Self-Assembled Magnetically Isolated Co Nanoparticles Embedded Inside Carbon Nanotubes

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Abstract. We investigate the influence of carbon nanotubes (CNTs) aligned array on the magnetic properties of an ensemble of densely packed Co nanoparticles (NPs) embedded inside CNTs. Samples are synthesized by chemical vapor deposition activated by current discharge plasma and hot filament. Each CNT contained only one NP of Co, which had preliminarily been formed on the surface of the SiO2/Si substrate. Co NPs are elongated along the CNT axis. The reference Co NPs ensemble and Co NPs embedded inside CNTs behave differently in a magnetic field. In the former case, Co NPs are strongly coupled by the dipole–dipole interaction (DDI); the easy axis plane is oriented parallel to the substrate. For Co-CNT samples, Co NPs are magnetically isolated. The reason for suppressing the contribution of the DDI is the magnetic anisotropy. It increases significantly because of the peculiar morphology of Co embedded in CNT and stresses. We evaluate the values of shape, magnetocrystalline, and magnetoelastic anisotropy constants. The magnetoelastic anisotropy is estimated for both the crystalline structures of Co, fcc and hcp, observed in Co NPs. The maximum stresses are reached in the case of hcp Co, when the hexagonal axis is oriented along the radial CNT direction. The influence of stresses onto the magnetic structure of Co inclusions is investigated by the micromagnetic simulations.

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