Anomalous Grazing Incident Small Angle X-ray Scattering Investigating the Surface Morphology of FePt Magnetic Nanoparticles Monolayer on Functional Modulated Substrate

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In recent years, the study of magnetic nanoparticles becomes a growing interesting area due to their potential application on ultrahigh-density recording. One of the most important goal is to fabricate an ordering layer on substrates for industrial applications. Chemical methods to control one particle layer on the substrate by using polymer coating on the surface was reported [1, 3]. Those polymers such as polyethylenimine (PEI) or [3-(2-aminoethlyamino) ropyl]trimethoxysilane (APTS) play a linking role to combine the silicon dioxide and the surfactants on the particle surface. However due to the limitation of disordered orientation of those polymers, the original self-organized behavior of the nanoparticles system was destroyed and the stacking condition of those particles on the surface was not compact any more. In order to enhance the magnetic properties, in this work, an overlayer of Au is vacuum deposited on the top of nanoparticles to keep the particle intact and to enhance a pinning effect of the magnetic moment rotation by reducing the exchange integral between each particle. Anomalous grazing incident small angle x-ray scattering (anomalous GISAXS) was used to characterize the morphology of the system before and after the annealing process.The results show that, at 800 ^{o}C high temperature annealing, the polymer are burnt out resulting in coalesced nanoparticle if we did not add Au overlayer [4]. With Au overlayer, the morphology of the surface did not show a significant change after annealing.

Figure 1a and 1b show the results of anomalous GISAXS of the FePt nanoparticles monolayer on the functional APTS substrate with Au coverlayer at different annealing condition. Without Au coverlayer, the identical SAXS spectrum (see inset) below and at the Pt absorption edge shows the nanoparticles were in a well mixed alloy FePt structure with well defined particle size. After adding Au as a coverlayer, conformity morphology and closer electron density enable difficulty to recognize the completeness of particles after the annealing process. The Au layer might cover the outside of FePt nanoparticles and remain the similar shape on the surface. However, from preliminary fitting results, the particles retain intact in the Au matrix before the high temperature annealing. After the 800 ^{o}C vacuum annealing process for 1 hour, significant particle form factor was disappeared which might indicate the surface morphology became more flat and smooth. Fig. 1 b shows the anomalous GISAXS results, the slightly intensity difference at the moment transfer range between 0.1 to 1 nm^{-1} imply that in a gold-FePt core-shell structure, the particle core containing Pt is still keeping the particle shape as the one before annealing. In short summary, adding Au overlayer on top of the FePt monolayer enhance the stability of the FePt nanoparticles during the annealing.

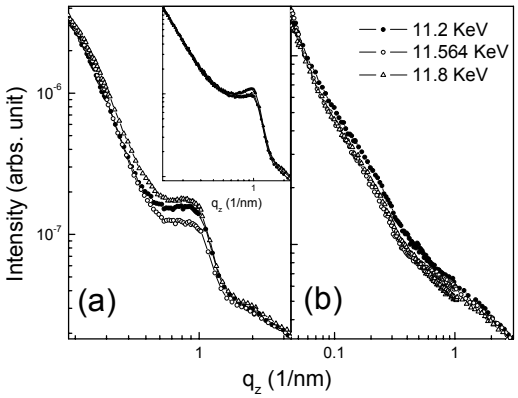

Figure 1. The anomalous GISAXS results for a) monolayer FePt nanoparticles with Au coverlayer and b) after 800 ^{o}C 1 hour annealing process. The inset in a) is for a monolayer of FePt nanoparticles without Au coverlayer.

References:

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