Ferromagnetic Nanomaterials: Synthesis and Properties

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The physical and chemical properties of ferromagnetic materials significantly change during the transition to the nanoscale, which is very important, both from a scientific and practical point of view [1].

This study deals with the synthesis and investigation of three types of ferromagnetic nanomaterials: M-type barium hexaferrite, ferrites with the spinel structure and lanthanum-strontium manganites with the perovskite structure.

It was investigated the effect of the fractal structure on the phase composition and physic-chemical properties of M-type barium hexaferrite nanoparticles, synthesized by precipitation from the solutions and via sol-gel method. The conditions at which the amorphous nanoparticles form the three-level complicated fractal structure, that allow obtaining the weakly agglomerated monodisperse crystalline nanoparticles, were determined. It was shown the possibility to control the shape of Ba-hexaferrite nanoparticles (plates and rods).

$A Fe_2O_4$ ferrite nanoparticles (A = Mn, Fe, Co, Ni, Zn) and based on them core/shell structures were synthesized by different methods (precipitation from diethylene glycol solution and microemulsions, criochemical method). Weakly agglomerated nanoparticles with particle size 3 – 15 nm and superparamagnetic properties were obtained. It was shown the possibility to effect on the magnetic properties of nanoparticles by the formation of the core/shell structures.

Weakly agglomerated crystalline nanoparticles of heterosubstituted $La_{1-x}Sr_xMnO_3$ manganites with the narrow size distribution and the average size 30 – 40 nm were synthesized via sol-gel method [2].

Based on the synthesized ferrite nanoparticles with the spinel and perovskite structures magnetic fluids were developed. They heat up effectively under the action of an alternating magnetic field. It was shown that obtained fluids are compatible with living organisms and are of particular interest for their possible application in medicine as the inducers of hyperthermia treatment.

The film-forming solutions for obtaining nanocrystalline thin films of M-type Ba-hexaferrite were created. Thin films with uniform distribution of Ba^{2+} and Fe^{3+} ions in the film volume with the thickness 200 nm, rod-liked grains ($d_{av.}$, $l_{av.}$= 62 nm, 320 nm, $l_{av}/d_{av.}$= 5) and high level of magnetic characteristics were obtained by "spin-coating" method.

Based on thick films of Ba-hexaferrite and Ni-ferrite with the spinel structure magnetic resonant microwave elements were developed. They include α-Al_2O_3 high-Q dielectric resonator and thick ferrite film. It was shown that obtained elements might be perspective for application in the microwave equipment.

Based on ferroelectric-semiconductors and $La_{1-x}Sr_xMnO_3$ ferromagnetic film heterostructures in which magnetic properties may be effected by the electromagnetic field, were created for the first time.

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[2] S.O. Solopan, O.I. V'yunov, A.G. Belous, T.I. Polek, A.I. Tovstolytkin, Effect of nanoparticles agglomeration on electrical properties of $La_{1-x}A_xMnO_3$ (A = Sr, Ba) nanopowders and ceramic solid dolutions, *Solid State Sci.* **14** (2012) 501 – 505.