International Conference on the Applications of the Mössbauer Effect

ICAME 2015

Hamburg, Germany
13 - 18 September 2015

Conference Programme

and

Book of Abstracts

Synchrotron Mössbauer Source for reflectivity investigations of cluster-layered $[Fe/Cr]_n$ structures revealing Kondo-like behaviour

M. Andreeva, Yu. Babanov[1], L.Romashev[1], M. Milayev, A. Korolev, B. Goloborodsky[1], D. Ponomarev[1], D. Devyaterikov[1], V. Ustinov[1], G.V. Smirnov[2], A.I. Chumakov[2,3], R. Rüffer[3]

Faculty of Physics, M.V. Lomonosov Moscow State University, Moscow 119991 Russia
[1]M.N.Mikheev Institute of Metal Physics RAS, S.Kovalevskaya 18, Ekaterinbirg 620990 Russia
[2] National Research Centre "'Kurchatov Institute", Pl.. Kurchatova, 1, Moscow 123182 Russia
[3] European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble, France

The magnetic and structural properties of the cluster-layered [Fe/Cr] multilayers revealing the Kondo-like behavior [1] were investigated by nuclear resonance reflectivity in a wide range of low temperatures and applied magnetic fields using the Synchrotron Mössbauer Source (SMS) [2] recently installed at the Nuclear Resonance beamline (ID18) of the ESRF.

The Al_2O_3/Cr(70 Å)/[^{57}Fe(1.2 Å)/Cr(10.5 Å)]$_{30}$/Cr12 Å and Al_2O_3/Cr(70 Å)/[^{57}Fe(2.1 Å)/Cr(10.5 Å)]$_{30}$/Cr(12 Å) samples (having the thinnest ^{57}Fe layers) did not show any periodicity in the reflectivity curve, and they were studied by measurements of the Mössbauer spectra of reflectivity slightly below the angle of the total external reflection. These two samples are not magnetic at room temperature (RT), but the spectra measured at 4 K reveal the appearance of the ferromagnetic ordering: We observe the successive enhancement of the 2nd and 5th lines with the field increase in the transverse-field (perpendicular to the x-ray beam) geometry, and the successive suppression of these lines in the longitudinal geometry. Therefore, their Kondo-like behavior is not explained by the antiferromagnetic interlayer coupling of the ^{57}Fe layers as it could be supposed a priori.

The Al_2O_3/Cr(70Å)/[^{57}Fe(8Å)/Cr(10.5Å)]$_{30}$/Cr(12Å) and Al_2O_3/Cr(70Å)/[^{57}Fe(8Å)/Cr(20Å)]$_{30}$/Cr(12Å) samples (with the thicker ^{57}Fe layers) are magnetic even at RT. The angular dependences of the nuclear resonance reflectivity were measured by integrating the reflectivity spectra over the velocity range of about ±10 mm/s. The reflectivity curves show the Bragg peaks of the first order and, in addition, the ½-order Bragg peaks of almost pure nuclear nature confirming the doubling of the magnetic period (Fig. 1). For the second sample having the 20 Å-thick Cr spacer it is surprising. The enhancement of the 1st and 6th lines for the weak fields suggests the spin-flop effect [3]. For the stronger field, the system shows the ferromagnetic magnetization of the entire sample, and the "magnetic" (½-order) maximum in the reflectivity curve disappears. The specific (satellite-like) feature in the "nuclear" reflectivity curve near the 1st-order Bragg peak will be studied further.

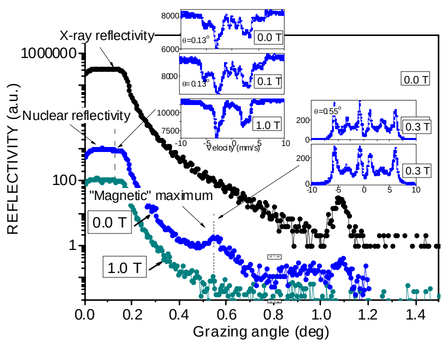

Figure 1: The X-ray and nuclear reflectivity curves measured for the [^{57}Fe(2.1 Å)/Cr(10.5 Å)]$_{30}$ sample without the external field and with the external field applied perpendicular to the beam direction. In the inserts: the Mössbauer spectra of reflectivity measured at the critical angle and at the "magnetic" (½-order) maximum.

The support from RFBR grants (No. 09-02-01293-a and No. 15-02-01502-a) is thankfully acknowledged.

References

[1] V. V. Ustinov, L. N. Romashev, M. A. Milayev, *et al.*, *JMMM* **300**, 148-152 (2006).
[2] V. Potapkin, A. I. Chumakov, G. V. Smirnov, J.-P. Celse, *et al.*, *J. Synchrotron Rad.* **19,** 559 (2012).
[3] J. Meersschaut, C. L'abbé, F. M. Almeida, et al., Phys. Rev. B **73**, 144428-1-7 (2006).