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Induced Unusual Magnetism in Monodisperse Nanoparticles

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Magnetic materials at the nanoscale have exposed rich physical phenomena with unusual properties and observed spectacular technological developments [1, 2]. In the prospective of converging multi-disciplinary nanotechnology, we have created magnetic nanostructures for potential biomedical applications [3]. The investigation on magnetic nanoparticles proceeds in two major nanoarchitectures, nanocomposites and core-shell configuration [3, 4]. The approach allows versatile composition and geometric multiplicity, so it offers promising candidates to meet future demands. We have employed a modified polyol synthesis strategy in preparing various types of monodisperse nanoparticles (Fig. 1) [3, 4]. In the presentation, we first address the induced ferromagnetism and enhanced susceptibility observed in highly crystalline, monosized Fe₃O₄(Fe)/Au magnetic-optic multifunctional core-shell nanocrystals [3]. Then, we tackle the issue with respect to the giant diamagnetism obtained in Au_{0.5}Fe_{0.5} alloy nanoparticles, which elegantly integrate magnetic and optical elements in one single entity. The giant diamagnetism is measured on the order of -10^{-2} emu g⁻¹ Oe⁻¹. Reflecting deviation from bulk properties as a result of dimension shrinkage, the origin for the unusual behavior of the magnetic nanoparticles can be complex and is discussed in terms of viewpoints from unique spatial arrangement, geometrical confinement, physical proximity, self-organization, surface magnetism, spin-orbital effects to special interactions out of elemental composition.

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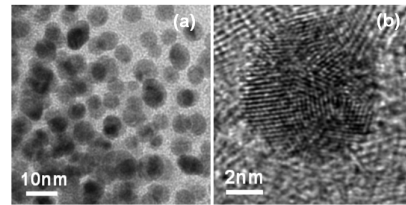


Fig. 1. TEM images of Au_{0.5}Fe_{0.5} alloy nanoparticles. (a) Morphology and (b) Lattice image.

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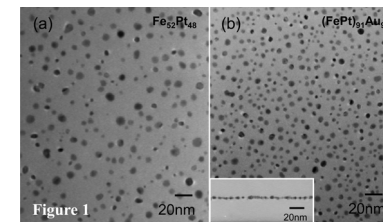
Synthesis of L10 (FePt)_{1-x}Au_x Nanoparticle Monolayer on Polyimide Film

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FePt nanoparticles are often considered for future high density magnetic recording medium because of the large coercivity resulting from the high magnetocrystalline anisotropy [1]. In present research, we demonstrate that monolayer of ordered L1₀ (FePt)_{1-x}Au_x nanoparticles can be produced on a polyimide (PI) film for possible applications in flexible magnetic data storage. Monodisperse Au nanoparticles were produced during thermal imidization of the polyamic acid (p-phenylene biphenyltetracarboximide) with 0.3-nm-thick Au layer deposited. On top of the Au nanoparticle layer, 3.2-nm-thick Fe-Pt layer was deposited using dc magnetron sputtering. The preexisting Au nanoparticles helped to tighten the size distribution of the FePt nanoparticles formed during the sputter deposition by providing heterogeneous nucleation sites. TEM image of the Fe₅₂Pt₄₈ nanoparticles without Au is shown in Fig. 1(a). The average particles size for the Fe₅₂Pt₄₈ nanoparticles was 5.1 ± 1.8 nm. Introduction of the Au into the FePt particles as seen in Fig. 1(b) drastically changed the particle morphology as well as the particle density. While the average particle size for (FePt)₉₁Au₉ decreased to 3.8 ± 1.1 nm, the size distribution became considerably tighter. The inset in Fig. 1(b) verifies that the particles were formed in a monolayer. It was previously shown that Au deposited on the PI film formed finely dispersed nanoparticles due to the minimal wettability of Au on the polymer film [2]. It is conjectured that the Fe-Pt film tended to heterogeneously nucleate and grow on the preexisting Au nanoparticles, resulting in improved particle size distribution. Electron diffraction analysis indicates that the (FePt)₉₁Au₉ nanoparticles were converted to the ordered face-centered tetragonal structure by annealing at 800°C.



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