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The Structural and magnetic properties of ordered arrangements of magnetic nanoparticles

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Magnetic nanoparticles and their assembly in highly ordered structures are fundamentally interesting regarding the understanding of magnetic interactions and for a rational design towards potential applications in information technology as e.g. magnetic data storage media or as material for spintronics. With regard to these applications, the main aspects of fundamental interest include magnetic anisotropy, Van-der-Waals forces and interparticle interactions leading to aggregation or even ordered assemblies of nanoparticles.

In order to obtain long-range ordering between magnetic nanoparticles in two and three-dimensions, we use pre-patterned substrates with a feature-size of the same order of magnitude as the diameter of the nanoparticles.
A part of this work focuses on the structural and magnetic characterization of monolayers of CoFe2O4 nanoparticles on silicon substrates. The system was characterized laterally by Scanning Electron Microscopy (SEM) and Grazing Incidence Small Angle X-ray Scattering (GISAXS) at the laboratory high brilliance GALAXI instrument [1] with simulation using the BornAgain software [2]. We deduce both the height profile of the individual nanoparticles, and a hexagonal ordering between the nanoparticles. Macroscopic magnetization measurements and polarized neutron reflectometry on a MARIA reflectometer [3] were used to find that the nanoparticles are weakly magnetized with respect to bulk CoFe2O4 and that a random in plane relative orientation of the nanoparticle magnetizations is obtained at zero applied field.
Also, we report on the structural characterization of pre- patterned silicon substrates. And the structural characterization of silica and magnetic nanoparticles that are self-assembled from toluene-based dispersions on flat and pre-patterned substrates laterally by Scanning Electron Microscopy (SEM) and vertically by Grazing Incidence Small Angle X-ray Scattering (GISAXS). Simulation and data analysis is performed using the Born Again software [2].
References
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