Magnetic properties of $Zn_{1-x}Mn_xO$ and $Zn_{1-x}Co_xO$ nanoparticles synthesized by solvothermal method

Myroslava Omelchenko[1], Jacek Wojnarowicz[2], Jaroslaw Rybusinski[1], Andrzej Majhofer[1], Andrzej Twardowski[1], Witold Lojkowski[2]and Jacek Szczytko[1]

[1]*Institute of Experimental Physics, Faculty of Physics, University of Warsaw, Pasteua 5 02-093 Warsaw, Poland*
[2]*Institute of High Pressure Physics, Polish Academy of Sciences, Sokolowska 29/37, 01-142 Warsaw, Poland*

E-mail: Myrosava.Omelchenko@fuw.edu.pl

Recently, transition metal doped II-IV semiconductor nanoparticles with luminescent and magnetic properties attracted interest in spintronic, optoelectronics, photocatalysis and biol-med applications. Among all these materials ZnO stand out due to its biocompatibility and biodegradability. ZnO can be considered as a suitable optoelectronic and photocatalytic material with a wide band gap (3.37 eV) and a high exciton binding energy (60 meV). Theoretical calculations have predicted that ZnO-based DMS, such as V-, Cr-, Fe-, Co-, Ni [1] and Mn –doped ZnO compounds [2] can exhibit ferromagnetic behavior without any additional doping to increase the band electron concentration.

In view of that magnetization of ZnO:Co and ZnO:Mn nanoparticles was studied as a function of magnetic field (up to 7 T) and temperature, in the range 2 K < T < 300 K.
Zinc oxide based nanoparticles, i.e. $Zn_{1-x}Mn_xO$ ($0 \leq x \leq 3\%$) and $Zn_{1-x}Co_xO$ ($0 \leq x \leq 13\%$) were synthesized by solvothermal method [3] and characterized by X-ray diffraction (XRD), specific surface area (SSA), inductively coupled plasma optical emission spectroscopy (ICP-OES), extended X-ray absorption fine structure spectroscopy (EXAFS), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS). Pure ZnO wurtzite structure with no other crystalline phases was detected. The average size of nanoparticles was found to be about 20 nm.

Magnetization of lightly doped ZnO, namely with x < 1% of Mn or Co, reveals paramagnetic, Brillouin-type behavior. The data can be reasonably well described by effective Brillouin function, assuming antiferromagnetic interactions between Mn and Co ions incorporated into ZnO lattice. On the other hand for samples with higher concentration of magnetic dopands (i.e. x > 1%), a ferromagnetic-type (FM) contribution to the measured magnetization is clearly visible.

For the samples with the highest Mn and Co concentration hysteresis of magnetization is observed, as well as its history dependence (difference between Zero Field Cooled and Field Cooled magnetization).

Possible origin of the observed FM behavior will be given.

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