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Perpendicularly oriented self-assembled $L1_0$-FePt nanorods directly synthesized

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Abstract – Synthesis and self-assembling of the monodisperse FePt nanorods directly synthesized in the chemically ordered *L1₀* tetragonal phase with 60 ± 5 nm in length, diameter of 2-3 nm and single-crystal character was reported. The nanorods can be self-organized longitudinally or perpendicularly ordered according to the chemical spacers used during this processes: oleic acid/oleylamine or hexadecylamine, respectively. Perpendicularly ordered nanorods and their magnetic properties as S = 0.81 and H_C ~10 kOe suggest a strongly candidate to single-particle/bit ultrahigh density magnetic recording (Tbit/in^2) media applications.

FePt nanoparticles (NP) with controlled size, shape, chemical composition and magnetic alignment has become an important goal in developing NP arrays for applications in high performance permanent-magnets, information storage, biomedicine and catalysis [1,2]. Literature works have been focused effort in the spherical FePt NP synthesis [1-3], but magnetic aligning the spherical NP has constantly been a challenge for practical applications, since individual magnetic axes remain randomly oriented in the assembly. This alignment is essential for single-particle ultrahigh density magnetic recording devices fabrication [1,2]. Thus, FePt nanorods (NR) seem to be more interesting because it is expected to have magnetic shape and crystalline anisotropies. Few efforts were recently made on the FePt NR synthesis resulting in the thermal unstable *fcc* phase which is converted to spheres during the thermal treatment need to transform the chemically disordered *fcc* to ordered *fct* (*L1₀*) phase [4,5]. In this work self-assembled FePt NR with size and composition control were directly synthesized in the fct phase. Typical synthesis of *L1₀*-FePt NR following: in a three-necked round-bottom flask under N_2 flow and stirring, $Pt(acac)_2$, oleylamine (OAm) and octadecene (OD) -2:1 (v/v)- at total volume of 20 mL were mixed and heated to 60 °C. 1,2-hexadecanediol and $Fe(acac)_3$ were added and the temperature slowly increased to 120°C for 30 min. The temperature was slowly raised up to 180°C for 3 h and then the suspension was cooled down to room temperature, and NR was separated by adding hexane/ ethanol and centrifuging. Self-assembled NR systems were obtained dispersing the NP in hexane/octane mixture containing oleic acid (OA) and OAm or hexadecylamine (HAD), respectively, and evaporating it at room temperature. NR length and composition can be realized by tuning the volume ratio of OAm/OD and the Fe/Pt molar ratio, respectively. TEM results (Fig 1a) indicate a monodisperse system with 60±5 nm in length and diameter of 2-3 nm. The solvent evaporation of the dispersion with OA/OAm or HAD led to longitudinally (Fig. 1b) or perpendicularly (Fig. 1c,) oriented self-assembled systems, respectively. According to the HRTEM image (Fig 1b, inset), NR are single-crystals and the result suggests the [001] direction parallel to the rod-growth direction and infer that the *fct* phase was directly obtained during the NR synthesis [2,4,5]. The presence of the *fct* phase was confirmed by the XRD patterns (Fig 1d) and agrees with the related one for spherical FePt NP [5] when the reaction kinetic was enhanced by using the slow heating rate, low temperature and gently stirring. The fast reaction kinetic favor the size decrease, but also favors the unstable *fcc* phase. In contrast, in this work, the reaction rate is slow and the most stable *fct* phase was realized. *M x H* curve of the assembly shows the good squareness (S = 0.81) with the coercivity reaching 10 kOe (Fig 1e).

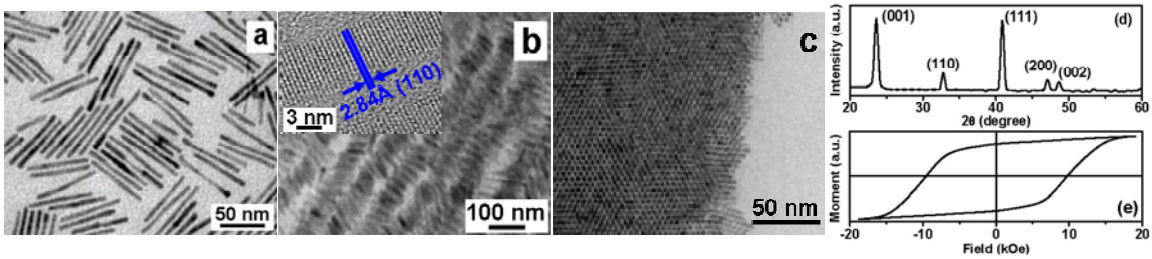

Figure 1: TEM images of the *L1₀*-$Fe_{55}Pt_{45}$ nanorods (a) as-synthesized, (b) longitudinally and (c) perpendicularly oriented self-assembled, (d) XRD pattern showing the *L1₀* phase with strong increases in the (001) reflection, and (e) *M x H* curve indicating strongly ferromagnetic behavior (H_C ~10 kOe). Inset in (b) shows the HRTEM image presenting the texture along the (110) planes and indicating that the [001] direction is parallel to the rod growth direction.

References

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