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Structural and magnetic studies of thin Fe^{57} films formed by ion beam assisted deposition

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ABSTRACT

Thin Fe^{57} films with the thickness of 120 nm have been prepared on glass substrates by using the ion-beam-assisted deposition technique. X-ray diffraction, electron microdiffraction and Mössbauer spectroscopy studies have shown that as-deposited films are in a stressful nanostructured state containing the nanoscaled inclusions of α-phase iron with the size of ~10 nm. Room temperature in-plane and out-of-plane magnetization measurements confirmed the presence of the magnetic α-phase in the iron film and indicated the strong effect of residual stresses on magnetic properties of the film as well. Subsequent thermal annealing of iron films in vacuum at the temperature of 450 °C stimulates the growth of α-phase Fe crystallites with the size of up to 20 nm. However, electron microdiffraction and Mössbauer spectroscopic data have shown the partial oxidation and carbonization of the iron film during annealing. The stress disappeared after annealing of the film. The magnetic behaviour of the annealed samples was characterized by the magnetic hysteresis loop with the coercive field of ~10 mT and the saturation magnetization decreased slightly in comparison with the α-phase Fe magnetization due to small oxidation of the film.

1. Introduction-

At present the synthesis and study of nanostructured materials are of high scientific and practical interest because they exhibit properties that are substantially different from the properties of single-crystal or bulk polycrystalline samples [1–3]. The development of new methods for the formation of nanostructured materials and the study of the effect of size effects (nanostructuring) on properties of the material is a topical problem.

Ion-beam and ion-plasma methods of the deposition of thin films and coatings should be separated among the variety of methods for producing nanostructured materials, since they are the most technologically advanced and easily controllable. It is possible to produce films and coatings with a wide range of structural characteristics, different phase structures and physical and performance properties by varying such parameters as the deposition rate, substrate temperature, composition of the reaction gas, composition of the sputtering target, etc. Earlier we used these techniques to synthesize and modify diamond-like carbon films [4,5], to form silver nanoparticles in the silica glass matrix [6,7], to prepare nanocomposite films of barium titanate-based multiferroics with magnetic cobalt nanoparticles [8], to fabricate thin germanium layers on silicon [9,10] and nanostructured ZnO and Al_2O_3 films [11]. The characteristic feature of above-listed single-elemental or composite films and layers is the nanocrystalline structure (when the dimensions of the crystallites of different phases are in the nanometer range), which determines their optical, magnetic and electro-physical properties.

In the past decade, interest in magnetic thin films of pure 3d-metals (in particular to iron films) have experienced a tremendous boost due to the high potential of thin-film magnetic heterostructures for existing and emerging technological applications [12]. Different techniques such as thermal evaporation in ultra-high vacuum [13], magnetron sputtering [14], electrodeposition [15] etc. [16,17] are used usually to produce thin iron films on the different substrates. However the application of the ion-beam-assisted deposition technique (IBAD) for the preparation of thin films of pure iron is of special interest. Unlike above methods, in the IBAD technique the material of iron film deposited on the substrate is

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