# Exploring structural dependence of magnetic properties in FePt nanoparticle by Cs-corrected HRTEM

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Well-separated and size-controlled FePt nanoparticles are promising for magnetic data storages with ultra-high areal densities [1]. Chemically ordered L1o-FePt shows high magneto-crystalline anisotropy and an enhanced coercivity as compared to disordered FePt state. A measurement of coercivity (Hc) of FePt, showing strongly size dependence (shown in another paper), indicates a lower anisotropy when nanoparticle is small, which could be structural dependence. Newly-developed TEM techniques, Cs-corrector and exit wave reconstruction, supplying less delocalized image, has enabled us to directly explore the structure of nanoparticle even with lateral dimension of only a few atoms[2]. In this work, an objective-lens Cs-corrected Titan FEI 80-300 microscope was used to explore the intrinsic structural characteristic of FePt particle with different sizes, and try to establish the structure-property relationship.

In this study, all FePt particles were prepared by micellar approach [3-4], and followed by plasma etching treatment and reduction at 700°C. A series of representative HRTEM images with particle size ranges from 1.6 nm to 8.5 nm, recorded under a small Cs (less than 1 μm) and small over-focus, either cross-sectional (on MgO) or plan-view images, are shown in Figure 1. FFT from 2.3nm particle shows no superlattice reflections due to ordering. From the images, it is clearly seen that planar or line defects, i.e twin and dislocation, are dominant defects in these FePt particles, which lead to simply- and multiple-twinned particle. With the increase of particle size, the amounts of defect generally increase due to lattice mismatch, such as multiple twins in 7.2 nm and 8.5 nm particles, respectively. Epitaxial growth on MgO is possible only when the particle is smaller, i.e 1.6 nm, whereas it is lost as particle is larger, i.e. 6.0 nm, as a result, dislocations are usually introduced at interface or within the particle. The effective volume in the particle which contributes to magnetic moment could vary with the defect amount. Besides absence of ordering in smaller particles, the presence of these different types of defects in FePt particle may partially account for the observed magnetic properties. A statistic measurement and quantification about the relation of defect and particle size will be presented, further uncovering the intrinsic reasons for the demonstrated property.

The stability of such FePt particle under electron beam and interface structure between FePt and MgO were investigated by both STEM and Cs-corrected HRTEM. Under STEM imaging, it is noted that Pt atom within a small FePt particle, i.e. 1~2 nm, is quite mobile. Closely examination on the behaviour of individual FePt under the

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beam reveals that atom cooperative movement in the particle occurs whereas the interface of FePt and MgO keeps quite stable due to a strong binding of Fe-O at the interface (Figure 2). Image simulations were conducted to prove the interfacial structure [5].

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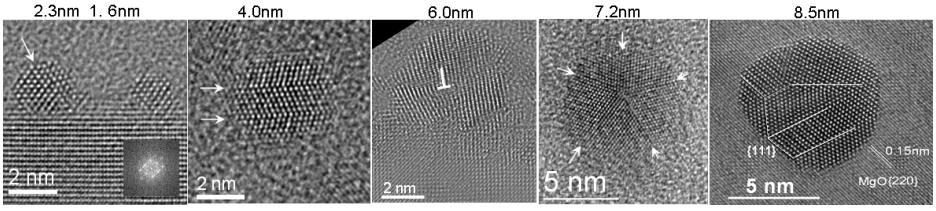


**Figure 1.** HRTEM images of L1o-FePt nanoparticles recorded under Cs =1 μm , particle size is: (a) 1.6 nm, 2.3 nm with one twin and corresponding FFT is inserted, containing no superlattice reflections; (b) 4.0 nm, 2 twins; (c) 6.0nm, one edge dislocation in the particle; (d) 7.2 nm, five-fold twin, exit wave reconstructed phase image; (e) 8.5 nm, multiple twins. Note that the defect amounts are different in each particle.

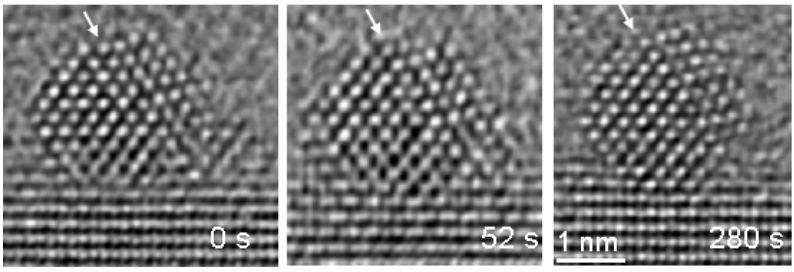


**Figure 2.** A series of HRTEM images (FePt particle on MgO, viewed along [011], Wiener filtered) demonstrate under electron beam (0.042 A/mm$^2$) the particle stability with exposure time, 0 s; 52 s and 280 s. It contains one twin boundary (indicated by arrow), atom cooperative movement along the boundary in the right part (three layer atoms) occurs.