Research interests:

Magnetic and magneto-resonance properties of diluted magnetic semiconductors:

- magnetic and charge ordering in semiconductors with mixed valence;
- heterostructures for spintronics problems.

Responsible people: B.E. Bekirov (PhD), I.V. Ivanchenko, N.A. Popenko

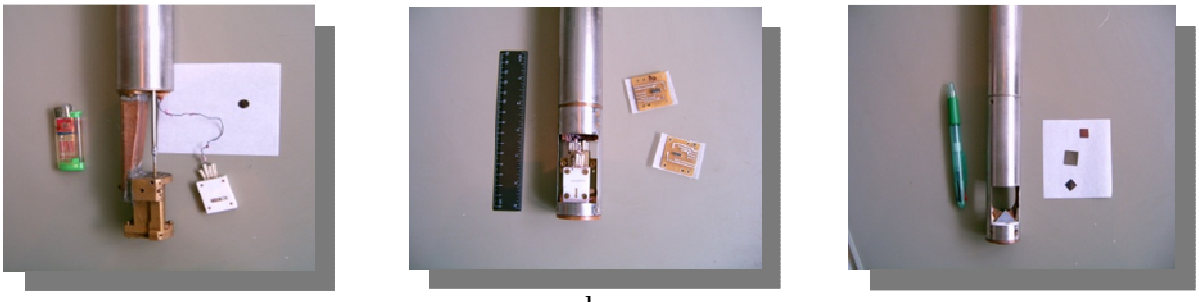
Experimental set up

Multifunction capabilities of cryomagnetic complex (T = 4.2 - 300K, the magnetic fields H=0 – 6.5kE) allow for studying the semiconductors by the following methods: ESR (*f*=9-10GHz), Hall's effect, measurement of volt-ampere characteristics, attenuated total reflection (ATR) technique (*f*=125–145GHz).

Multifunctional cryo-magnetic set up

The practical implementation of these methods is provided by using a number of measurement modules for comprehensive studies of semiconductors:

- the resonance cell of the 3-cm ESR spectrometer as a single mode rectangular resonator. The conditions for increasing the sensitivity of the spectrometer at a study of the magnetoresonance properties of materials with a high conductivity in a wide temperature range have been determined;
- measuring module for researching by Hall's method allows one to set two cassettes with different samples and to measure their galvanomagnetic characteristics;
- electrodynamic ATR module is designed to study the surface properties of crystals by using a prism converter of EM waves with a face of the total internal reflection, where the sample under test is located.



a b c

Modules for studying the semiconductor characteristics: ESR-module (a), Hall's cell (b), ATR module (c).

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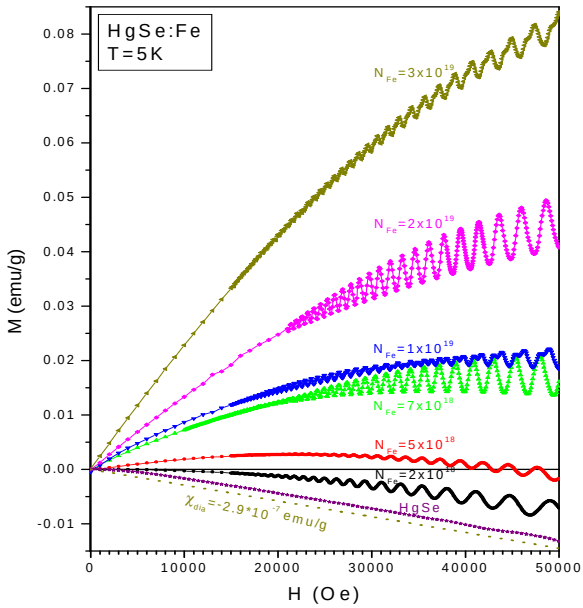
Experimental results:

As a result of a comprehensive study of multicomponent solid solutions of semiconductors $Hg_{1-x}H_xSe$ (*X = Co, Gd, Cr, V, Fe*) as promising elements of heterostructures, the following regularities in the behavior of temperature and magnetic characteristics have been determined:

- in the semimagnetic semiconductors *HgCrSe* and *CdHgCrSe* the transition mechanisms to the ferromagnetic ordering have been defined, namely: for the crystals *HgCrSe* the transition is due to the formation of spinel clusters $HgCr_2Se_4$, while for the crystals *CdHgCrSe* the transition is due to the *s-d* interaction;
- the nonlinear part of the current-voltage characteristic has been experimentally revealed in the new contact pair *HgCdCrSe/HgMnTe* that indirectly indicating the presence of spin-polarized current in this heterostructure;
- for the first time the EPR spectra of the gapless semimagnetic semiconductor *HgSe:Fe* have been recorded and analyzed in the temperature range $77K<T<300K$ with an concentration of iron impurity in the range of $2\cdot10^{18}cm^{-3}$ - $3\cdot10^{19}cm^{-3}$. The nonmonotonic temperature dependence of the absorption line width and effective *g*-factor has been established for these crystals with the different concentration of impurity iron that is due to the formation of ordered state of the charged donors;
- the intervals of iron impurity concentration have been determined, where a change of the dominant contribution in the *HgSe:Fe* crystals magnetization of its diamagnetic and paramagnetic components is observed, as well as the critical impurity concentration at which there is a sharp increase in the Curie-Weiss temperature due to the spontaneous spin polarization of the hybridized electronic states system.



Field dependences of the HgSe:Fe crystals magnetization with the different iron concentration and mercury selenide HgSe at T = 5K.

A detailed summary of the results is presented in publications:

1. N.N. Beletskii, S.A. Borysenko, I.V. Ivanchenko, N.A. Popenko. Investigation of solid state surfaces by non-linear polaritons. Surface Science, 2000, Vol.454-456, pp.1063-1068.
2. Beletskii N.N., Borysenko S.A., Ivanchenko I.V., Popenko N.A. Nonlinear surface polaritons in semimagnetic semiconductors. Surface Science, 2002, Vol.507-510, pp.512-516.
3. S.E. Ostapov, I.N. Gorbatyuk, S.G. Dremlyuzhenko, V.V. Zhikharevich, I.M. Rarenko, R.A. Zaplitnyy, I.M. Fodchuk, V.G. Deibuk, N.A. Popenko, I.V. Ivanchenko, A.A. Zhigalov, S.

Yu.Karelin. HgCdMnZnTe: Growth and physical properties. *Journal* of *Alloys and Compounds*, 423 (2006), pp.139-143

4. K. Lamonova, I. Ivanchenko, S. Orel, S. Paranchich, V. Tkach, E. Zhitlukhina, N. Popenko, and Yu. Pashkevich. Spectroscopic evidence of spinel phase clustering in solid solutions $Hg_{1-x}Cr_xSe$ ($0.03 \leq x \leq 0.1$). "*Journal of Physics: Condensed Matter"*, vol. 21, no. 4, (045603), Jan. 2009.
5. Бекиров Б. Э., Иванченко И.В, Попенко Н.А., Чернобровкин Р.Е. Резонансная ячейка спектрометра ЭПР для исследований образцов с высокой проводимостью. *Радиофизика и электроника*, № 2, 2012, сс. 87-94.
6. B. Bekirov, I. Ivanchenko, N. Popenko, V. Tkach. HgCrCdSe as the element of new heterostructure HgCrCdSe/HgMnTe. *"Functional Materials"*, Vol. 19, No. 3, 2012, pp.319-324.
7. Б. Бекиров, И. Иванченко, А. Луханин, Н. Попенко. ЭПР спектрометр миллиметрового диапазона для исследования образцов с высокой проводимостью. Радиофизика и Электроника, 2013, т. 4(18), № 4, сс. 86-91.
8. B. Bekirov, I. Ivanchenko, N. Popenko, A. Bludov, V. Pashchenko, V. Tkach. Magnetic and magnetoresonance properties of the solid solution $Hg_{0.5}Cd_{0.4}Cr_{0.1}Se$. *"Applied Magnetic Resonance"*, vol. 45, No 1, 2014, pp. 75-82.
9. Б. Бекиров, И. Иванченко, Н. Попенко, К. Ламонова, Е. Житлухина, В. Бурховецкий, С. Орел, Ю. Пашкевич. Особенности температурного поведения ЭПР спектров селенида ртути, легированного железом, "*ФНТ*", 2014, т. 40, № 7, с. 842–850.
10. N. Popenko, B. Bekirov, I. Ivanchenko, A. Bludov, and V. Pashchenko. Concentration Anomalies of the Magnetization of HgSe:Fe Crystals. *"JETP Letters"*, 2014, Vol. 100, No. 4, pp. 247–250.