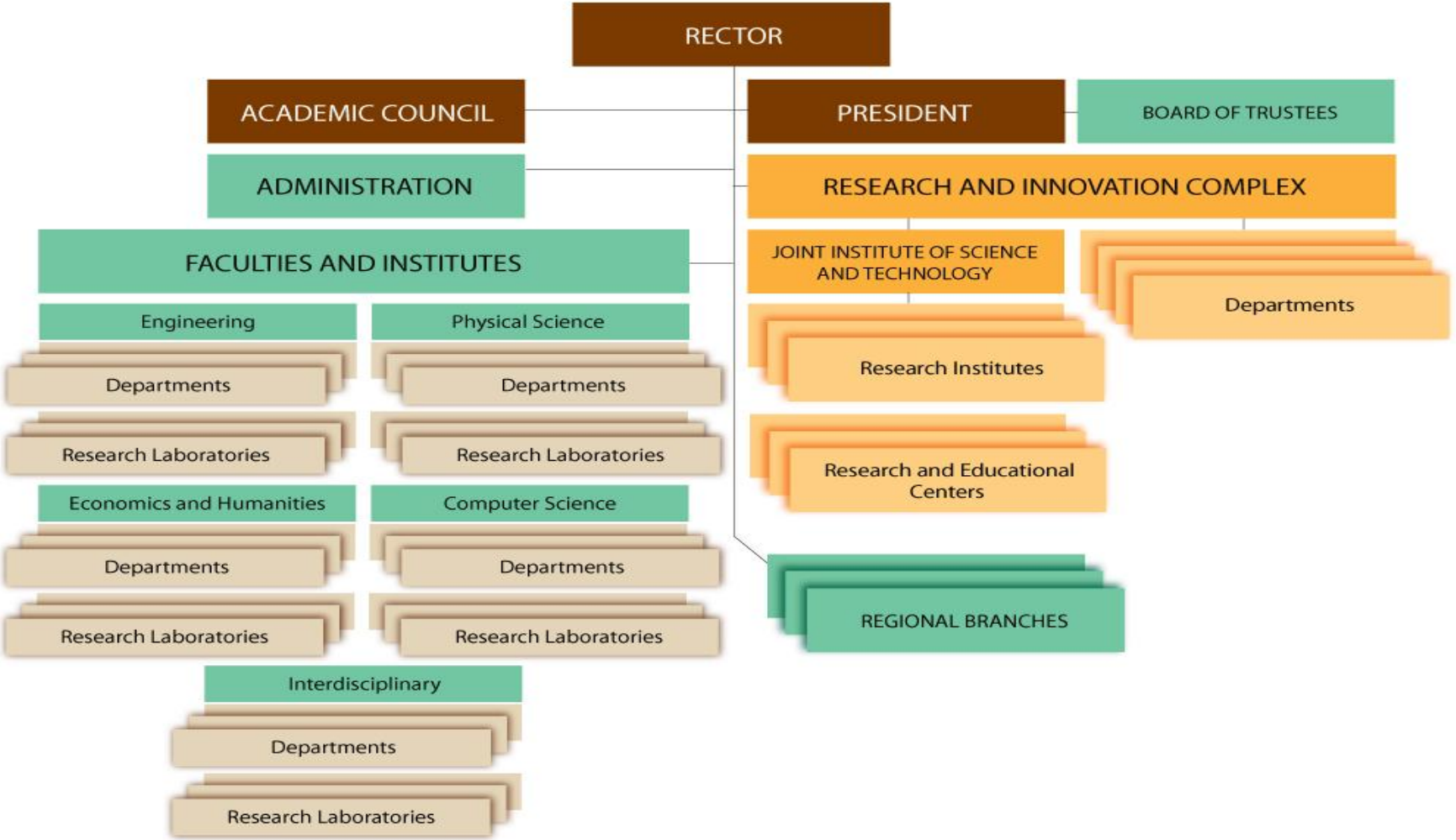
- Total area - **102** hectares
- Total number of buildings - **112** (total area of **386 061** sq.m)
- Faculties - **21**

In 2010 SPbSPU was awarded the status of "National Research University"

In 2010, ***29*** Russian Universities were awarded the status ***"National Research University"*** by the order of Russian Federation Government

University Structure

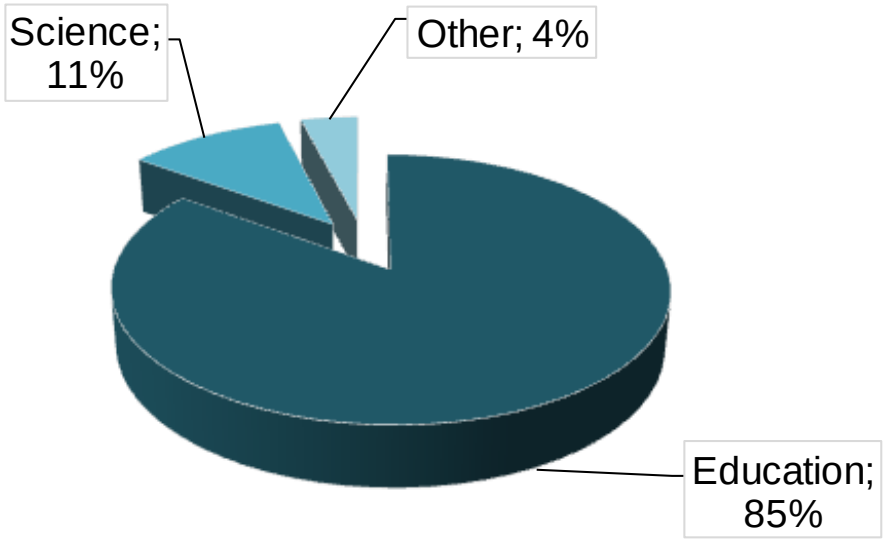


Structural Units

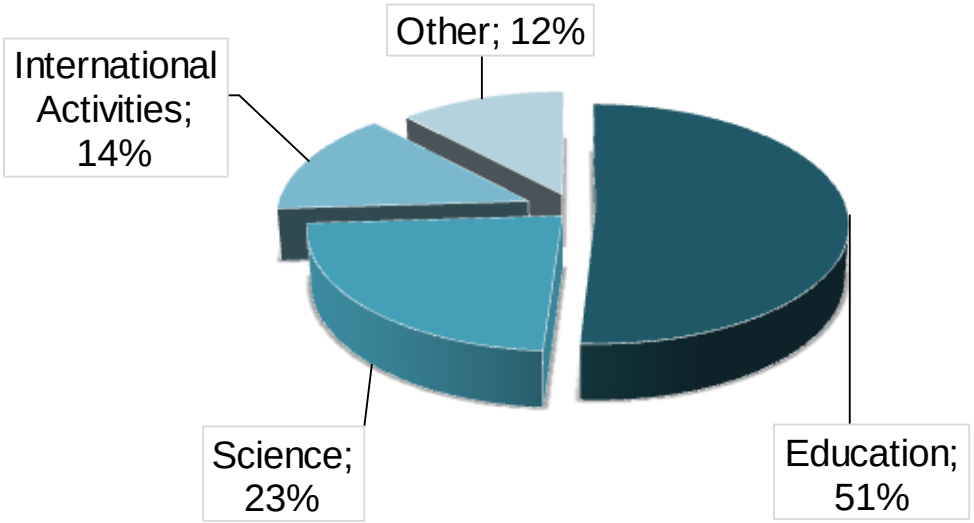
- Joint Science and Technology Institute including
  8 Innovative Research Institutions
- 21 faculties and institutes
- Over 150 departments and 120 R&E laboratories
- 26 research and educational centers
- More than 20 small innovative enterprises
- Science park and incubating
- Faculty of foundation programs and institute of professional trainings
- 3 branches and 6 representatives
- St. Petersburg College of Information and Management

Budget

Government Financing (60%)



Non-Government Financing (40%)



International Research Projects and Programs

- EU Framework Programs
- ENPI CBC
- International Science and Technology Center (ISTC)
- NATO-Russia Science for Peace Project
- Civilian Research and Development Foundation (CRDF)
- Forskningradet - Cooperation Program with Russia (RUSSIA)
- National Science Foundation (NSF)
- National Fund of Canada

Cooperation with Foreign Companies

Joint Science and Technology Institute

According to the Program in 2010 was founded **Joint Science and Technology Institute** includes the following **Innovative Research Institutions**:

- **Research Institute of Materials and Technologies**
- Research Institute of Energy, Resources Saving and Environmental Technologies
- Research Institute of Nano-biotechnologies
- Research Institute of Electronic Systems
- Research Institute of Mathematical Modelling and Intelligent Control Systems
- Research Institute of Machine-Building Technologies (MashTeh)
- Research Institute of Computer Cybernetics
- Research Institute of Nuclear Physics

Nanotechnology Competence and Innovation

Research Institute of Materials and Technologies :

- Gas Phase Synthesis of Nanoparticles
- Li-ion Battery Technologies
- Refractory Metal Composites
- Polymer-Inorganic Nanocomposites
- Magnetic Nanocomposites
- LaB_6 contained heat – resistive transparent films and coatings
- Solid Lubricants Nanoparticles

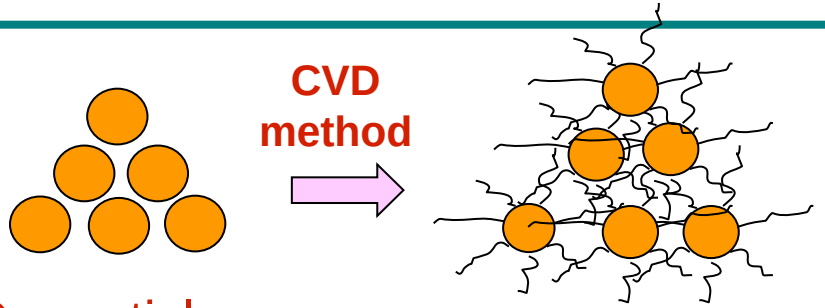
Technologies of nanopowders synthesis

- Gas Phase Synthesis of nanopowders (Fe, Fe-Co, W, WC, W(S,Se)2, Cu, Ni, TiO2, MgO, ZnO, carbon nanostructures, etc.)
- Spray-drying and thermal destruction of salt solutions (Cu-Al2O3, WC-Co-(VC, TaC))
- Electrochemical synthesis (LaB6, TiB2)
- Direct synthesis of carbon nanostructures on the surface of metallic powders (Fe, Cu, MgO, cement)
- Microwave synthesis (Al2O3, CuInSe2, spinels, etc)
- Mechanical Alloying (LaB6, HfC, ZrC, etc.)

Potential Application Areas

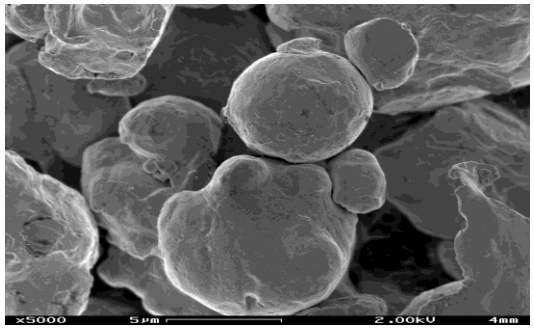
- **M**agnetic recoding media
- **M**agnetic liquids
  - **M**edical and biological applications:
    - ✓ **Magnetic Resonance Imaging**
    - ✓ **Magnetic Hyperthermia**
    - ✓ **Drag delivery systems**
- **P**ermanent magnets
  - **F**illers for composite materials:
    - ✓ **Magnetic plastics**
    - ✓ **Sensors**
    - ✓ **Low friction materials**
- **N**anoelectronics
- **P**igments
- **C**atalysis

Copper – Carbon Composites

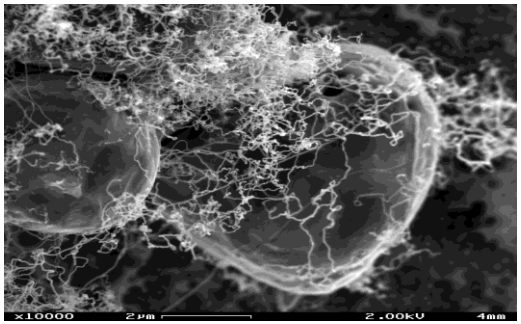


Cu particles

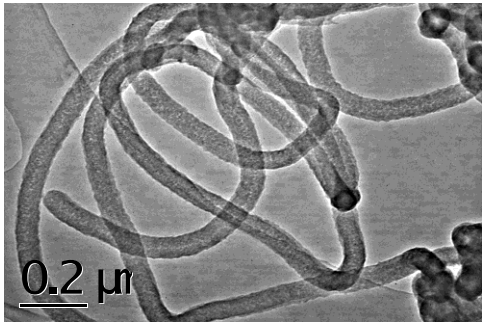
Cu- CNFs composite



Pristine powder



Treated at 750˚C with acetylene

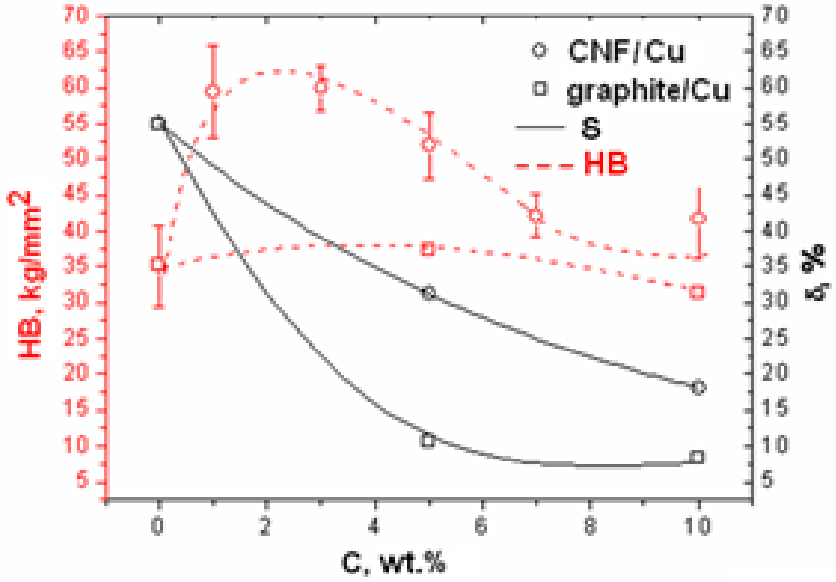


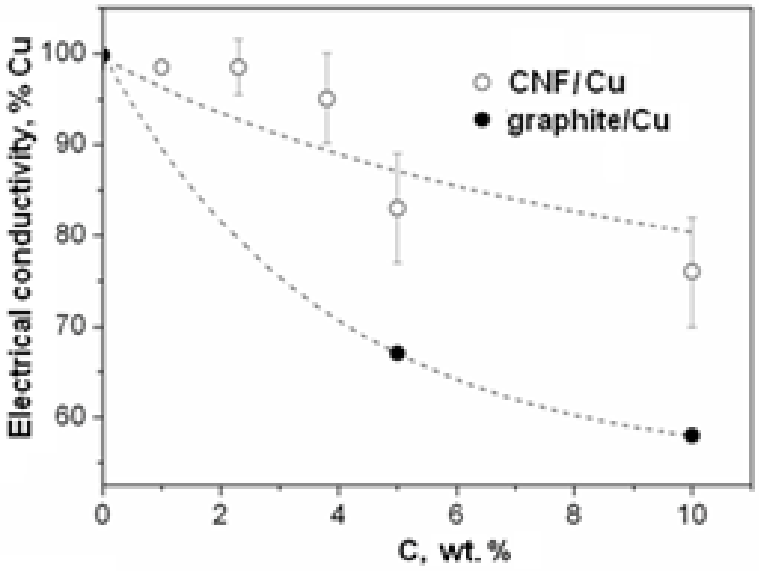
CNFs synthesized at 750˚C with acetylene

Sample Preparation and Properties

1, 3, 5, 7 and 10% -
Cu/CNFs in pristine copper

Sintering: at 950˚C, for
2 hours in H_2



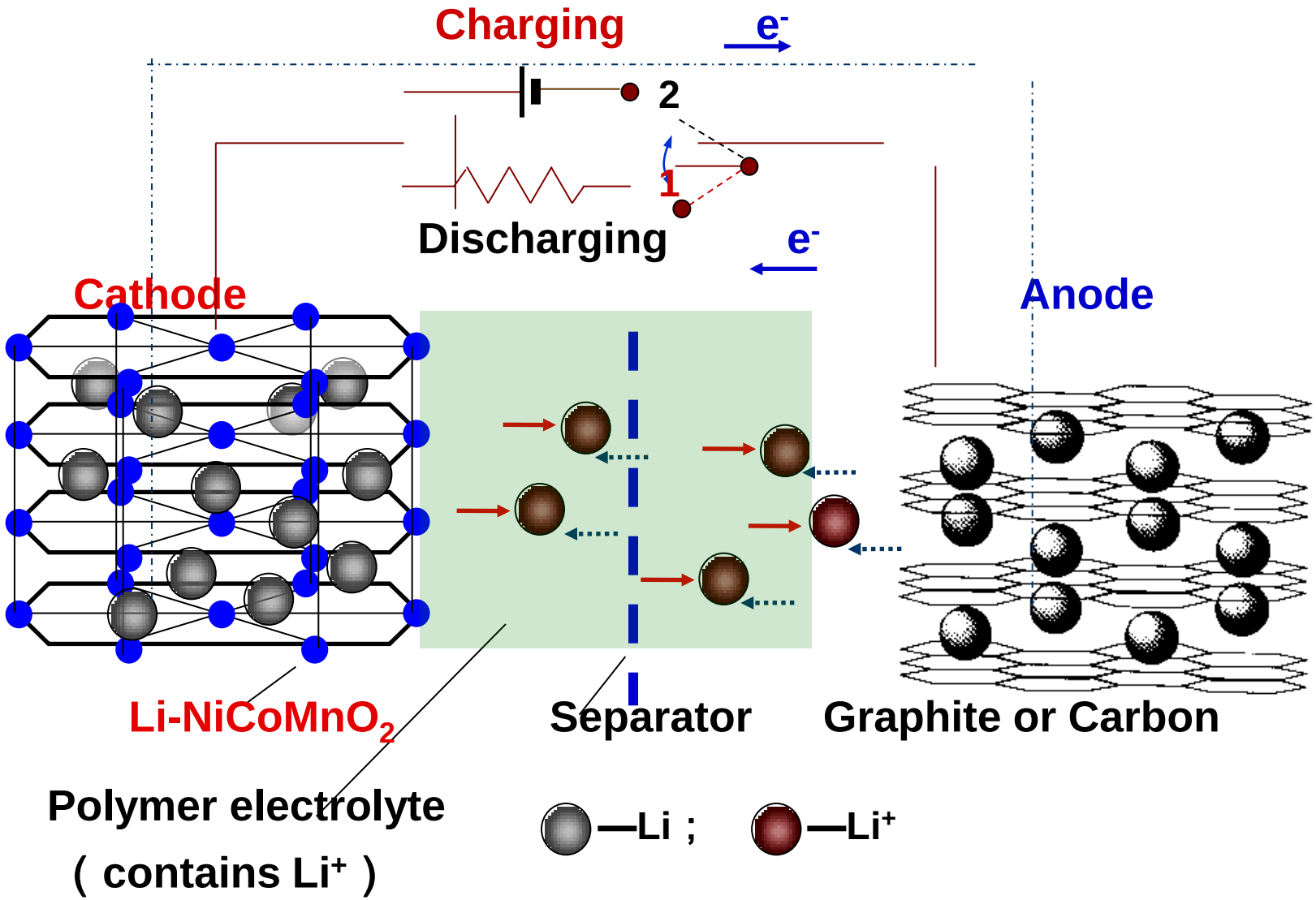


Mechanical and Electrical Properties

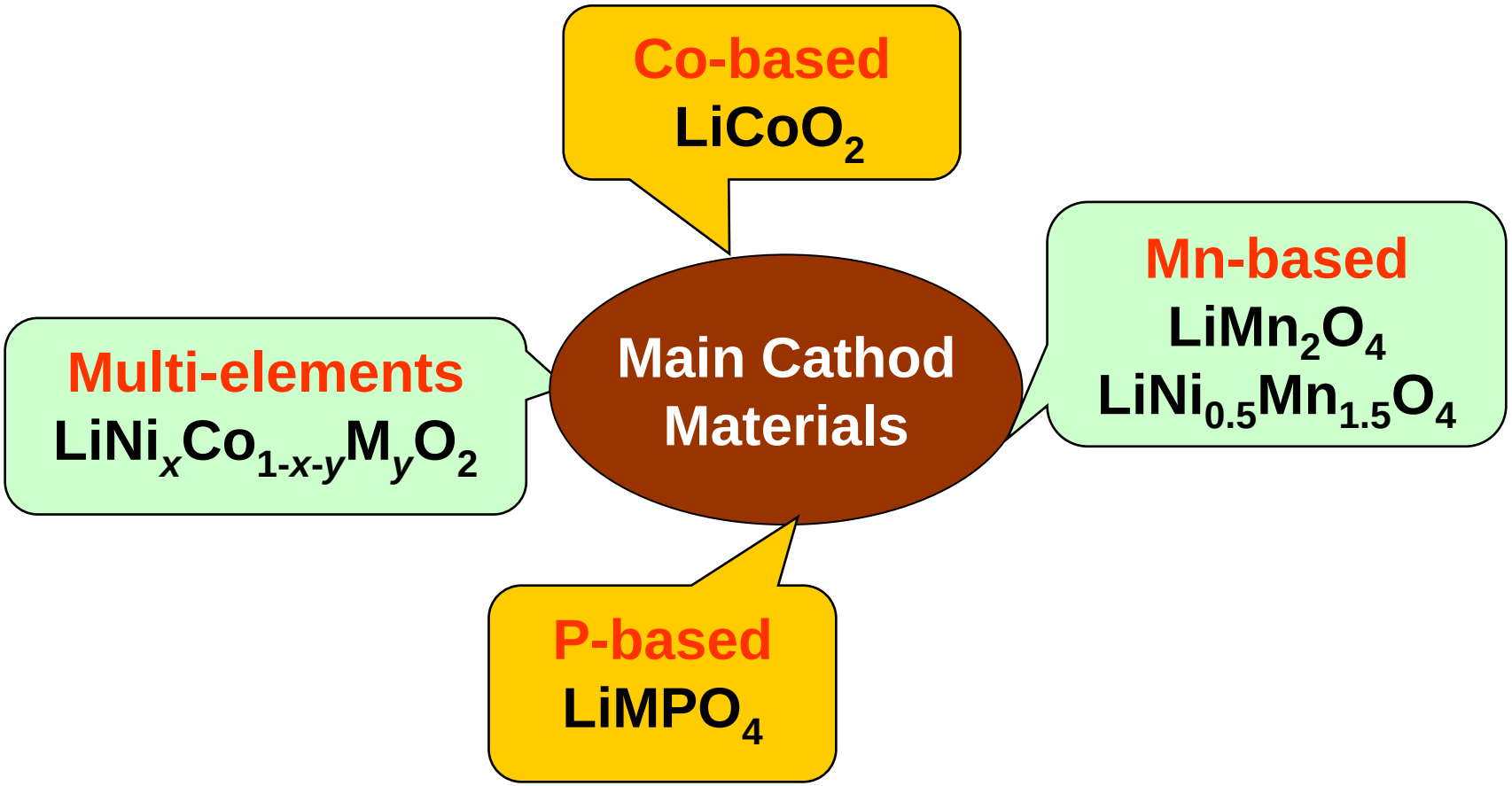
Antifriction materials:
rings, bushings, self lubricating bearings, flange gaskets.

Sliding electrical contacts:
brushes of low power electrical machines, low-voltage generators

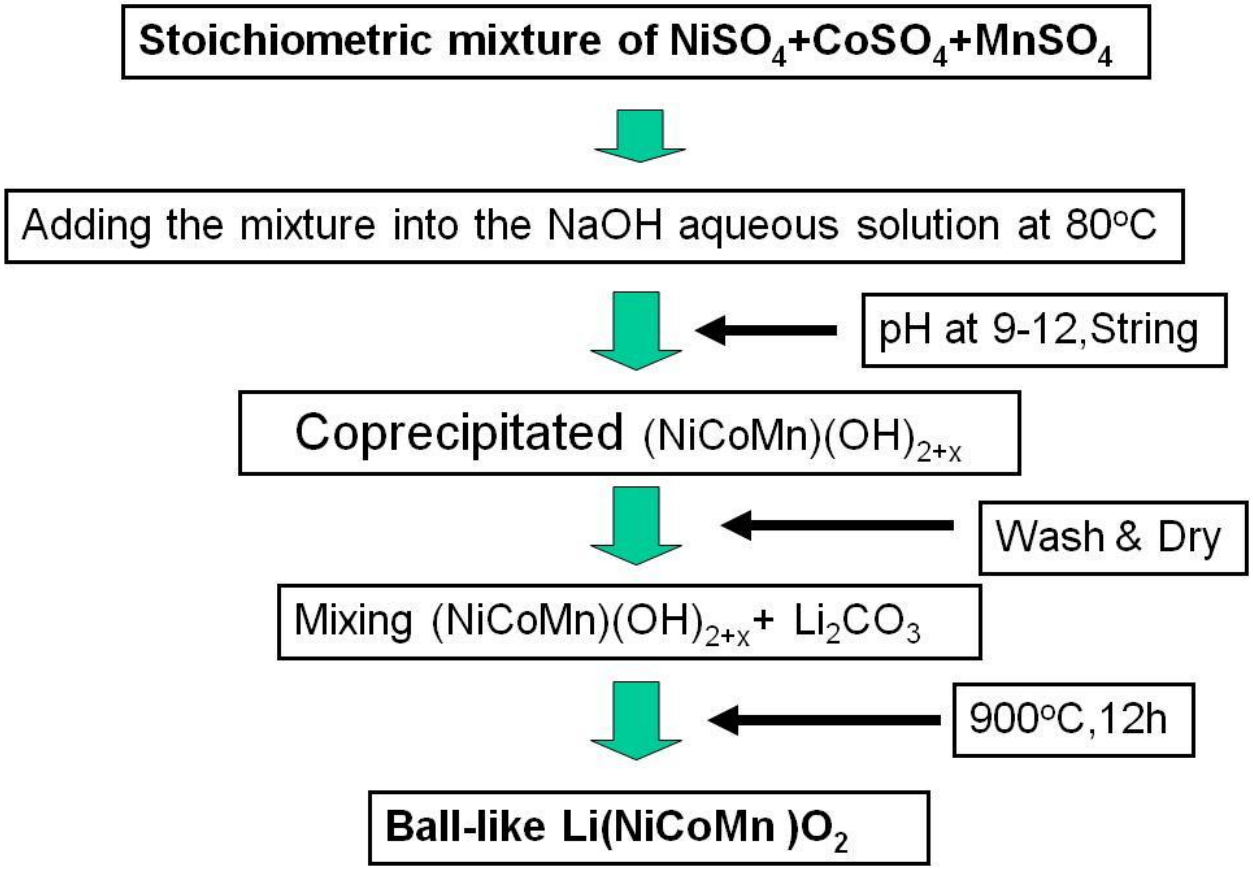
Lithium Polymer Battery (working imitation)



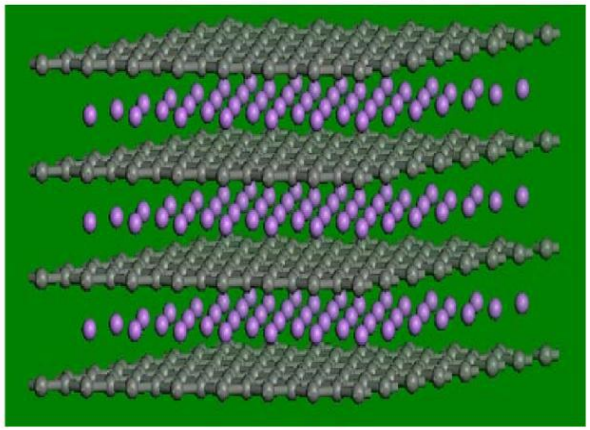
Cathode Materials



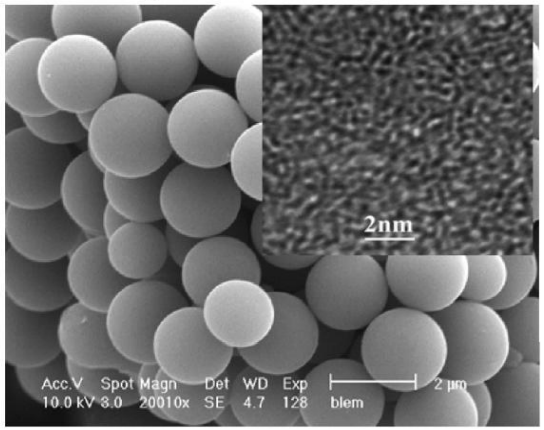
Cathode Material Preparation



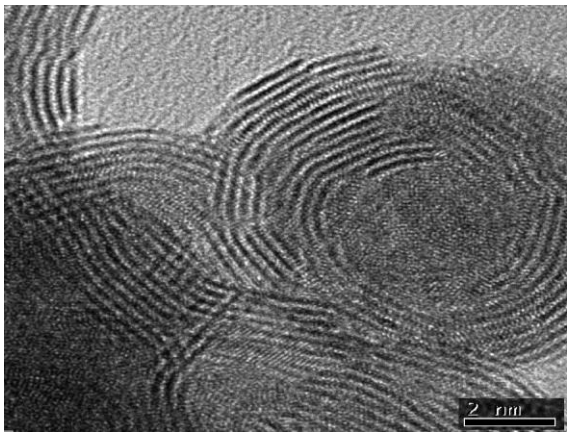
Anode Materials



Graphite
(370 mAh/g)



Disordered carbon
(200-500 mAh/g)



Layered halcogenide
(>600 mAh/g)

Hybrid polymer-inorganic composite material

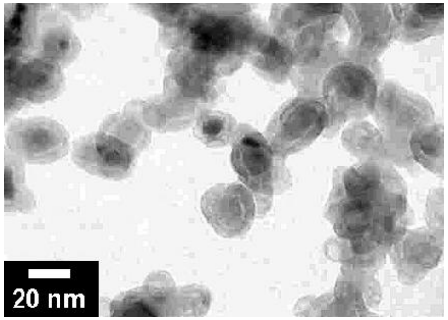
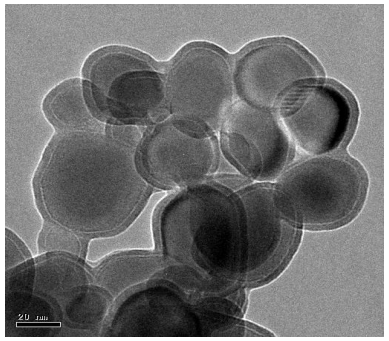
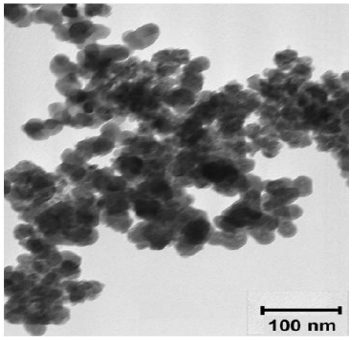
Outline

- Polyimide-based magnetic hard materials
- LaB_6 contained heat – resistive transparent films and coatings
- Polycarbonate based materials for tribological applications

WHY Polymer-Inorganic NANOCOMPOSITES ?

1. **Sufficient improvement of mechanical (modulus, strength) properties of polymers with small loading of nanoparticles**
2. **Sufficient improvement of thermal stability and flammability of polymer based materials**
3. **New functional properties (Magnetic, Electric, Transport, etc.)**

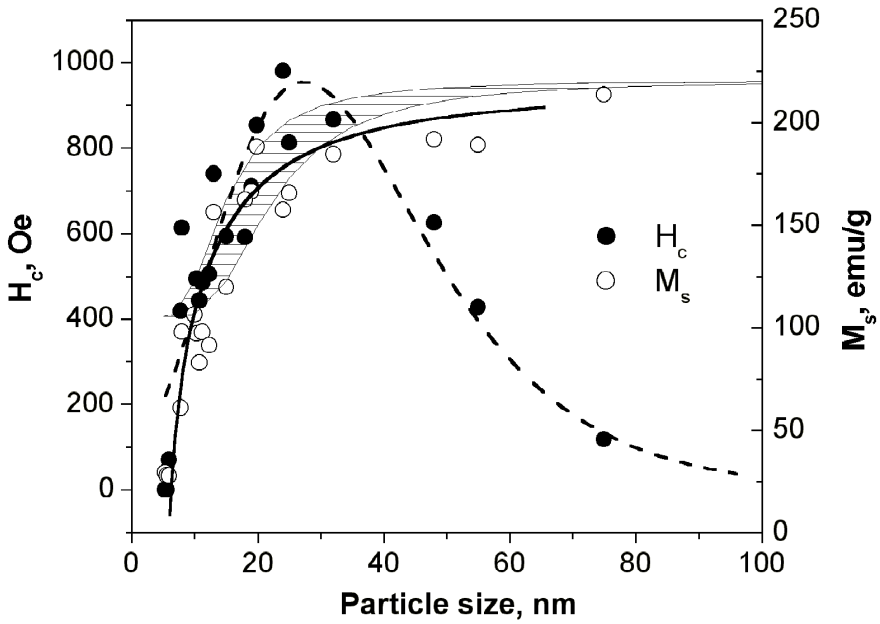
Nanoparticles used for polymers modifications

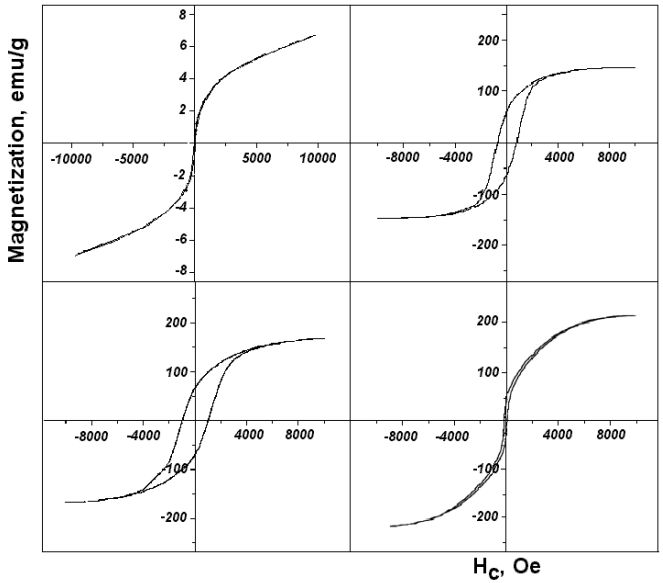
№	nanoparticles	Polymer matrix	Microstructure	Synthesis method
1	Iron-based magnetic nanoparticles	Polyimide		Gas phase synthesis
2	LaB6 nanoparticles with the average size of 40-80 nm	Polyimide, polyurethane		Thermal synthesis, electrochemical synthesis
3	WS_2, WSe_2 nanoparticles	Polycarbonate		Gas phase synthesis

Potential application areas

- Magnetic plastics;
- Magnetic shields for high frequency applications;
- Optical materials;
- Tribological applications;
- Transparent heat-resistive materials.

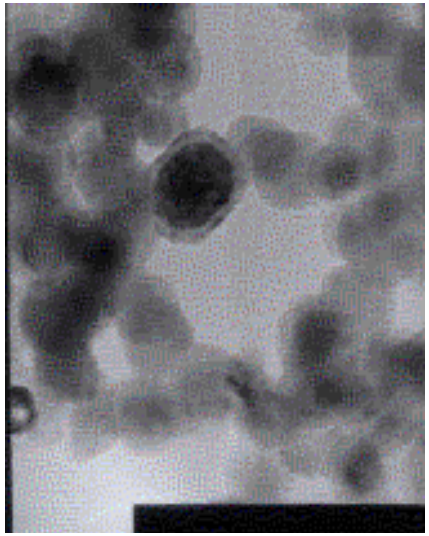
Magnetic properties of iron based nanoparticles

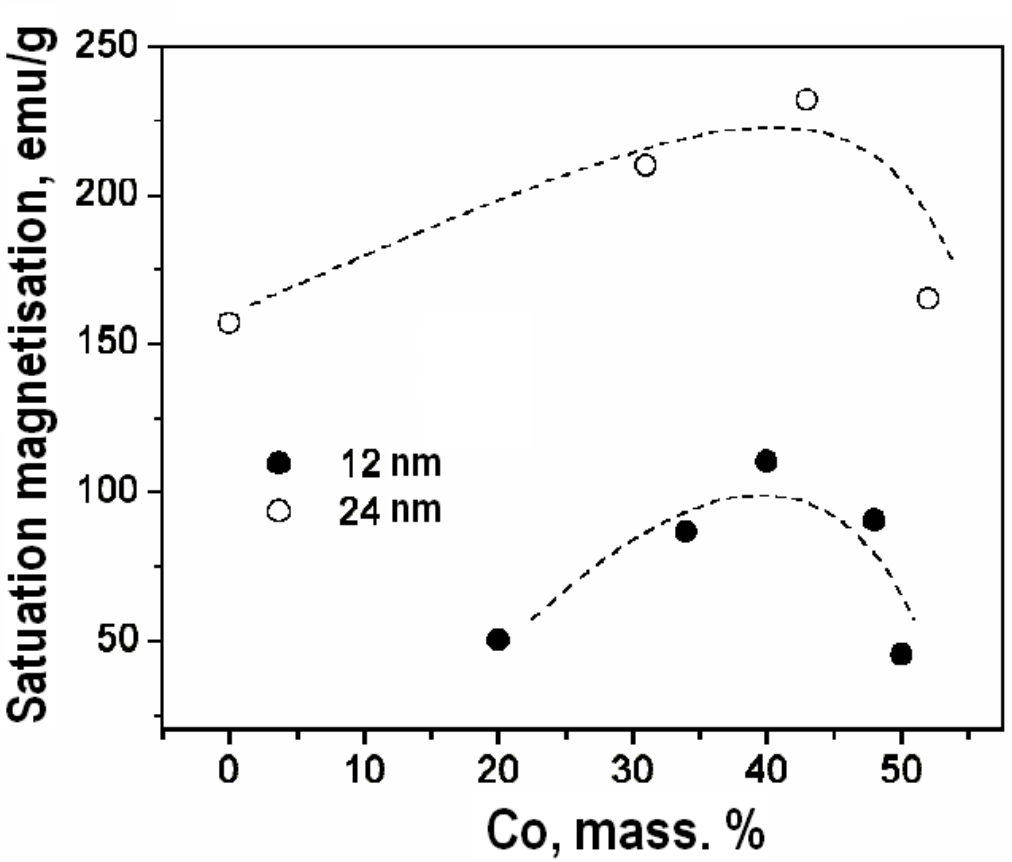




Coersivity (H_c) and magnetization (M_s) in the field of 10 kOe

Fe-Co alloyed nanoparticles

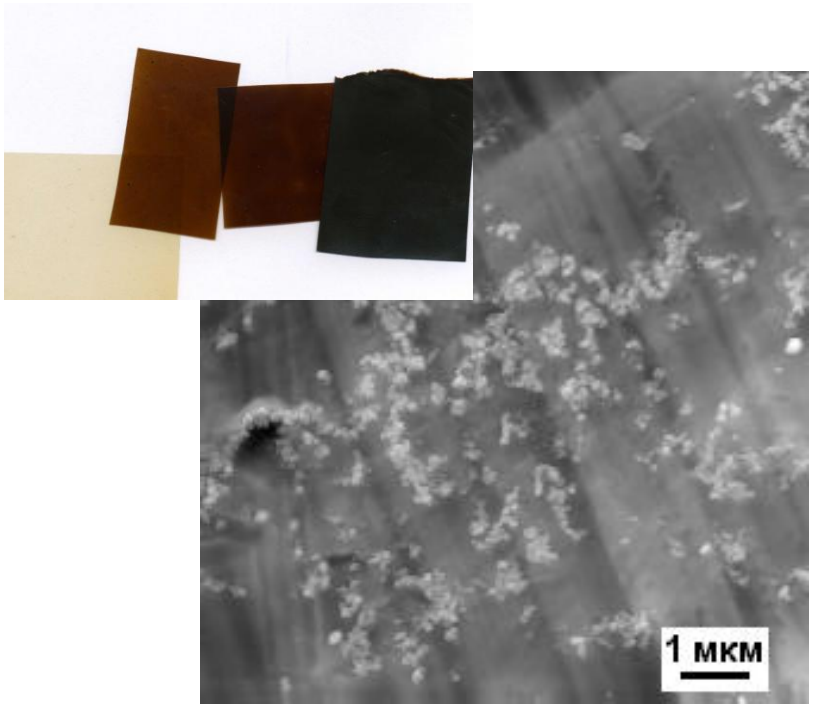


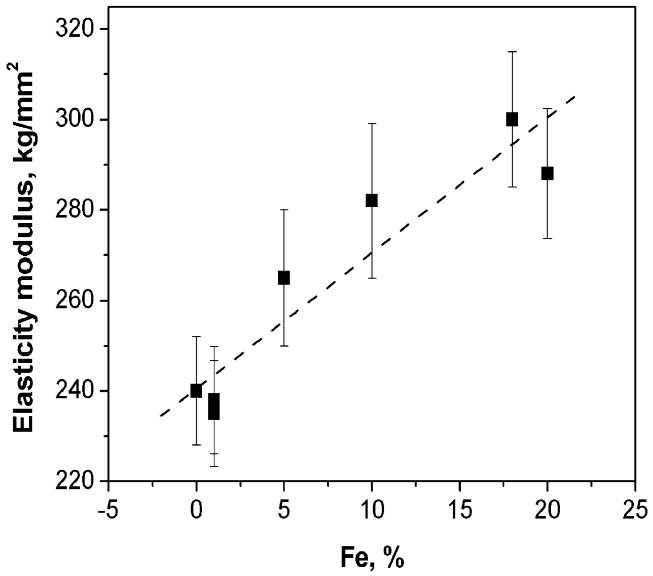


✓ Coersivity of Ir-Co nanoparticles increased up to 1300 Oe;

✓The increasing of Co content up to 40% significantly increase saturation magnetization of nanoparticles (up to 245 emu/gr).

Polyimide-based composites



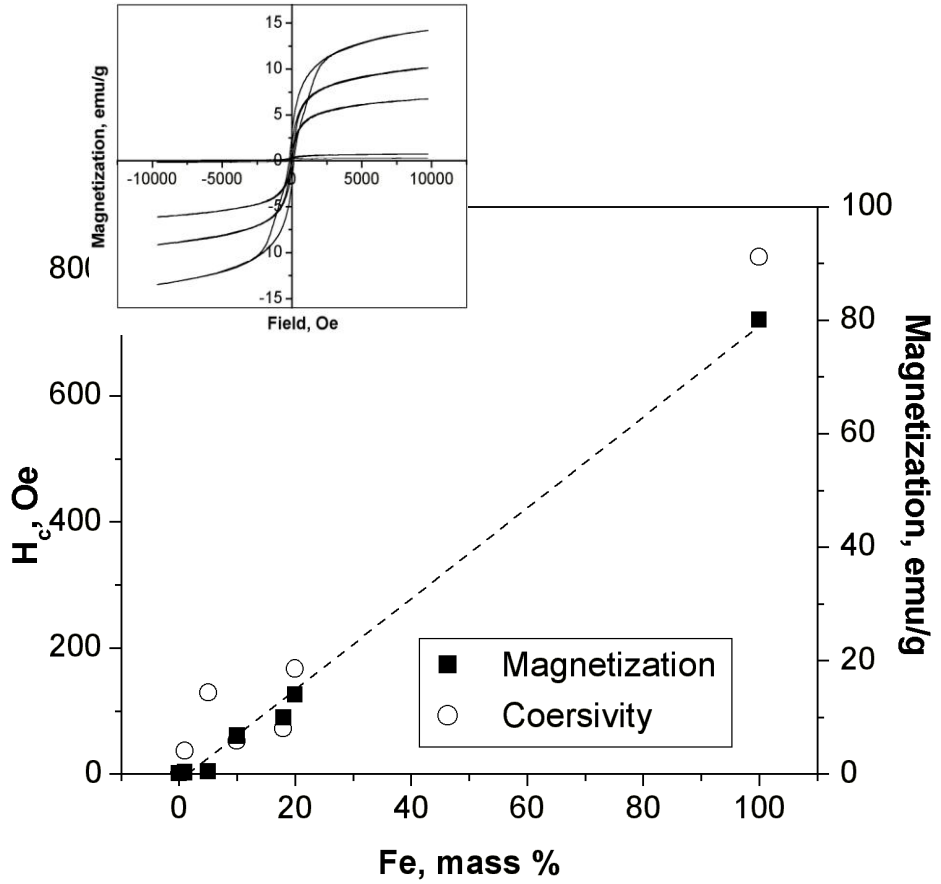


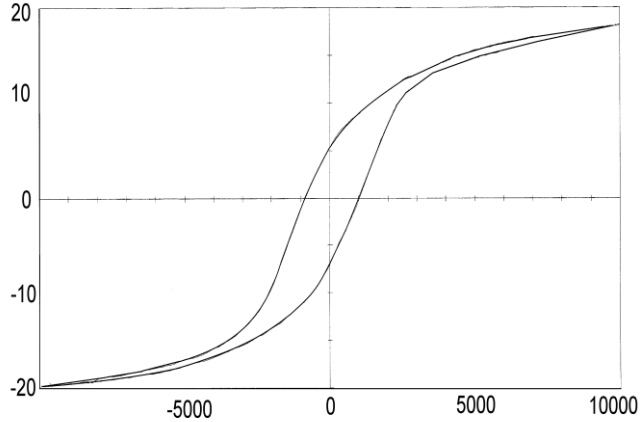
Advantages: 1) **Uniform distribution** of nanoparticles in amorphous matrix;

2) **Identical structure and chemical composition** of initial powder and powder in dispersed polymer;

3) High level of polymers' **magnetic properties**.

Magnetic properties



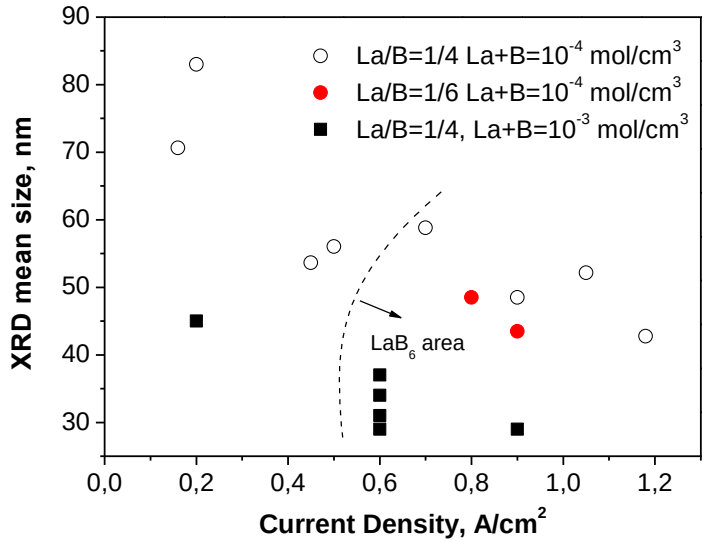


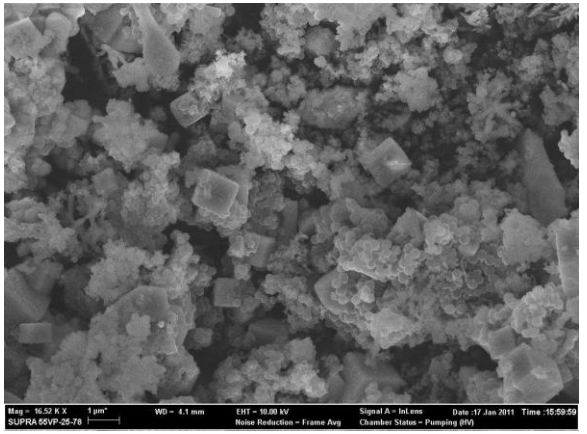
Nanoparticles of Fe-Co – polyimide composite solidified in magnetic field.

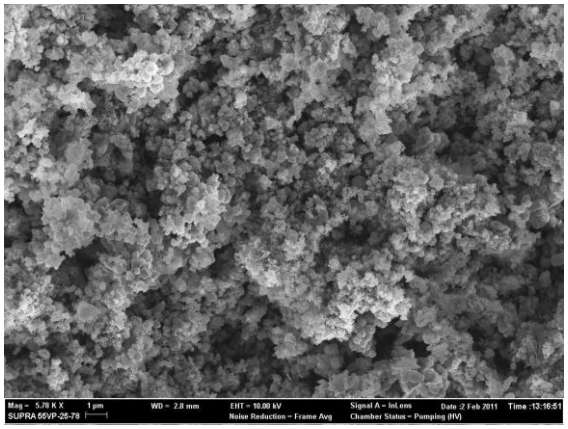
Coersivity is 890 Oe

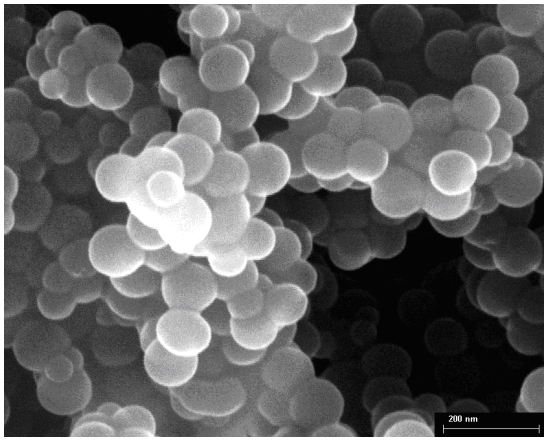
(Much higher as compare with cast permanent magnets)

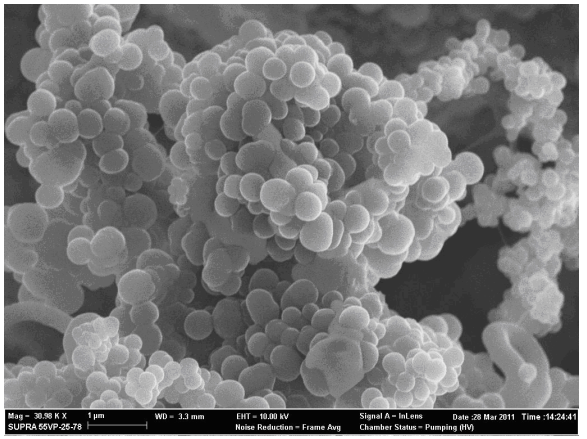
SEM micrographs and size of LaB6 nanopowders



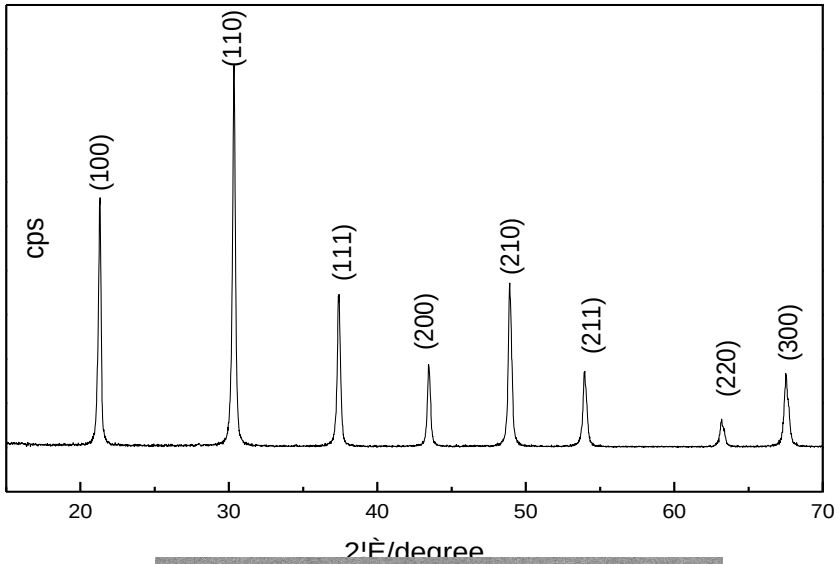


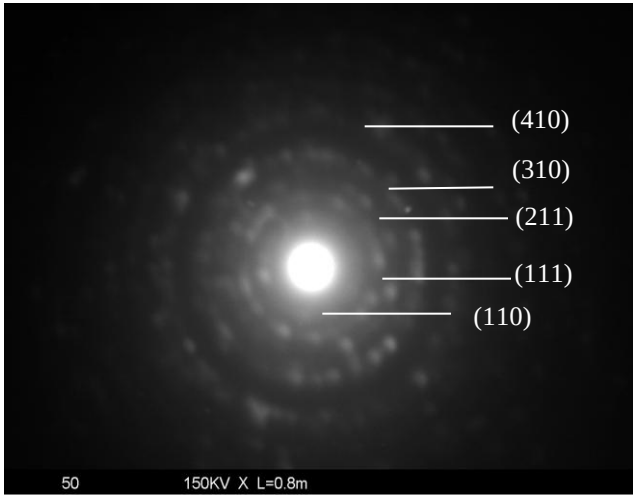


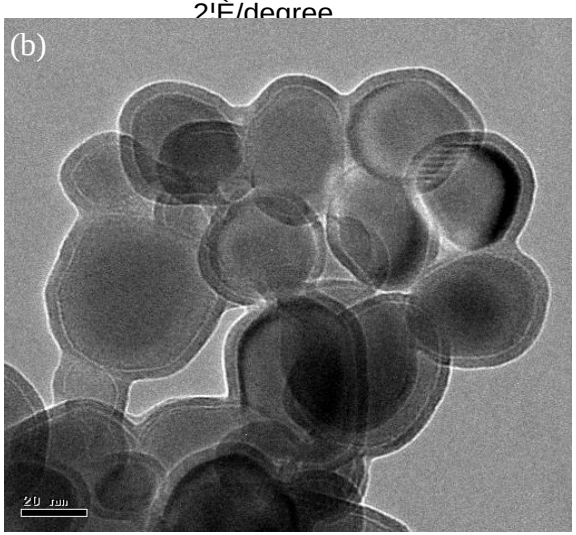


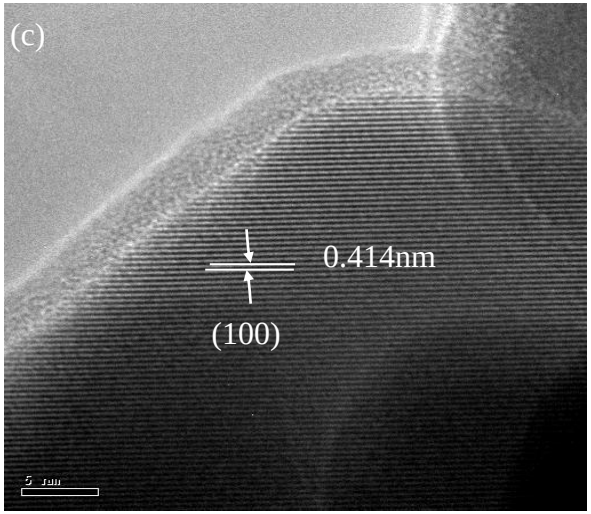


Structure of LaB_6. nanoparticles









Comparison of IR spectra of polyimide films contained nanoparticles

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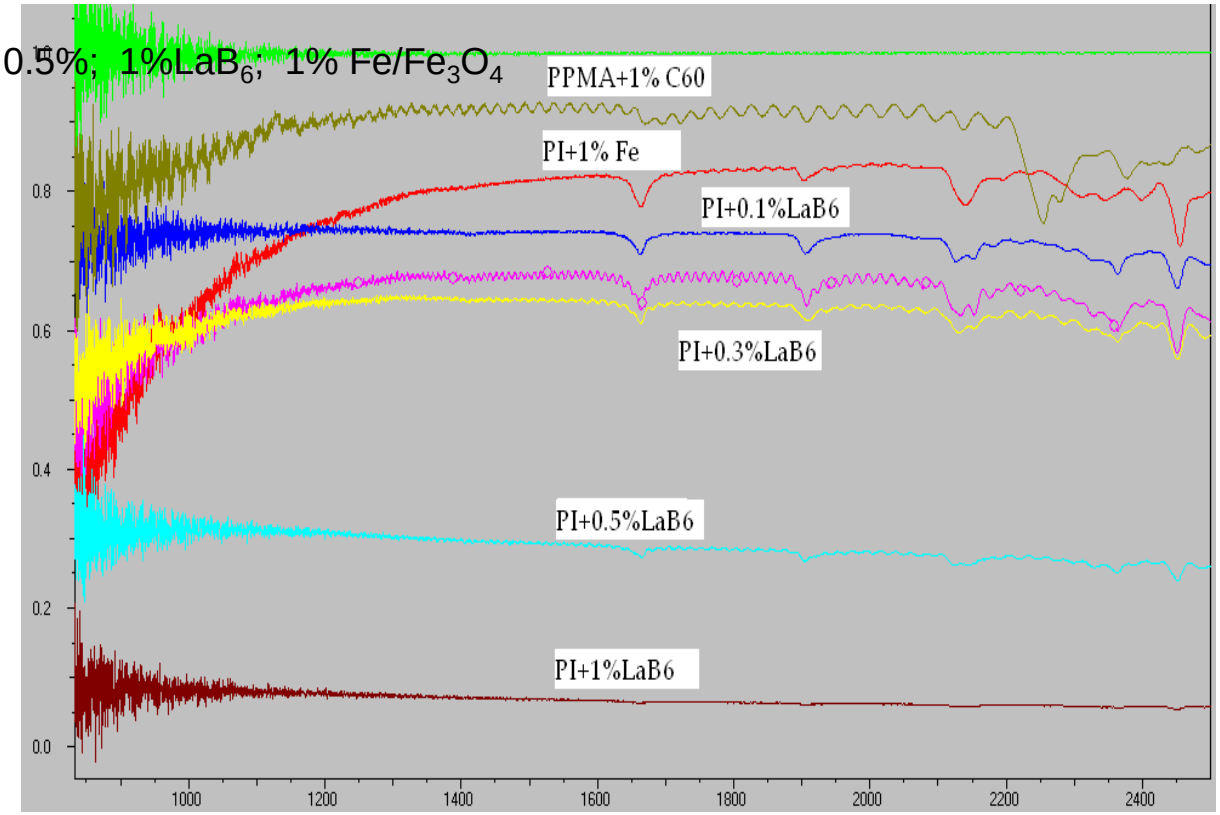
Metallurgical Faculty

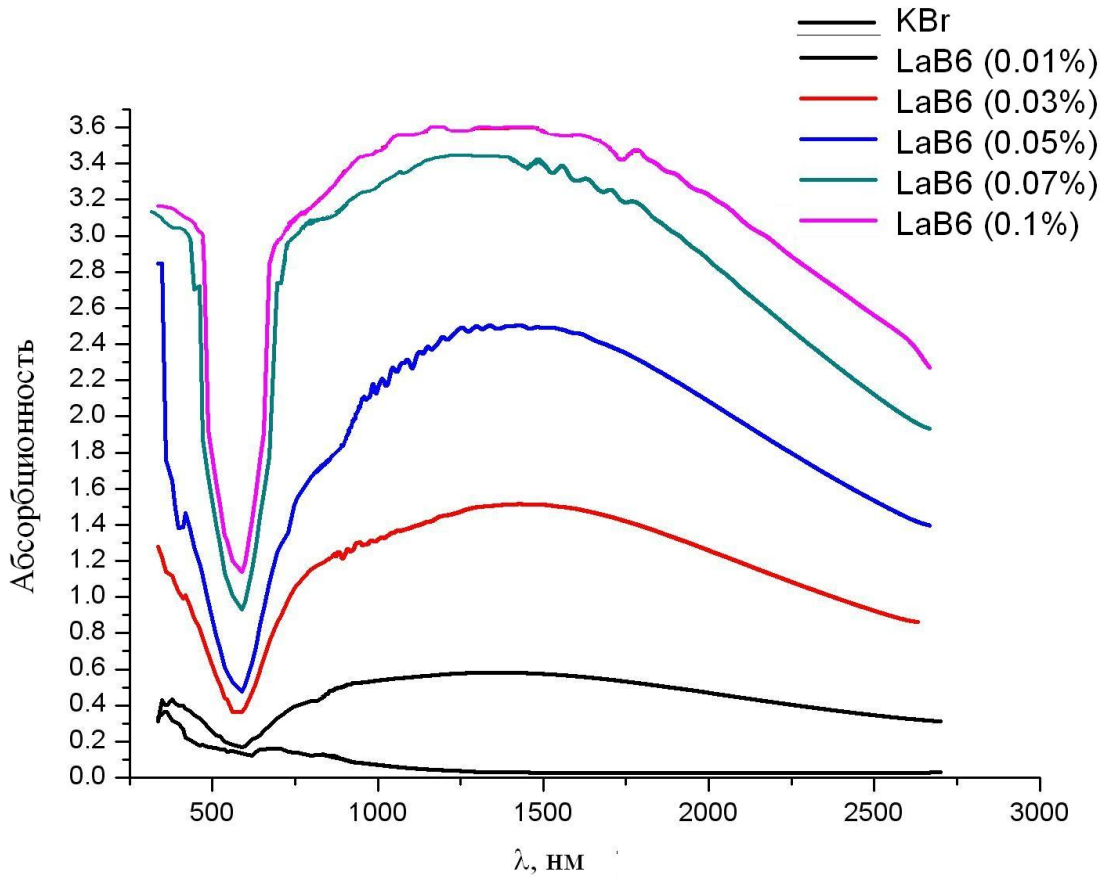
0.1%; 0.3%; 0.5%; 1%LaB_6; 1% Fe/Fe_3O_4



Transmissions, a.u.

Wave length , nm

Light absorption by LaB_6 in KBr matrix



PU based composites

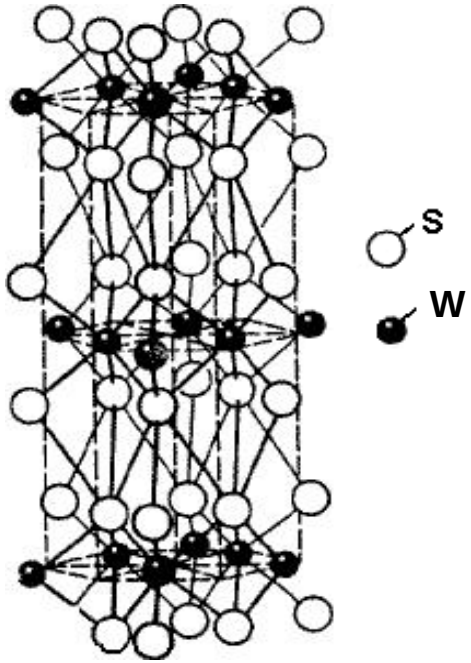
Potential applications

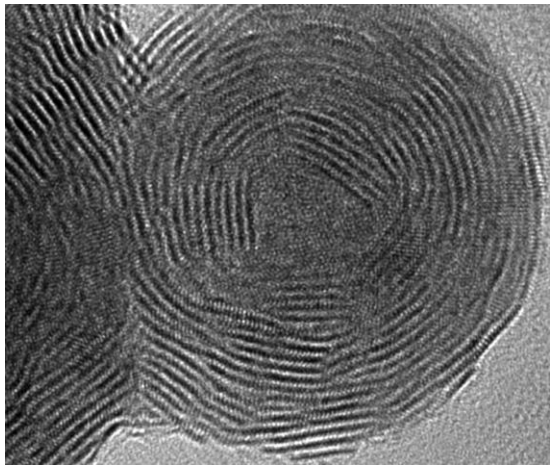
Automobile glasses

Windows

Wear and glasses for special applications

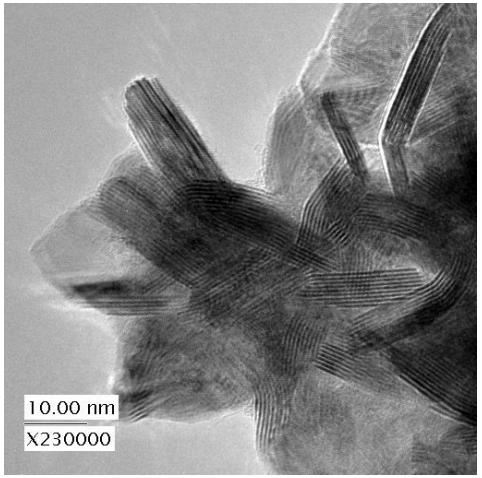
Solid Lubricant Nanoparticles





nanoparticles

WS_2

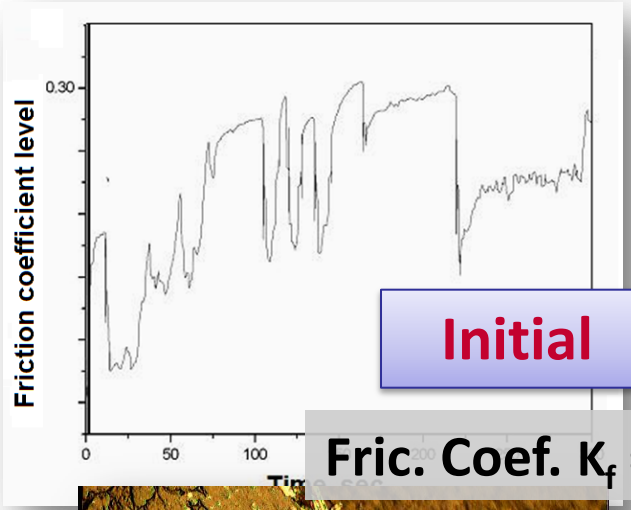


WSe_2

Low friction mechanism:

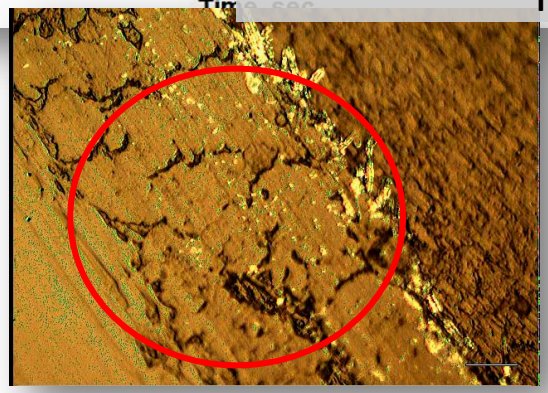
•Van der Waals forces between sulfur planes explain low inter-planar shear strength like so it works under high load and low speed.

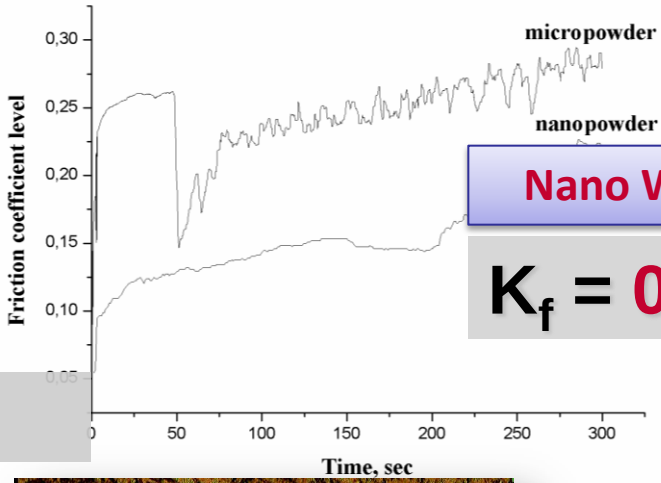
Polycarbonate-based nanocomposites



Initial

Fric. Coef. K_f = 0.25





Nano WS2

K_f = 0.12

Contacts

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Thank you!