Nanoscale physics

Percolation magnetism in ferroelectric nanoparticles

Iryna S. Golovina[1] , Sergiy V. Lemishko[1], Anna N. Morosovska[2]

[1] *Institute of Semiconductor Physics, National Academy of Sciences of Ukraine, pr. Nauky 41, 03028 Kyiv, Ukraine*
E-mail: sleeper1986@ukr.net

[2] *Institute of Physics, National Academy of Sciences of Ukraine, pr. Nauky 46, 03028 Kyiv, Ukraine*

In the present work, magnetic properties of ferroelectric nanoparticles are studied. $KTaO_3$ and $KNbO_3$ nanocrystals were synthesized by oxidation of metallic tantalum and niobium in molten potassium nitrate with the addition of potassium hydroxide. While these compounds are nonmagnetic in bulk, they exhibit a weak ferromagnetism on a nanoscale level.

Our approach is based on the percolation of magnetic polarons. It describes the formation of surface magnetic clusters (polarons) in which an exchange interaction between randomly situated magnetic impurity Fe^{3+} ions occurs indirectly via nearest K^+ ions and/or oxygen vacancies V(O). The dependence of effective exchange radius R_{ex} on the concentration n of the magnetic defects is determined in the framework of percolation theory. Appeared that the dependence is well-described by the formulae , where the values of the constants a 2.7 nm and b 1.5 nm depend on the defect radius. It is established that the real magnetic exchange radius cannot be smaller than 3.46 nm for $KTaO_3$ and 1.31 nm for $KNbO_3$. Experimentally measured magnetic hysteresis loops are well-described using two shifted Langeven-type formulas. Magnetization saturation value M_S depends on the magnetic moments S_1, S_2 of Fe^{3+} and V(O) respectively and on their amounts N_1, N_2 in the infinite cluster as $M_S S_1 N_1 S_2 N_2$, that is in a complete agreement with Ref.[1]. Theoretical calculations adequately describe the experimental results obtained in $KTaO_3$ and $KNbO_3$ ferroelectric nanocrystals.

1. *L. Sangaletti, F. Federici Canova, G. Drera, G. Salvinelli, M. C. Mozzati, P. Galinetto, A. Speghini, and M. Bettinelli*, Magnetic polaron percolation on a rutile lattice: A geometrical exploration in the limit of low density of magnetic impurities // Phys. Rev. B 80, 033201 (2009).