A role of carbon in formation of structure and magnetic properties of hybrid Ni@C-films

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Hybrid nanomaterials with the metal encapsulated in a carbon cover (Me@C) attracts attention of researchers in recent years. The methods of obtaining the Me@C structures require high temperatures [1]. In present work the method of obtaining the similar materials without the high temperatures is proposed a method of magnetron deposition.

The purpose of the present work is to obtain the nickel ferromagnetic nanoparticles and hybrid Ni@C-films protected by a carbon cover, and to investigate their structure, magnetic properties and modification at heating in growing process.

Nanostructure hybrid Ni@C-films were grown by a method of magnetron sputtering of composite graphite-nickel target. Series of films of Ni@C system at a variation of carbon concentration in a range of 10…50 at. % and substrate temperature T_S in a range of 30…300 C have been grown up.

The AFM-image of a film surface in Ni@C system after a 10-second sputtering is the surface is practically in regular intervals filled by cluster elements from 8 to 15 nm in size. Thus, it is possible to conclude, that for Ni@C system under the given magnetron sputtering the nucleation prosesses have a cluster character: clusters of sputtered material of nanometer in size already formed in plasma are deposited on a substrate surface [2].

The measurement of saturation magnetisation $4\pi MS$ in Ni-C-films confirmed, that at Ni@C-clusters material there is nitrogen. Hence, in Ni@C-clusters it is possible to explain specific behaviour of $4\pi MS$ not only by dimensional effect, but also by formation of solid solution of carbon in nickel with increasing in parameter of a Ni-crystal lattice. Thus obviously, magnetic ordering in Ni@C-clusters is broken already at their big enough size.

[1] *El Mel A., Gautron E.,* Synthesis of nickel-filled carbon nanotubes at 350°C // CARBON.-2011.-**49**.-4595.

[2] *Kashtanov P., Smirnov B.,* Magnetron plasma and nanotechnology // Phys. Usp.-2007.-**50**.- P.455–488.