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JÜLICH FORSCHUNGSZENTRUM

CORRELATION OF MAGNETIC PROPERTIES, CHEMICAL COMPOSTITION AND ATOMIC STRUCTURE OF Fe/Fe-O NANOCUBES.

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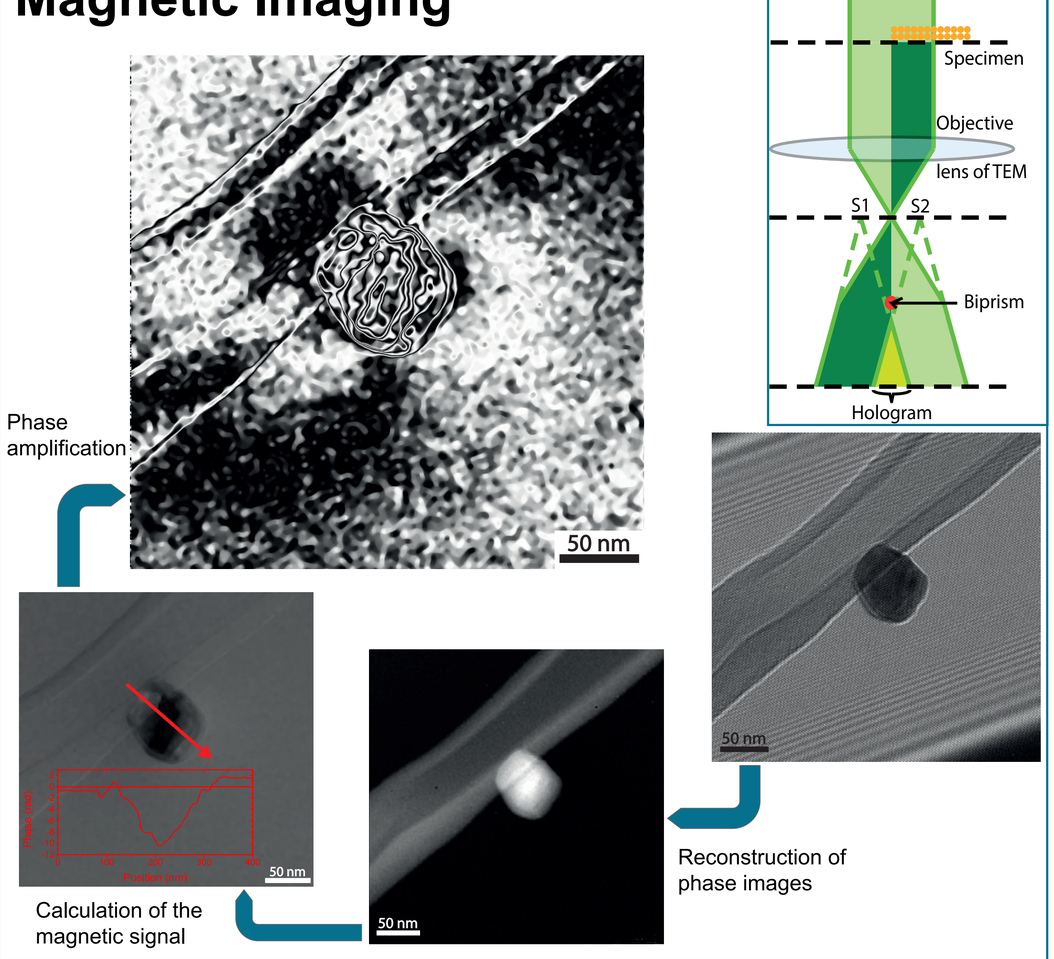
Introduction

- Magnetic Fe/FeO_x nanocubes find numerous applications in spintronics, sensorics, magnetic manipulations, and biomedicine;
- Modifications of their morphology and atomic structure enables possibility to tune the magnetic properties for particular applications;
- It has been recently shown that the nanocubes after reduction of the oxide using hydrogen plasma treatment shows 30% reduction with respect to the bulk value of the saturation magnetization M_s = 1.2 x 10^6 A/m [1]

Magnetic Imaging



Conclusions

- The remanent magnetization estimated from holographic images is $M_R \approx 2 \times 10^5$ A/m;
- Low remanence might be a sign of complicated magnetic state;
- Non-uniform magnetization in the remanent state confirms observed decrease of magnetocrystalline anisotropy [1,3] which might be due to the recrystallization after the plasma treatment.

Acknowledgements

- Authors thank Horst Zähres and Dieter Schädel for technical help;
- The work was funded by German Research Foundation (DFG)

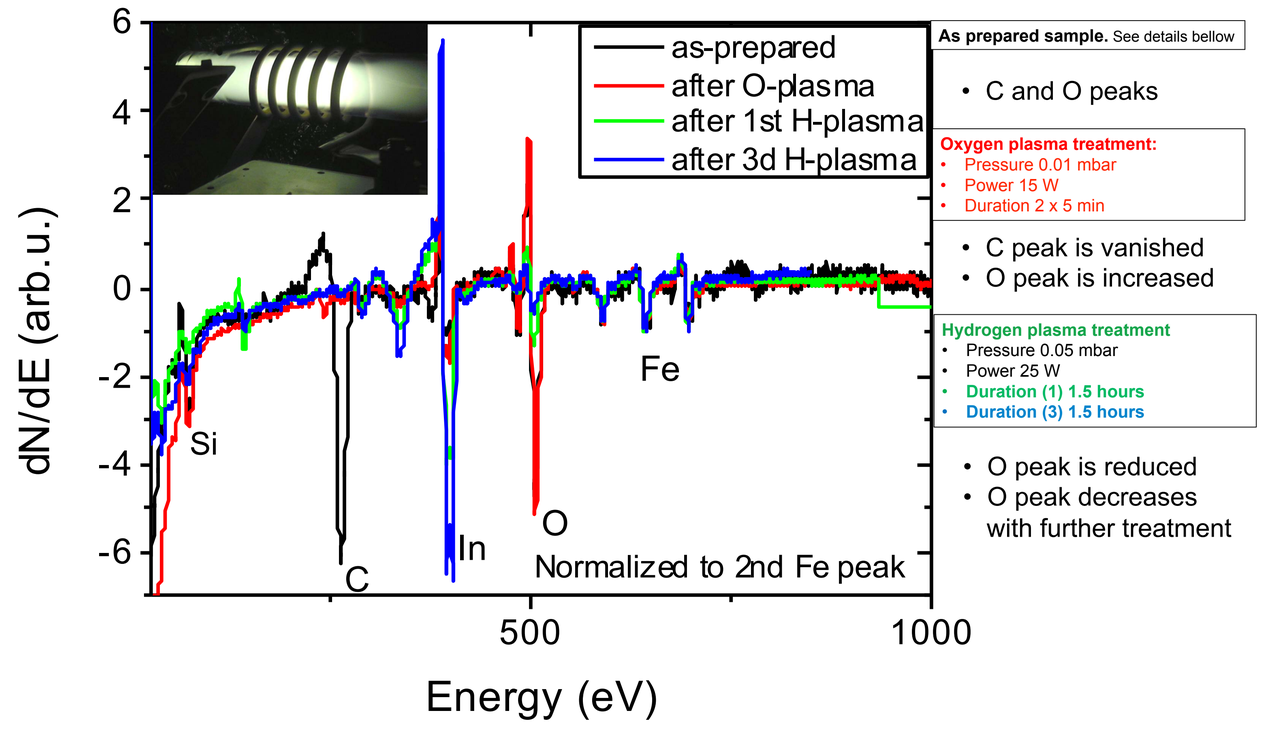
References:
[1] Trunova et al. J. Appl. Phys. 104, 093904 (2008)
[2] Shavel et al. Phys. Chem. Chem. Phys. 11, 3762-3766 (2009)
[3] Kronast et al. Nano Lett. 11, 1710–1715 (2011)

Experimental

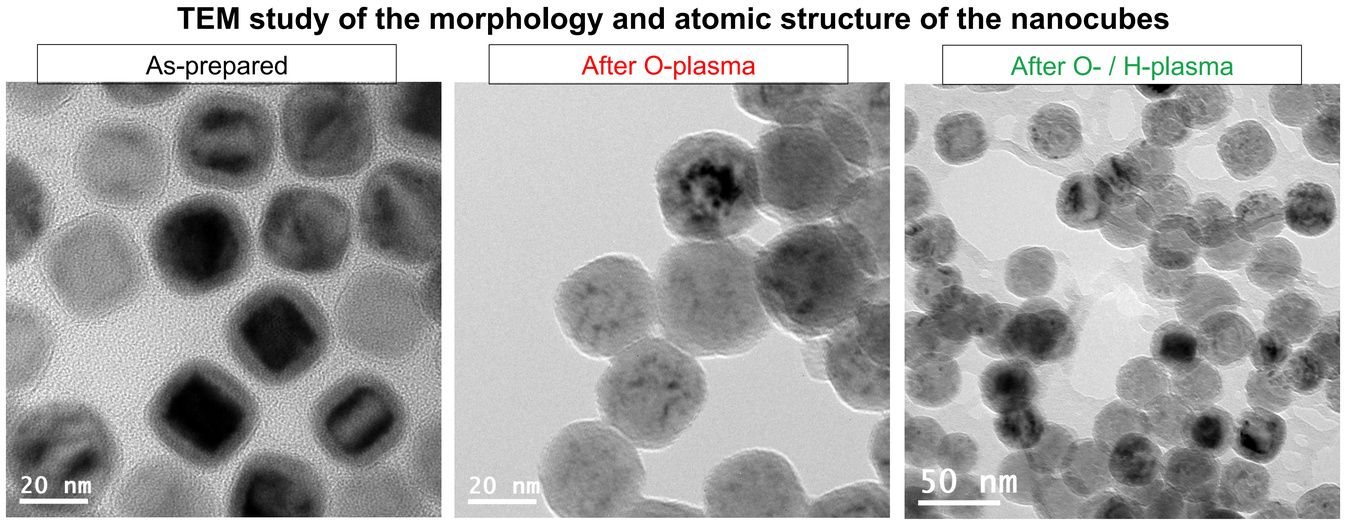
Reduction of FeO_x

- Oxygen plasma (O-plasma) treatment to remove organic ligands;
- Hydrogen plasma (H-plasma) treatment to remove the oxide shell;
- Auger electron spectroscopy (AES) to confirm the change of chemical states *in-situ* after the plasma treatments;
- Transfer of the nanocubes into transmission electron microscope (TEM) under vacuum conditions and high resolution TEM (HR-TEM) study of structural and morphological changes.

Auger electron spectroscopy of the nanocubes before and after plasma treatment



TEM study of the morphology and atomic structure of the nanocubes

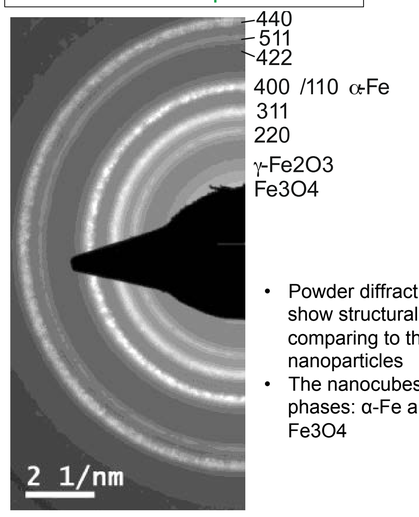


- α-Fe core / γ-Fe_2O_3 shell
- Size 25 ± 3 nm

- Further oxidation, increase of the oxide shell by about 50-70 %;
- Coalescence due to high plasma power.

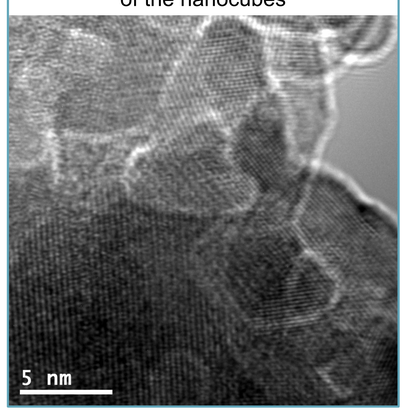
- Recrystallization at the surface into Fe due to partial reduction of the oxide;
- No significant decrease of the oxide shell.

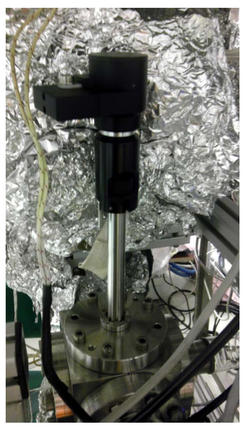
After O- / H-plasma



- Powder diffraction does not show structural changes comparing to the as-grown nanoparticles
- The nanocubes consist of two phases: α-Fe and γ-Fe2O3 or Fe3O4

HRTEM confirms the recrystallization of the nanocubes





TEM transfer holder in UHV plasma chamber

Synthesis of the nanocubes [2]

- Iron (II) stearate (1.24 g) and sodium oleate (0.1 g) were mixed with oleic acid (10g):
- Degassing for 1 hour at 100ºC;
- The solution was heated to 380ºC at the rate of 5ºC/min with vigorous stirring. The reaction mixture was maintained at this temperature for 1 hour. All process was done under a continuous Argon flow.