

**High coercivity carbon embedded L1<sub>0</sub>-FePt ferromagnetic nanoparticles** Marco Villani<sup>b</sup>, Mattia Gaboardi<sup>a</sup>, Gianluca Calestani<sup>a,b</sup>, Chiara Pernechele<sup>c</sup>, Massimo Solzi<sup>c</sup>, Andrea Migliori<sup>d</sup>

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Stoichiometric FePt nanoparticles in the tetragonal L1<sub>0</sub> phase, ( $K_u = 6.6 \times 10^7$  erg/cm<sup>3</sup>) are one of the leading candidates for next generation high-density recording media, allowing theoretical grain stability down to 3nm [1]. As-synthesized FePt nanoparticles produced by the conventional soft chemical route (polyol process) [2,3] shows disordered face centered cubic (*fcc*) structure with low  $K_u$  and superparamagnetic behavior at RT. The ordered L1<sub>0</sub> tetragonal structure is usually obtained by post-annealing in a reducing environment [4,5] giving rise to particle aggregation produced by sintering that affects significantly both the final particle size and the polydispersity. A preliminary work we performed pointed out that a direct synthesis of ferromagnetic particles, based on the decomposition of Fe(acac)<sub>3</sub> and Pt(acac)<sub>2</sub> in reducing solvent and inert atmosphere, is made possible by the increase of the reaction temperature at 290-330°C obtained by the use of Triton X-100 as solvent and polyvinylpyrrolidone (PVP) as protective agent. The resulting nanoparticles are ferromagnetic at RT with coercitive field ( $H_c$ ) ranging from 0.4 to 1.0 KOe depending on the synthesis temperature. However, as evidenced by TEM analyses, they are magnetically aggregate and, for synthesis temperatures above 300°C, embedded in an amorphous matrix produced by partial decomposition of the solvent. These observations suggested us a novel approach to the synthesis of non-aggregate ferromagnetic nanoparticles. The basic idea is to block the nanoparticles in a rigid matrix, during the synthesis, before they become ferromagnetic, to prevent magnetic aggregation. Using PEG-600 as solvent and quickly raising the temperature above 300°C cause the polyol to condense in flakes. The rapid heating, joined to the increased viscosity, limits the diffusion of the nutrient phase to the growing nuclei, resulting in monodisperse nanoparticles, with a typical size ranging around 5nm (determined by XRD and TEM), randomly dispersed in the condensed matrix. In agreement with the XRD analysis, pointing out a disordered *fcc* structure, the magnetic measurements show at RT a superparamagnetic behaviour of the as-grown particles, with a blocking temperature  $T_B$  of 60K and large distribution of energy barriers. The phase transformation to the ferromagnetic ordered tetragonal L1<sub>0</sub> structure is achieved by thermal annealing in dynamic high vacuum; the annealing transforms the organic matrix into amorphous carbon that preserves the original nanoparticle size and prevents the aggregation up to 1000°C, where it transforms into pyrolytic graphite. XRD shows the appearing of the L1<sub>0</sub> diffraction peaks after a 1 hour treatment at 650° and an almost complete phase transition after 4hours at the same temperature, where a coercitive field ( $H_c$ ) of 2,5kOe at RT and 13kOe at 5K is detected. Annealing at higher temperatures, even if results in a further enhancement of the structural properties, gives rise to complex behaviour of the hysteresis, whose origin is still under investigation.

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