Local atomic structure Fe/Cr multilayer films with Kondo effect

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Introduction. For a long time the Kondo problem attracts continuing interest from theoreticians and experimentalists. The crucial point in the theory is the interaction between spins of conduction electrons with the magnetic moments (including orbital ones) of impurities, quantum dots, clusters on the surface, etc., which increases with decreasing temperature. 10 years ago we found that the cluster-layered [Fe/Cr]n multilayers exhibits a Kondo-like behavior [V.V. Ustinov, L.N. Romashev, *et al*. Kondo-like effect in the resistivity of the superparamagnetic cluster-layer Fe / Cr nanostructures // JMMM, 300 (2006) 148-152.]: the electrical resistivity has a minimum at certain temperature and increases by a factor of 20 when the temperature decreases up to ~2 K. The effect significantly depends on the Fe layer thickness and applied external field.

A conventional EXAFS analysis fails to answer the questions about the local structures of these systems, and, perhaps, the regularization method is the only one that can be useful here. We are going to give the answer the question: how can the regularization method provide more information than a conventional EXAFS analysis, given that the challenges (similarity in scattering properties of Cr and Fe photoelectrons) are inherent to the data and, thus, will limit any analysis method.

Methods. The local atomic structure of a Fe-Cr material can be described by three partial pair correlation functions (pPCFs): $g_{CrCr}(r)$, $g_{CrFe}(r) \equiv g_{FeCr}(r)$, and $g_{FeFe}(r)$. The function $g_{ij}(r)$ is the probability to find atom *j* at the distance *r* from the central atom *i*, by definition. The regularization method of solving ill-posed problem is used to determine three pPCFs $g_{ij}(r)$ by combining two Cr and Fe K EXAFS spectra for Fe/Cr sample. The main feature of this system is overlapping coordination spheres. The problem reduces to solving a system of two linear integral Fredholm equations with three unknown functions.

Results and discussion. 3 samples have been studying: cluster-layered nanostructures Al_2O_3/Cr(70Å)/[^{57}Fe(1,2Å)/Cr(10,5Å)]$_{30}$/Cr(12Å) (K1); Al_2O_3/Cr(70Å)/ [Fe(1,2Å)/ Cr(10,5Å)]$_2$ / Cr(12Å) (K2); and a sample of solid solution Al_2O_3/Cr(63Å)/$Fe_{0.17}$ $Cr_{0.83}$/Cr(24Å) (SS) which demonstrates Kondo-like effect. All samples are obtained in ultrahigh vacuum by the method of molecular beam epitaxy (MBE). Investigations of the physical properties of Fe / Cr nanostructures have been performed on modern scientific equipment. The EXAFS spectra for Cr and Fe K-absorption edges at room temperature has been measured using synchrotron facilities (National Research Centre "Kurchatov Institute").

Conclusion. All partial characteristics (interatomic distances, coordination numbers) of the local atomic structure Fe/Cr multilayer films have been obtained.

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