CHEMICAL POTENTIAL INVESTIGATIONS OF THE SURFACE OF FERROMAGNETIC-SUPERCONDUCTING MULTILAYERS

K. Filar [1], K. Rogacki [1,2], P. Przyslupski [3], A. I. Kharkovskii [4], V. I. Nizhankovskii [1]

[1] *International Laboratory of High Magnetic Fields and Low Temperatures, Gajowicka 95, 53-421 Wroclaw, Poland*
[2] *Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okolna 2, 50-422 Wroclaw, Poland*
[3] *Institute of Physics, Polish Academy of Sciences, Lotnikow Ave. 32/46, 02-668 Warsaw, Poland*
[4] *Institute of High Pressure Physics, Russian Academy of Sciences, 142190, Troitsk, Moscow Region, Russia*

Chemical potential μ is the only one thermodynamical parameter which can be easy measured on low-dimensional systems like thin films or a two-dimensional electron gas. It is especially useful for multilayers because the properties of the topmost layer with thickness about the Debye screening length are investigated.

The method to measure the change of the chemical potential $\Delta\mu = \mu(H) - \mu(0)$ is based on the determination of the change in charge on the measuring capacitor consisting of the sample under investigation and the reference electrode. The idea is closely related to Lord Kelvin's investigations of the contact potential difference. In general, the contact potential difference differs from the chemical potentials difference by the magnitude of the potential difference of the double charged layers present at the surface of bulk metals. If the influence of a magnetic field on the capacitance C and in the work function of the reference electrode is negligibly small then $\Delta Q = -C\Delta\mu/e$, where e is the charge of current carriers.

Measurements of the chemical potential of superconducting and ferromagnetic films in stationary magnetic field were published many years ago [1]. The purpose of the present work is to investigate heterostructures consisting of superconducting and ferromagnetic layers [2], superconducting monocrystal and pure nickel. The heterostructures and monocrystal were characterized by magnetic and transport measurements. Chemical potential investigations were done with and without using the field-modulation technique. The field-modulation technique significantly increases the sensitivity of the method.

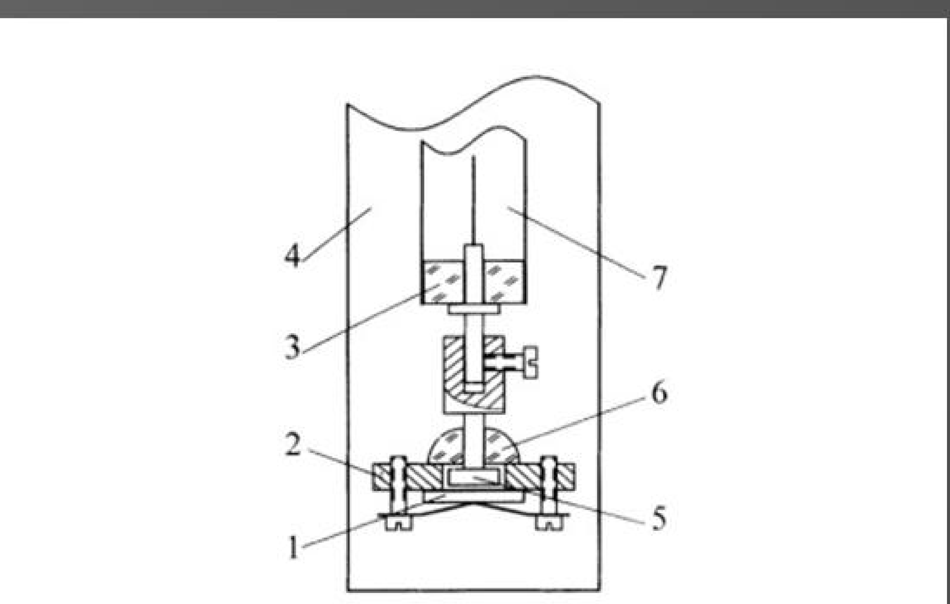


FIG. 1. Schematic diagram of the device for the chemical-potential measurements. 1—sample, 2—base plate, 3—sapphire insulator, 4—protective tube, 5—reference electrode, 6—glass insulator, 7—coaxial line to an electrometer.

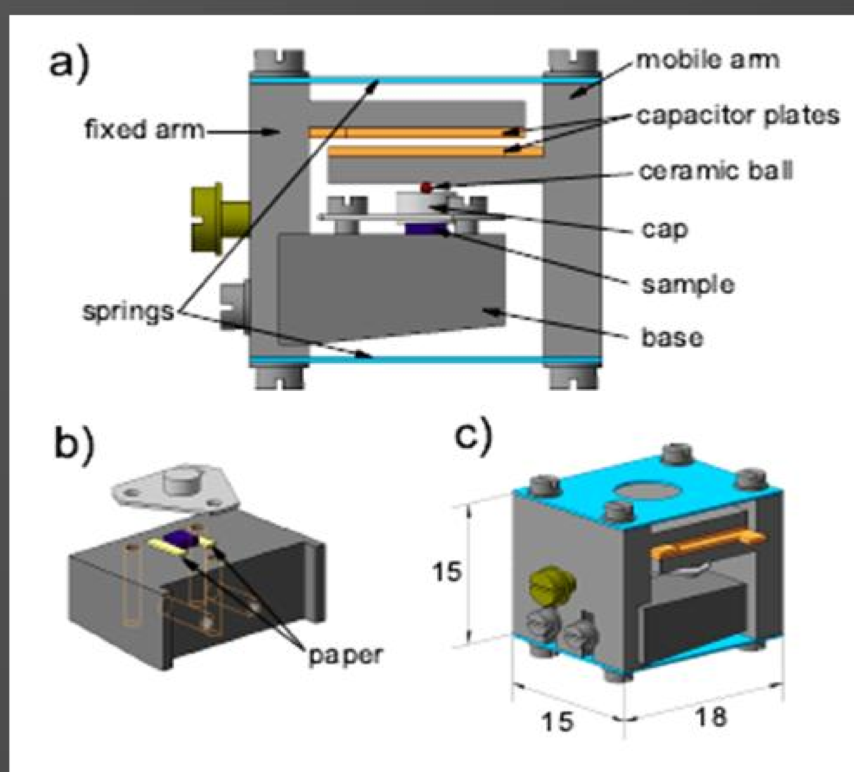
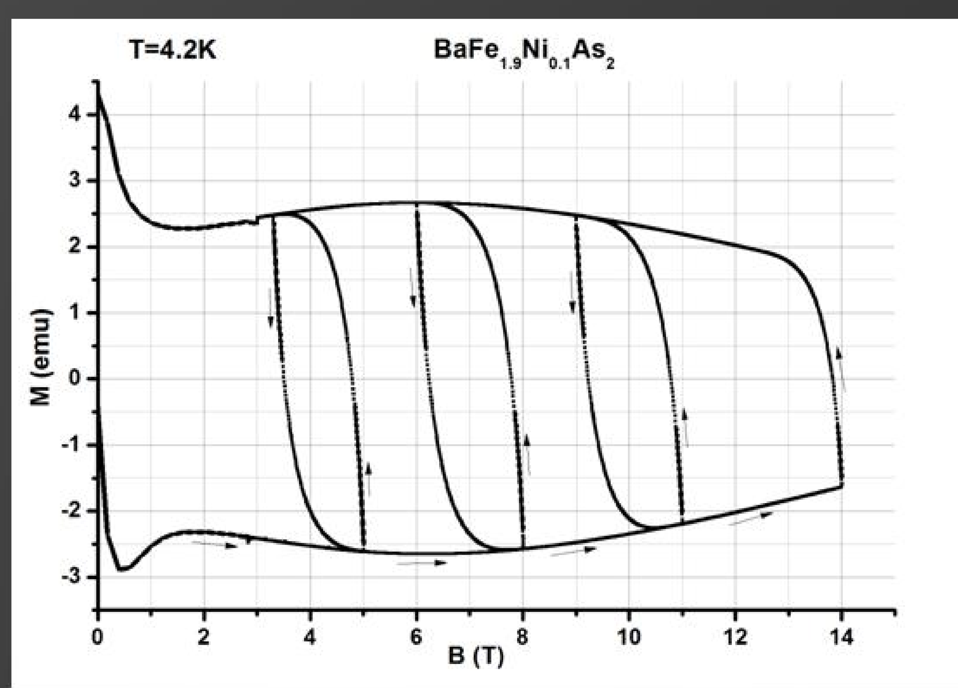
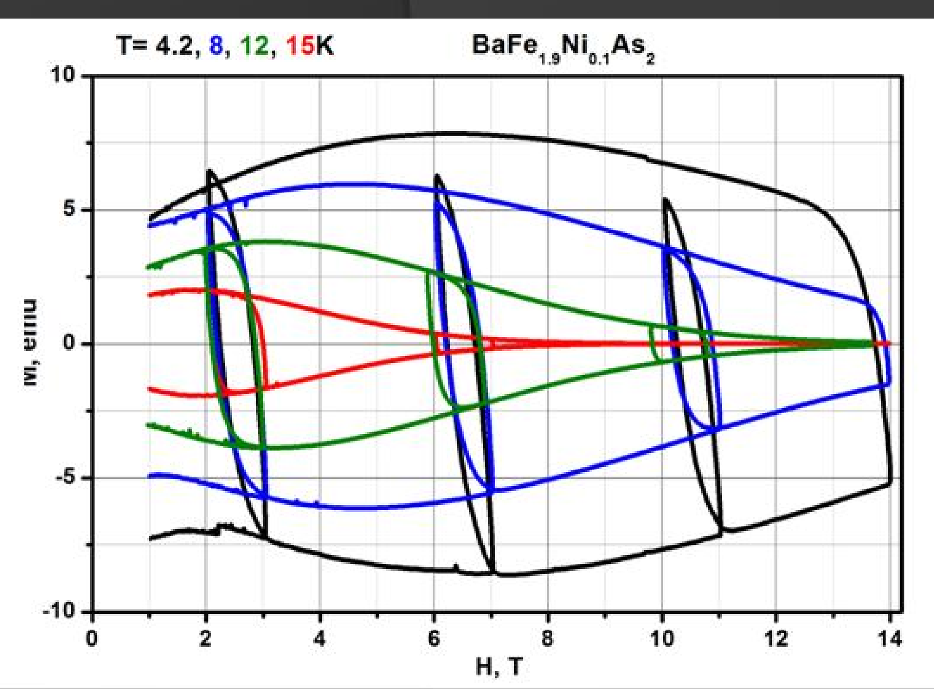
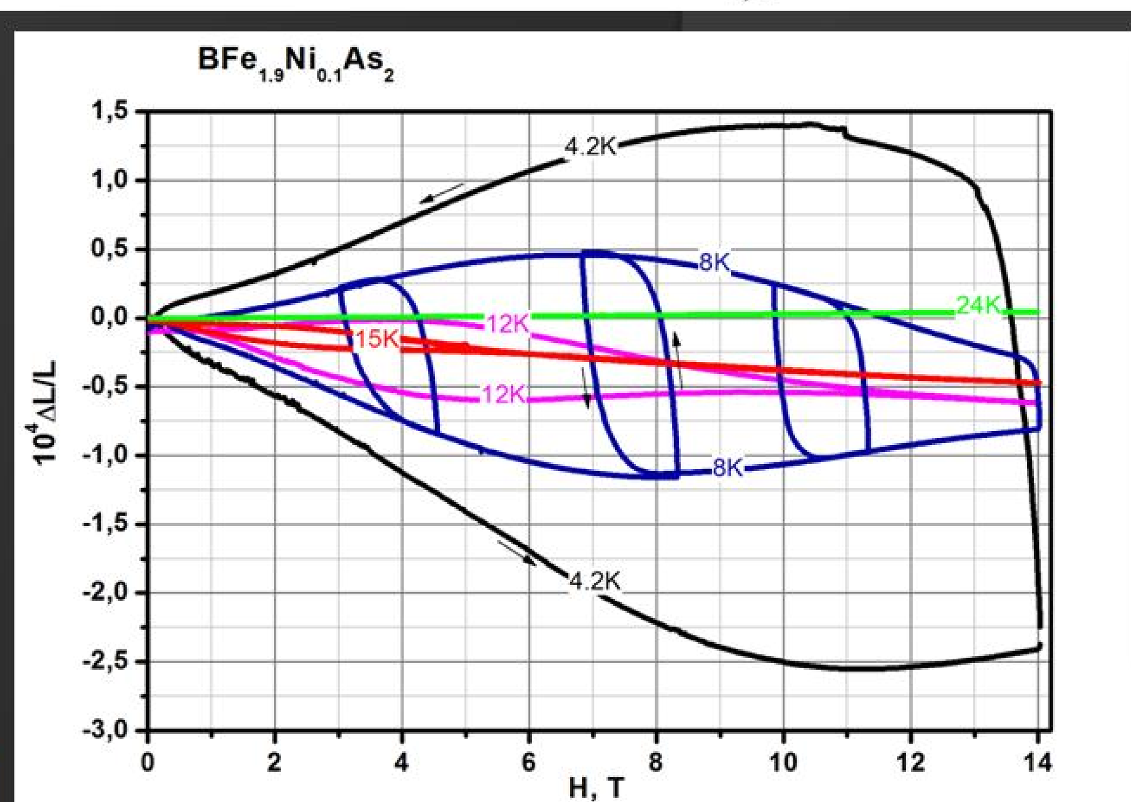


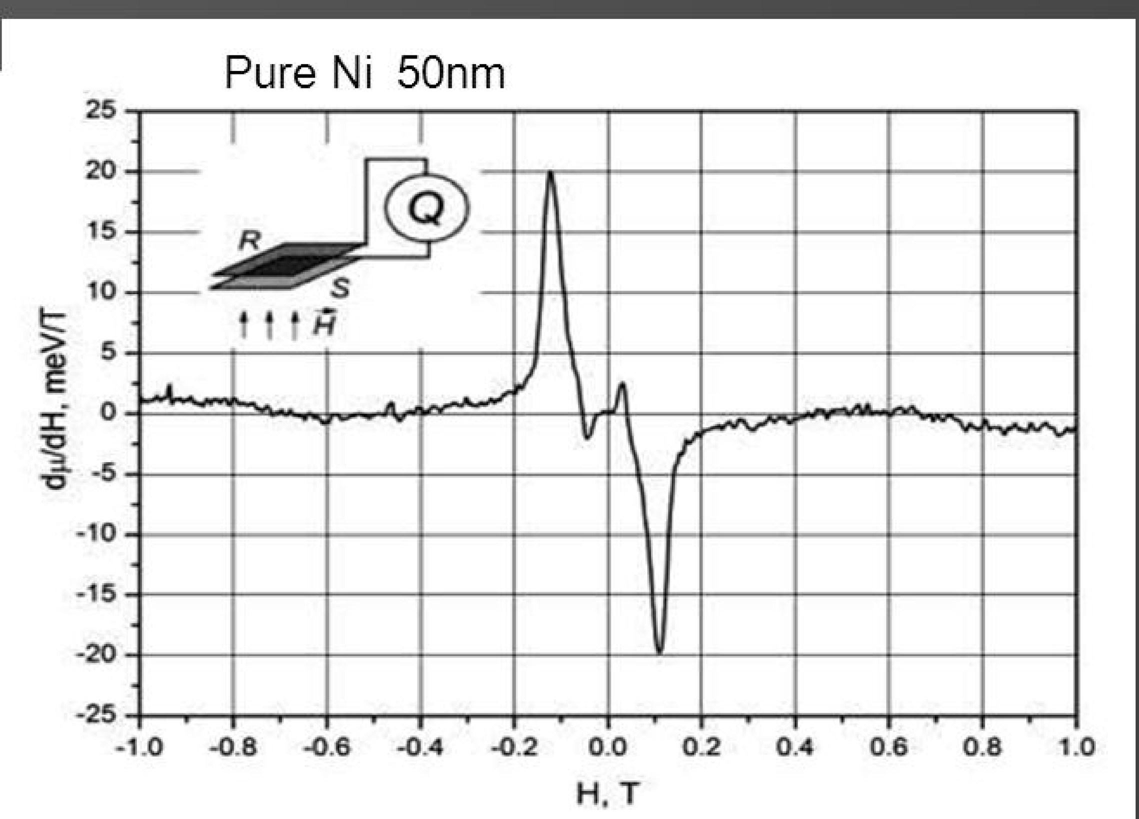
Fig. 2. a) Schematics of the dilatometric cell, b) details of the sample mounting, c) view of the cell with dimensions in mm's.





Monocrystal
$BaFe_{1.9}Ni_{0.1}As_2$

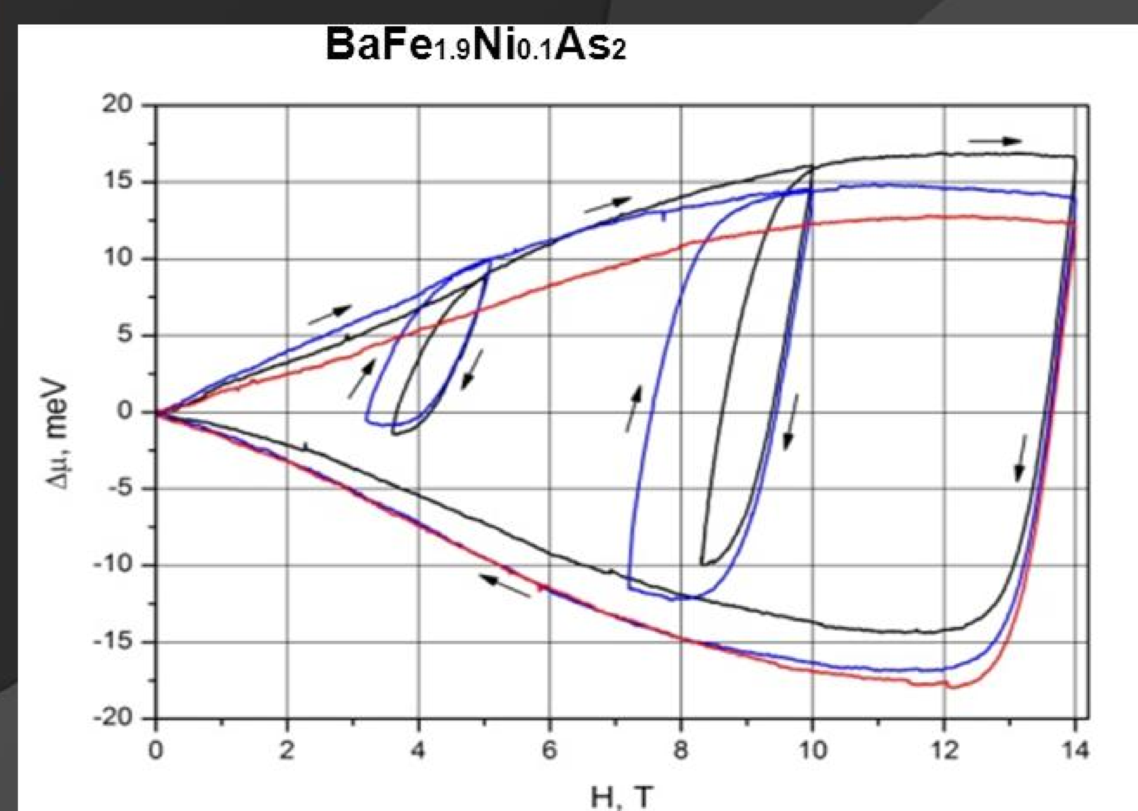


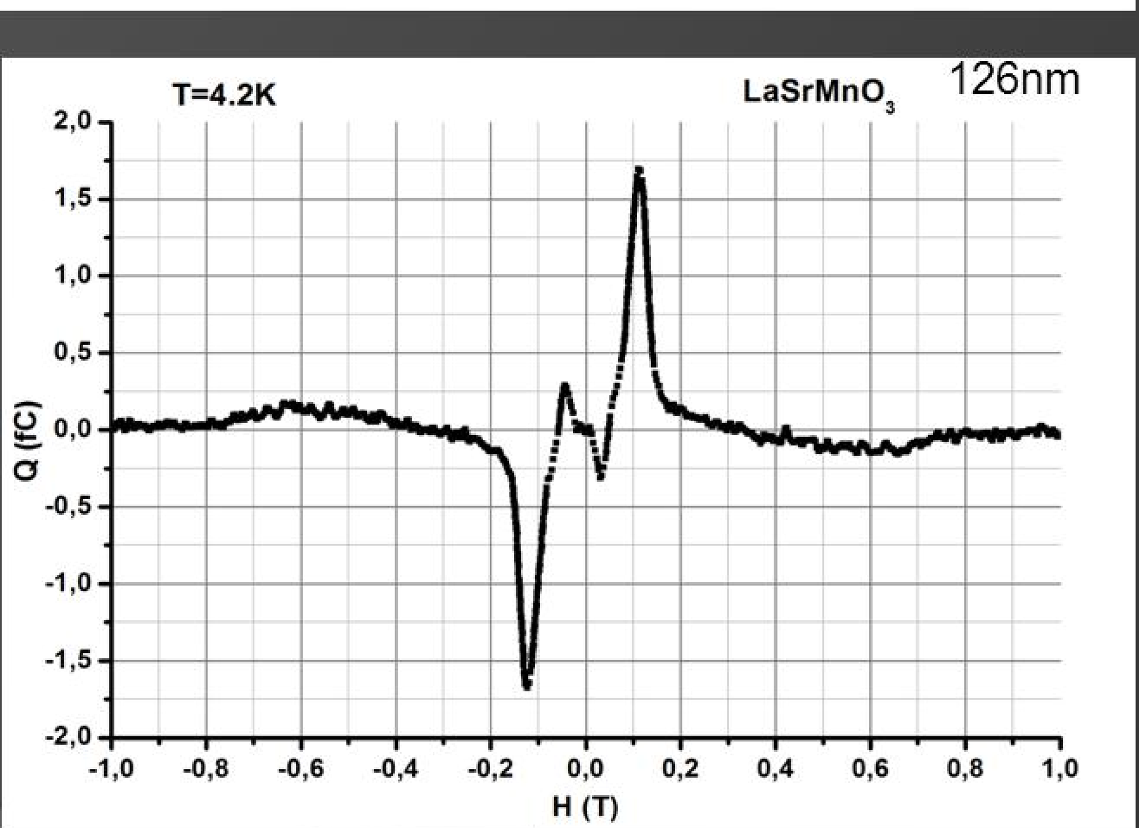


Sample:
Base: MgO
Layer: pure Ni 50nm

Magnetostriction of nickel is positive [3].

$$\varepsilon_F = \mu\,(T = 0K) \propto V^{-\frac{2}{3}}$$





Sample:
Base: LSAT = $((LaAlO_3)_{0.3}(Sr_2AlTaO_6)_{0.7})$
Layer: LSMO = $LaSrMnO_3$

Magnetostriction of manganite is negative [4].

References:

[1] V. I. Nizhankovskii, S. G. Zybtsev, Phys. Rev. B **50**, 1111 (1994).

[2] P. Przyslupski et al., Phys. Rev. B **69**, 134428 (2004).

[3] V. I. Nizhankovskii, Eur. Phys. J. B, v.53 no.1 pp.1-4 (2006).

[4] A. I. Abramovich, L. I. Koroleva, and A. V. Michurin, Journal of Experimental and Theoretical Physics, Vol. 95, No. 5, 2002, pp. 917–926.