UNIVERSITÉ DU LUXEMBOURG

Physics seminar

Tuesday 28th June 2011 at 16h15
(coffee at 16h00)

Belval
Room F.0.1.1

Talk by Prof. Dr. M. Farle
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Influence of nanoparticle shapes and morphologies on magnetic hardness

Correlating the electronic structure and magnetic response with the morphology and crystal structure of the same single ferromagnetic nanoparticle has been up to now an unresolved challenge. Here, I will present measurements of the element-specific electronic structure and magnetic response as a function of magnetic field amplitude and orientation for chemically synthesized single Fe nanocubes with 20 nm edge length.

The hysteresis loop of a single Fe nanocube [1] with 20 nm edge length was recorded by x-ray photo electron emission microscopy (XPEEM) [2] along different crystallographic directions. The important role of roughness on the shape, coercive field and angular dependence of the hysteresis loop is evaluated by a detailled analysis using OOMF simulation. For the OOMF simulation we use the morphological parameters measured for a nanocube by three-dimensional tomography in the transmission electron microscope as shown in the attached figure. We find by comparing an idealized cuboid with no roughness to one with a roughness of 1-2 nm as taken from the 3D tomography, large differences in the magnetic reversal behavior of the magnetization vector. By analyzing the x,y, and z components we identify and visualize non-collinear states of the magnetic moments in the cuboid. As a result we find good agreement with the experimental hysteresis loop of a single real (not idealized) cuboid being able to explain some unexpected shape of the hysteresis and a very small coercive field.

In addition, we present hysteresis loops of two nanocubes [3] in a row interacting via magnetic dipolar forces. The hysteresis loop is shifted with respect to the magnetic field axis, indicative of a unidirectional magnetic anisotropy or the presence of magnetic stray fields from neighboring Fe particles. By careful analysis we can eliminate both possibilities as the origin for the shift of the hysteresis loop. While no final explanation can be given at present, the preliminary analysis indicates a complex influence of the magnetic dipolar coupling.

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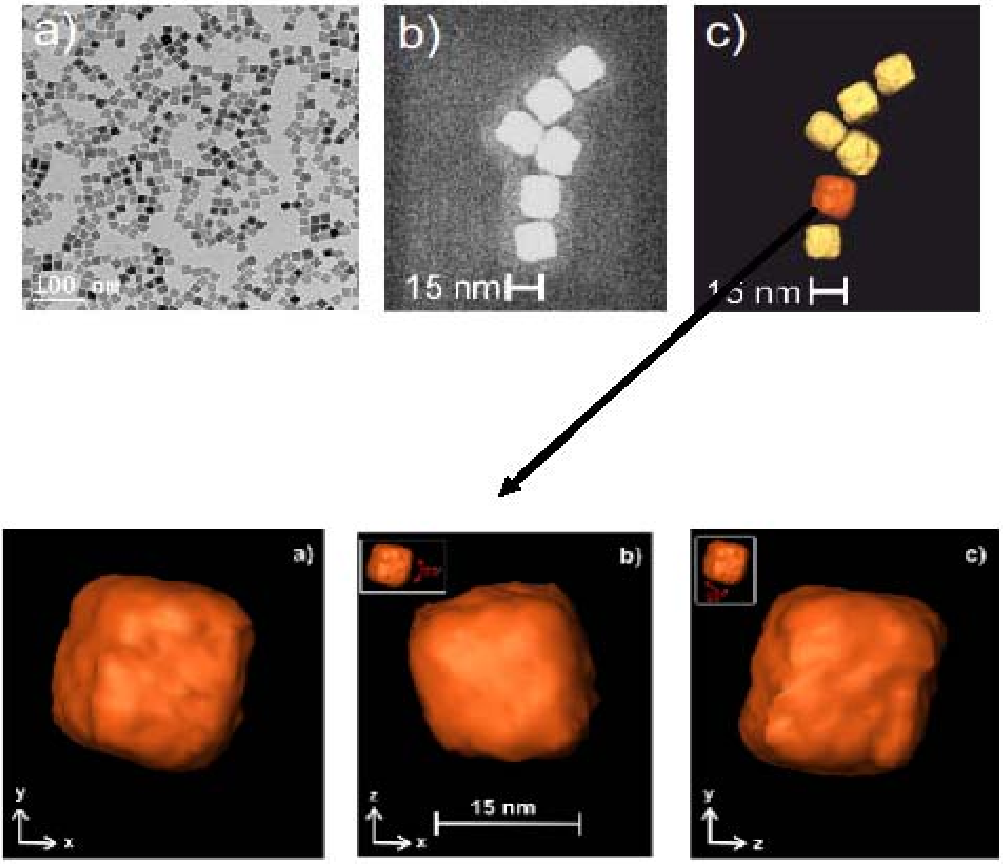
References:

[1] A. Shavel, B. Rodríguez-González, M. Spasova, M. Farle, L.M. Liz-Marzán,. Advanced Functional Materials 17, 3870-3876 (2007)
[2] F. Kronast, J. Schlichting, F. Radu, S. Mishra, T. Noll, H.A. Dürr, Surface and Interface Analysis 42, 1532-1536 (2010)
[3]F. Kronast et al. Nano Letters 11 (4), pp 1710-1715 (2011)

Figure 1:



x = 19 nm ± 2 nm
y = 22 nm ± 2 nm
z = 20.5 nm ± 2 nm

3D – Tomography of Fe nanocubes