ANGULAR DIVERGENCE OF NEUTRON MICROBEAMS FROM PLANAR WAVEGUIDES

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Planar waveguides are resonant tri-layer structures transforming a conventional collimated neutron beam into a slightly divergent neutron microbeam [1] with the width about 1 – 10 μm. Such extremely narrow microbeam can be used for the investigations of quasi one-dimensional local microstructures (wires, magnetic domains, lithographic gratings, magnetic vortices) with high spatial resolution [2,3]. The neutron microbeam width depends on its angular divergence and the distance from the waveguide exit to the investigated sample. Therefore, the investigation of the neutron microbeam angular divergence is an actual task. The angular divergence of the neutron microbeam is mainly defined by Fraunhofer diffraction on a narrow slit as $\delta\alpha_f \propto \lambda/d$ where λ is the neutron wavelength and d is the width of the middle guiding layer (or channel) of the planar waveguide [4,5].

We investigated the neutron microbeam divergence $\delta\alpha_f$ as a function of the incident neutron beam divergence $\delta\alpha_i$. The experiments were done on the time-of-flight polarized neutron reflectometer REMUR at the pulsed reactor IBR-2 (FLNP JINR, Dubna, Russia). Experimental details can be found in [6]. The waveguide structure $Ni_{67}Cu_{33}$(20 nm)/Cu(150)/$Ni_{67}Cu_{33}$(50)//Si(substrate) was investigated. The substrate sizes are $1 \times 1 \times 25$ mm^3. The alloy Ni(67 at. %)Cu(33 at. %) is nonmagnetic at room temperature and has high neutron scattering length density. The grazing angle of the incident beam is equal to $\alpha_i = 0.211°$. The corresponding neutron wavelength for the resonance order n = 0 is 2.5 Å. In the experiment, we registered the neutron microbeam intensity in dependence on the final scattering angle α_f for various values of the incident neutron beam divergence. It is obtained that the angular width of the neutron microbeam peak (FWHM) of the resonance order n = 0 is linearly depends on the incident neutron beam divergence as $\delta\alpha_f = 0.096 + 4.4 \cdot \delta\alpha_i$. The reason is broadening of the spectral width of the neutron resonances with increasing of the incident neutron beam divergence [6].

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