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Magnetic nanoparticles of core-shell structure

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Graphical abstract

Highlights
> comparative studies of nanoparticles properties dependence on the internal layered structure are presented;
> physical and chemical properties dependence on the layers composition are shown;
>properties modulations as a interlayer thickness effect are discussed.

Abstract

This paper describes preparation and characterization of magnetic core-shell nanoparticles with modulated magnetic core diameter and various thickness of the non-magnetic shell. Ag, Au and Cu are used as spacing layer metals. Nanoparticles were fabricated by the synthetic method based on modified seeds. During the preparation, the thicknesses of the core and shell were changed to control the influence of nanoparticles' magnetic properties in respect to the composition and thickness of the spacer material. Obtained nanoparticles were examined by X-ray diffraction, Transmission Electron Microscopy, Infrared spectroscopy and Differential Scanning Calorimetry. Magnetic properties of the nanoparticles were tested by Mössbauer spectroscopy.

Keywords: core-shell nanoparticles, Mössbauer spectroscopy, X-ray diffraction, magnetite, Infrared spectroscopy

1. Introduction

Intense and continuously growing interest in the fabrication of core-shell nanoparticles has been observed in recent years [1]. It is connected with the fact that unique properties in such kind of nanoparticles can be achieved. Core-shell nanoparticles can combine, for example, magnetic properties of the core and optical properties of the shell, which was observed in the case of Au nanoparticles [2]. It is particularly interesting to study amazing sensitivity of the properties to the changes of the particles' internal structure. One of the examples is exchange-bias effect which causes elevation of the Curie temperature of the system [3]. This feature can be used in the production of new, more suitable for particular applications materials. Studies on the dependence between the composition of the core and shell and such properties as, for example, superparamagnetism, allow to plan fabrication of nanomaterials with well controlled physicochemical properties [4].

The synthesis of layer-by-layer grown particles allows for the approximation of properties and composition of magnetic nanoparticles (MNP) by the addition of each consequent layer [5]. The application of ^{57}Fe Mössbauer spectroscopy (MS) helps in a very fine description of ^{57}Fe hyperfine structures in nanoparticles. Extremely sensitive experiments