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Co/Fe/CoFe- SiO_2 Thin Films Prepared by Magnetron Sputtering

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Magnetic and electrical properties of magnetic nanostructures are under intensive study due to their promising technological applications such as magnetic data storage, extra-high-frequency (EHF) switches, photonic materials etc. These nanostructures, either in nanolayered [1] or granular [1-4] form, show giant magnetic resistance (GMR), giant magnetic impedance (GMI), and giant Hall (GHE) effects. These phenomena reveal the remarkable change of resistance/impedance of the specimen at rather small applied static magnetic fields. Nanolayers have been studied more widely, since they could be approximated by the quasi-2D geometry.

Co/Fe/CoFe-SiO_2 nanostructured thin films were prepared by dual radiofrequency magnetron sputtering in argon. The deposition experiments were carried out in a vacuum chamber with base pressure $6x10^{-4}$ Pa at room temperature. The growth rates were 2.22 nm/min, 3.76 nm/min, and 1.48 nm/min for Fe, Co and SiO_2, respectively. The multilayer films were deposited by target alternating. The layers containing metallic nanoparticles with calculated thickness 3, 5 and 10 nm were separated by 10 nm SiO_2 layers. Films of ten metallic ultrathin layers on Si(100) were studied by SQUID, PPMS (physical properties measurement system), MOKE (magneto-optic Kerr effect) and MS, XRD, and XPS. For TEM analyses of plan view, samples composed of only one metallic layer surrounded by two SiO_2 films deposited on NaCl substrate were prepared.

The nanostructured thin films consist of metallic (Co, Fe and CoFe) nanoparticles embedded in amorphous SiO_2 matrix (Fig. 1). The size of particles corresponds to the calculated values according to the growth rates - 3, 5, and 10 nm. Bigger particles are formed at longer sputtering times. The volume ratio of amorphous matter, calculated from the image analysis of the plan view micrographs, does not agree with the theoretical values calculated for the expected thickness due to inhomogeneity of the film which is in fact composed of three layers (SiO_2-Co/Fe/FeCo-SiO_2). However, it exhibits the same trend as the expected ratio which suggests crystallization of all metal atoms or only very limited metal content in the amorphous SiO_2. This is confirmed by Mössbauer spectroscopy results which show max. 5% of amorphous Fe in the FeCo films. All measurements display influence of the magnetron sputtering process parameters on the structural and morphological properties of the nanostructured thin films.

References

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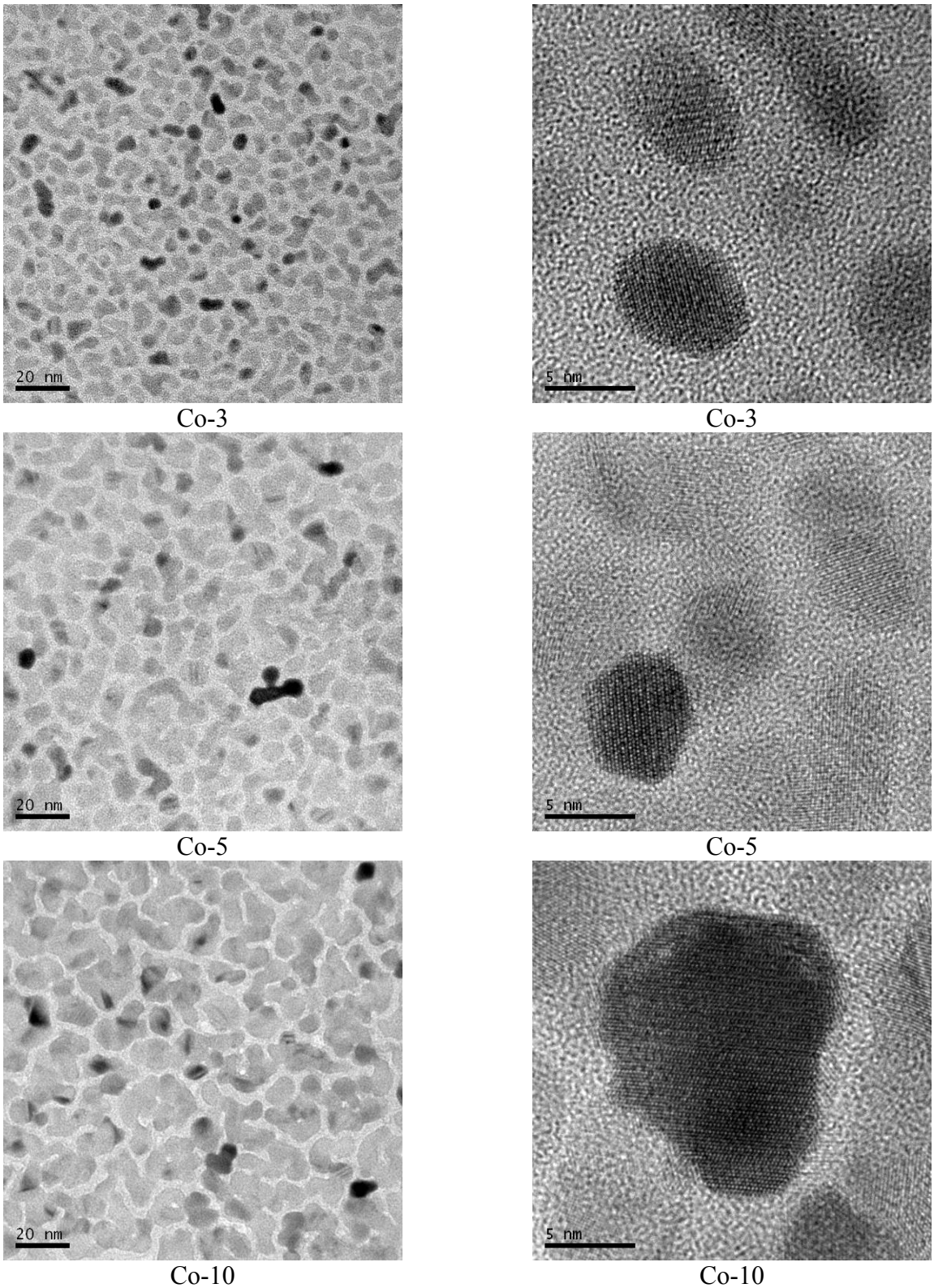

FIG. 1. TEM micrographs of the structure of SiO_2-Co thin films in plan view. Samples contain crystalline Co nanoparticles embedded in amorphous SiO_2 matrix.

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