Proposals for cooperation of Department of Technical Cryophysics of NTU “KhPI”

The head of the Department: Oleksandr Sipatov, Professor,
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- Teaching staff:
- Professor, D. Sc. – 3 persons;
- Senior teacher – 4 persons.

The training is conducting in specialty «Power Mashinery» :
Bachelor’s degree of Cryogenic & Refrigeration Engineering
Master’s degree of Cryogenic & Refrigeration Engineering

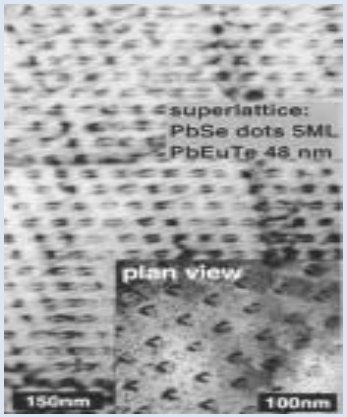
Research fields 2: Semiconductor nanostructures

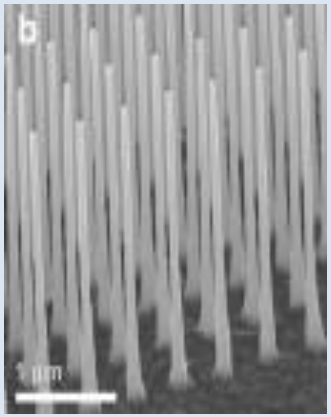
The Technical Cryophisics department (in cooperation with Physics of Metals and Semiconductors department) has the special vacuum technologies for growth of the different types of semiconductor nanostructures: 2D (superlattices, quantum wells [1]), 1D (nanowires [2]), 0D (quantum dots) and dislocation nanogrids [3].
We growth such nanostructures based on chalcogenide semiconductors (PbS, PbSe, PbTe, SnTe, EuS. EuSe, YbS, YbSe, SrS, SrSe) and study their structure (using electron microscopy and X-ray diffraction) and physical properties. We also growth the Bi2Te3 topological insulator nanostructures [4].

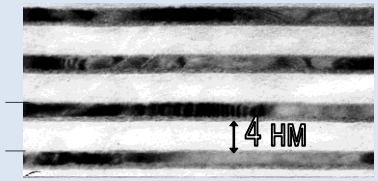
Applications:
- Lasers
- light-emitting diodes (LED)
- Spintronics
- X-ray mirrors

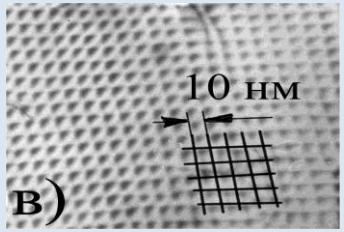
New effects:
- Size quantizations
- Resonant tunneling
- Superconductivity
- Giant magnetoresistance

0D Quantum Dots | 1D Nanowires | 2D Superlattices Nanogrids









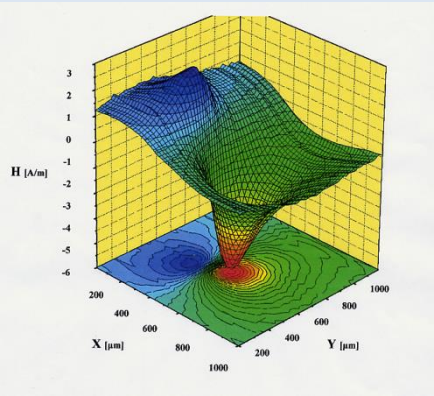
Our main results:

- The superconductivity has been discovered in the multilayer PbTe-PbS nanostructures [3] where there are no superconducting transitions in single-layer films. The superconductivity is connected with the presence of misfit dislocation nanogrids at the interfaces (there is no superconductivity if the dislocation nanogrids are absent).
- The quantum-size effects in the nanostructures were observed by photoluminescence spectra [4-5]: the blue shifts of the emission lines are in good agreement with predictions for **2D** and **0D** quantizations.
- The resonance tunneling of electrons via ferromagnetic EuS barriers was found for **2D** nanostructures. The antiferromagnetic interlayer coupling [6] of magnetic EuS layers via non-magnetic PbS, YbSe and SrS spacers has been found in semiconductor superlattices. Such coupling is observed for unusual wide range of spacer thicknesses for narrow-gap PbS semiconductor (from 0.4 nm to 40 nm), wide-gap YbSe (from 1 nm to 3 nm) and insulator SrS (from 1 nm to 2 nm).

Recent papers:

1. A.Yu.Sipatov. Superlattice nanostructures based on chalcogenide semiconductors // **Functional Materials**. – 2009. – V.16, # 4, - P. 374-383.
2. Volobuev, A.N. Stetsenko, P.V. Mateychenko, E.N. Zubarev, T. Samburskaya, P. Dziawa, A. Rezska, T. Story, and A.Yu. Sipatov. Bi catalyzed VLS growth of PbTe (001) nanowires // **J. Crystal Growth**, -2011. – V.318 , - P. 1105 – 1108.
3. N.Ya.Fogel, A.S.Pokhila, Yu.V.Bomze, A.Yu.Sipatov, A.I.Fedorenko, R.I.Shekhter. Novel superconducting semiconducting superlattices: dislocation-induced superconductivity. // **Phys. Rev. Letters**, 2001, v. 86, N 3, pp.512-515
4. E. I. Rogacheva, A. V. Budnik, A. Yu. Sipatov, O. N. Nashchekina and M. S. Dresselhaus. Thickness dependent quantum oscillations of transport properties in topological insulator Bi_2Te_3 thin films // **Applied Physics Letters**.- 2015.- V. **106**, p. 053103.
5. *I.V. Kolesnikov, A.Yu Sipatov.* Photoluminescence of PbS-EuS superlattices.// **Sov. Phys. Semicond**.-1989.-**23**, N 6.-P. 598 - 601.
6. *L.Kowalczyk, J.Sadowski, R.R.Galazka, A.Stachow-Wojcik, A.Yu.Sipatov, V.V.Volobuev, V.A.Smirnov, V.K.Dugaev.* A photoluminescence study in PbS-EuS superlattices // **Acta Physica Polonica**.- 1998.- **A94**, N 3.- P. 397-400.
7. H. Kepa, C. F. Majkrzak, A. Sipatov, A.G.Fedorov, T. A. Samburskaya and T M Giebultowicz. Interlayer coupling in EuS/SrS, EuS/PbSe and EuS/PbTe magnetic semiconductor superlattices // **Journal of Physics: Condensed Mater**. – 2009. – V. 21, - P. 124207 (8).

Research fields 2: Magnetics



- Complex studies of magnetic, magnetic noise and frequency characteristic of multilayer ferromagnetic cores for highly sensitive sensors - flux gates and non-violent magnetic microscopes.
- Development and research of materials with giant magnetocaloric effect for refrigerating devices.

- I.B. Kekalo, D.Z. Lubyanyi et al. Processes of structural relaxation in the amorphous alloy $Co_{69}Fe_{3.7}Cr_{3.8}Si_{12.5}B_{11}$ with a near-zero magnetostriction and their effect on the magnetic properties and the characteristics of magnetic noise caused by Barkhausen jumps // The Physics of Metals and Metallography, 2015, Vol.116, №7, p.p. 645-655.
- Л.З.Лубяный, В.Н. Самофалов и др. Оптимизация феррозондов с многослойными плёночными сердечниками // ИЗВЕСТИЯ РАН. СЕРИЯ ФИЗИЧЕСКАЯ, 2014, том 78, № 2, с. 142–146.
- Патент №98145 Україна, Малооб’ємна система постійних магнітів для генерування сильного магнітного поля розсіяння (варіанти). Луб’яний Л.З. та ін.: Заявл. 25.04.2012.
- European Patent EP1533817, Magnetic recorder head and method for high coercivity media employing concentrated stray magnetic fields, Lub’yaniy L.Z. etc, 01/04/2012.
- D.P. Belozorov, L.Z. Lubyaniy, A.G. Ravlik, A.V. Rusakova, and V.N. Samofalov Prospects of Development of Magnetizing Systems with Strong Stray Field for Refrigerators Based on Giant Magnetocaloric Effect // Metallofiz. Noveishie Tekhnol, 2010, т. 32, № 12, с. 1591-1599.

Research fields 3: Cryocooler

- The influence of the different parameters on the integral indexes (cooling capacity, COP) of the gas refrigerating machine under the moderate cooling temperatures are studied. The one-dimensional model based on structural-modular conception of the cryosystems and calculation algorithm of the time-varying parameters of the working fluid had been developed for the investigation.

1. Кухаренко В.Н. Математическое моделирование теплофизических процессов низкотемпературных газовых машин при помощи структурно-модульного подхода /В.Н. Кухаренко, В.В. Кузнецов // Холодильна техніка і технологія. – 2009. – с. 11-14
2. Кухаренко В.Н. О возможности создания газовых холодильных машин на основе существующих конструкций. / В.Н. Кухаренко, В.В. Кузнецов // Холодильна техніка і технологія. – 2015. – т. 51. - с. 13-17