Pressure Effects on Electronic Structures of Self-assemble Ordered Alloys FePt Nanoparticles

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The results of data analysis

FePt alloys are an important class of materials in permanent magnetic applications because of their large uniaxial magnetic crystalline anisotropy [Ku >7×10^6 J/m^3] and good chemical stability. As the magnetic stability of individual particles scales with the anisotropy constant, Ku, and the particle volume, V, small FePt particles may be suitable for future ultrahigh-density magnetic recording media applications. Oriented, ferromagnetic FePt nanoparticles have been produced by the decomposition of platinum acetylacetonate and iron pentacarbonyl in the presence of oleic acid and oleylamine stabilizers was reported. These self-assembly, synthesis and magnetic recording performance nanoparticles could generate considerable interests for recording media in future ultrahigh-density magnetic data storage.

The thermal annealing converts the internal particle structure from a chemically disordered face-centered cubic (fcc) phase to the chemically ordered face-centered tetragonal (fct) phase (L10) and transforms the nanoparticle superlattices into ferromagnetic nanocrystal assemblies. The temperature of FePt ordering might cause particle coalescence occur that increases the particle sizes and lead to loss of particles positional order. Particle coalescence leads to an increase of switching volume, which defeats the point of making small particles. The loss of positional order comes from the decomposition of the surfactant layers allowing particle motion. It would be highly desirable if the temperature required for the fcc to tetragonal phase transformation were lower, at least below temperatures where the particles coalesce, preferably below the temperature where the organic surfactants decompose.

FePt alloys in-situ powder diffraction under high pressure measurement were performed in the 01C2 beamline during Apr. 7 ~ 11 2004. Figure 1 displays series of XRD patterns of $BaTiO_3$ crystalline for various loading runs and the process of decompression to ambient pressure.

Figure 1 plots the standard pressure lines of internal gold (111), (200), and (220) respectively. In the loading run process, the lattice parameters of FePt alloys at ambient pressure, a=4.0278±0.001 Å and V_0=65.3442 Å^3 were slightly larger than those of the bulk, reported by Joint Committee for Powder Diffraction Standards, JCPDS card 89-2475. Figure 1 reveals eleven reflections (100), (110), (111), (200), (210), (211), (220), (300), (310), (311), and (222) of the cubic phase. Bragg's relationship indicates that the d-spacings of the reflections in Fig. 1 were 4.0724, 2.8532, 2.3251, 2.0128, 1.8005, 1.6436, 1.4240, 1.3427, 1.2737, 1.2145, and 1.1621 Å for $BaTiO_3$ crystalline, respectively.

As the pressure increased to 14.1 GPa, starting the ambiguous phse transition region, up to 36.7 GPa. The reflections of the monoclinic phase of FePt alloys disappear completely and the reflection of the cubic phase appears at over 36.7 GPa. At pressures from 14.1 to 36.7 GPa, mixed cubic and rock-salt phases of FePt alloys. The orthorhombic phase are found to exist up to 50.6 GPa.

Figure 1 also shows the decompress process of FePt alloys powder. It was found that the $BaTiO_3$ crystalline powder had the irreversive property. The further analysis will reveal their relation precisely.

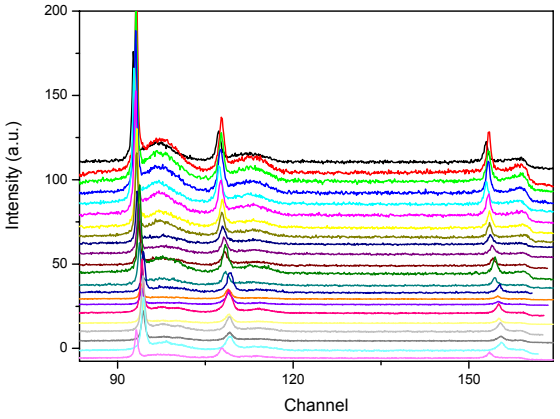

Figure 1. The spectra of the FePt alloys powder sample at various pressures recorded in a loading run. The spectra include the diffraction peaks of the gold particles in the sample.