Synthesis and properties of FePt-nanocrystallites

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FePt-nanoparticles have attracted considerable interest with respect to possible application potentials for future storage media. In addition, studies were initated recently aiming at the voltage-induced tuning of the magnetic properties of nanoparticles [1]. In this context, the present work aims at the synthesis of FePt-nanoparticles and the control of the ligand shell used for coating the particles.

FePt-particles with a nominal composition $Fe_{52}Pt_{48}$ were chemically synthesized by thermal decomposition of iron pentacarbonyl and reduction of platinum acetylacetonate [2]. The nanoparticles were coated with oleic acid and oleylamine during synthesis and subsequently dispersed in n-hexane. Studies by transmission electron microscopy reveal an ultra-fine particle size of 3.4 nm with a narrow size distribution (±0.6 nm) (Figs. 1a, c). Upon dipping the dispersion on the sample holder (polymer film on copper grid) and evaporation of n-hexane, the spherical nanocrystallites are assembled in a monolayer film and locally form a close-packed structure (Fig. 1a). X-ray diffraction reveals the fcc-structure in the as-received state; upon annealing the ordered $L1_0$ phase is formed (Fig. 2).

Exchange of the organic ligand shell opens up the way to control the interparticle distance [3]. Variation of the particle distance is achieved by a ligand exchange process, substituting the oleic acid/oleylamine shell by ligands of octanoic acid/octylamine or of hexanoic acid/hexylamine. With the latter shell a reduced interparticle distance of 1.9 nm (Fig. 1b) is obtained in comparison to ca. 3.4 nm as observed for the as-prepared state with the oleic acid/oleylamine shell (Fig. 1a).

Initial studies of the magnetic behaviour of FePt nanocrystallites were performed by SQUID magnetometry. Measuring cycles of zero field cooling and field cooling demonstrates the superparamagnetism down to a blocking temperature T_b of 23 K (Fig. 3). From T_b a crystalline anisotropy constant K of 15 kJ/m³ is estimated for the as-synthesized particles taking into account the relationship $KV = k_BT$, where k_B denotes Boltzmann's constant and V the volume of the nanoparticles. The narrow crystallite size distribution is reflected by the sharp superparamagnetic-ferromagnetic transition. Studies of the variation of the magnetic behaviour with the ligand shell are in progress.

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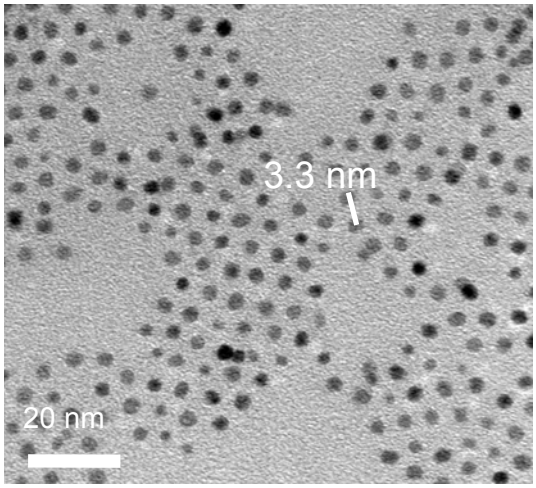

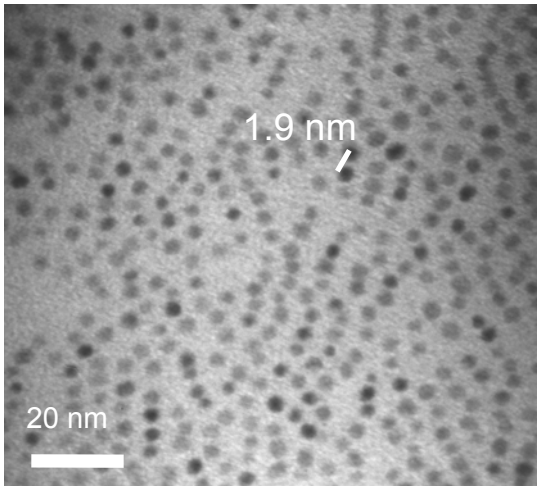

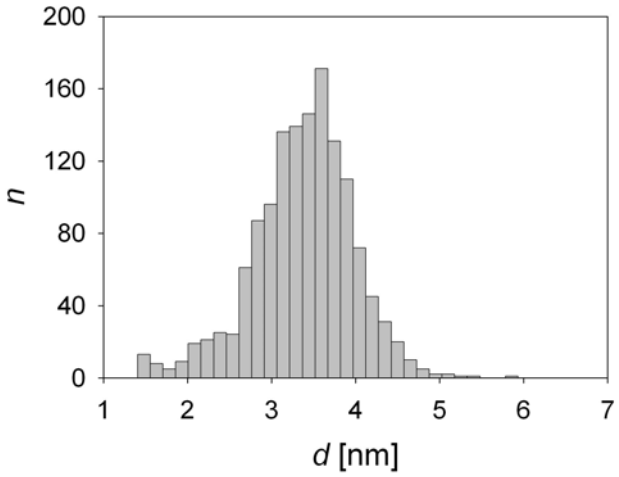

Figure 1. Transmission electron micrographs of FePt-nanocrystallites;
(a) Oleic acid/oleylamine ligand shell;
(b) hexanoic acid/hexylamine ligand shell;
(c) Crystallite size distribution determined for FePt with oleic acid/oleylamine coating.

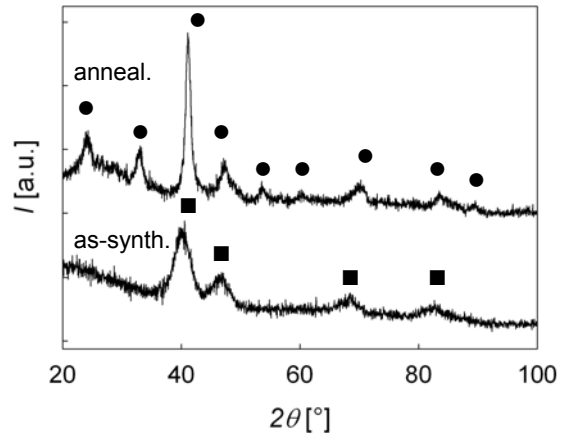

Figure 2. X-ray diffractogramme of FePt-nanocrystallites with ligand shell of octanoic acid/octylamine in the as-synthesized and after annealing (600°C, 2h). The positions of the Bragg peaks of the fcc phase (■) and of the ordered $L1_0$ phase (●) are depicted. θ: diffraction angle; Cu K_α-radiation.

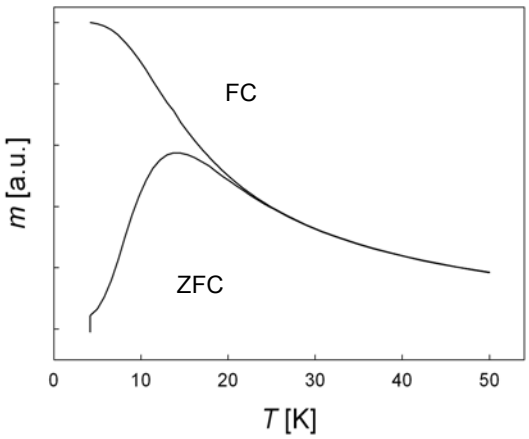

Figure 3. SQUID magnetometry of FePt-nanocrystallites with ligand shell of octanoic acid/octylamine. The zero field cooling (ZFC) and field cooling (FC) cycles are depicted. Measuring field 50 Oe. *m:* magnetic moment.

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