Ferrite nanoparticle chains studied using electron holography combined with magnetic force microscopy

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Nanoparticle chains are studied to push back the superparamagnetic limit. In this context, ferrite nanoparticles have been prepared by thermal decomposition and deposited on a C-membrane in a magnetic field gradient to form chains. The same objects have been observed by off-axis holography, magnetic force microscopy and high resolution transmission electron microscopy. Off-axis holograms have been recorded before and after reverse of the sample. The holography gives access to the magnetic component in the grid plane, whereas the magnetic force microscopy gives access to the perpendicular component. The individual 3D-magnetic configurations were so determined. The crystallographic orientations of the same particles were deduced from high resolution electron microscopy images. Some micromagnetic calculations were finally performed to understand the results.

Magnetic force microscopy showed a non-uniform magnetization component perpendicular to the plane. The electron wave phase was calculated from holograms using the GPA packing. The in-plane magnetic components of the magnetization, deduced through derivation of the phase difference, also rotate along the chain.

Using HRTEM, the individual particles were found to be truncated octahedral with (111) facets close to a regular hexagon. They share in majority a (111) facet with their neighbours and their axis perpendicular to the membrane is either [110] or [11-2]. Few of them are [111] oriented and induce defects in the chain.