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Polarized neutron reflectometry with secondary radiation registration

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One of the most actual problem at the physics of low-dimensional superconducting/ferromagnetic heterostructures is determination of the correlation between magnetic spatial profile and the spatial profiles of the elements at the interface between layers. Standard neutron reflectometry can't be used to measure neutron interaction with separate element, in particular, magnetic field induction. A new method allows one to determine the elemental and magnetic profiles. The reflected neutron beam and secondary radiation are simultaneously recorded in this method. Charged particles and gamma-quants can be secondary radiation because of neutron capture reaction. Also scattered neutrons and spin-flip neutrons can be secondary radiation.

At the REMUR reflectometer at the IBR-2 reactor, channels for secondary radiation registration were realized: spin flip neutrons, charged particles and gamma-quanta. Currently, a sufficiently large number of element isotopes are available for measurements. At measuring time $t = 1\,day$, resolution by the wave vector $\delta k/k = 0.1$, $\lambda = 1.5$, cross section of the beam at a sample of $0.1\,cm^2$, layer thickness 5 nm and neutron flux density at the sample of $2 \cdot 10^4\,cm^{-2}s^{-1}$ it's: a) for the charged particles registration channel, the minimum value of the cross section is $\sigma_{min} = 0.025\,barn$, the cross section $\sigma > \sigma_{min}$ has 22 isotopes; b) for the gamma-quanta registration channel, $\sigma_{min} = 0.3\,barn$, more than 100 isotopes have a cross section $\sigma > 0.3\,barn$; c) for the polarized neutrons registration channel, the minimum, perpendicular to the neutron polarization, component is 1 G.

Further progress is possible. The first is increasing of neutron intensity to 5–10 times. The second is the reduction of the fast neutrons and gamma-quanta background from the reactor core by 5-10 times. Third is increasing of the solid angle visible to gamma-ray detector by 4 times or increasing of the detectors number to 4. Realization of these improvements at the REMUR reflectometer make available cross section 1 mbarn for an absorbing layer 5 nm or cross section 50 mbarn for 1 Å layer. The spatial resolution can reach 1 Å by using super-mirror neutron reflector at the structure. In the case of studying periodic structures, high spatial resolution can be achieved by reducing the period of the structure. At nowadays technological level, structures with period 1 nm are available, which gives a value of 1-2 Å for resolution.

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