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Large Room Temperature Magnetoresistance of Magnetite Nanoparticles

Eung Young Jang[1]*, Deung Jang Choi[1], Jung-Tak Jang[2], Jin-Sil Choi[2], Jinwoo Cheon[2], and Tae Hee Kim[1]
[1]Department of Physics, Ewha Womans University, Seoul 120-750, South Korea
[2]Department of Chemistry, YonseiUniversity, Seoul 120-749, South Korea
† e-mail: taehee@ewha.ac.kr

1. Introduction

Rapid development in nanotechnology has made it possible to make nanoparticles with more precision and to manipulate them. Magnetite (Fe_3O_4) is currently one of key materials for applications in magnetic storage and many bioinspired applications, because bulk Fe_3O_4 has a high Curie temperature (Tc = ~850K) and nearly full spin polarization at room temperature.[1] Magnetite is perhaps the oldest magnetic material known, however the understanding of the correlation between magnetic properties and particle size is incomplete. It leads us to investigate systematically the magnetic and transport properties of Fe_3O_4 nanoparticles.

2. Sample preparation

Fe_3O_4 nanoparticles with different sizes ranging from 9 to 18 nm have been prepared in a well-controlled manner by a nonhydrolytic synthetic method. Iron oxide nanocrystals were synthesized by thermodecoposition of FeCl/and Fe(acac) in trioctylamine containing oleic acid and oleylamine under Ar atmosphere. The mixture was heated to 200 ℃, and, after 1 hr, was refluxed for an hour. Synthesized nanocrystals were precipitated by adding ethanol and supernant was removed by centrifugation. The nanocrystals were redispersed in toluene.

3. Results

X-ray diffraction and HRTEM analysis showed a single cubic inverse spinel phase for our samples. Chemical analysis was also performed using EDX for synthesized magnetite nanoparticles.

Here, we report the investigation of magnetism and magnetoresistance in Fe_3O_4 nanoparticle pellets. For our samples of 12 - 18 nm size the magnetic properties showed the same results with bulk properties, showing the Verway transition at 123 K and the magnetic moment per iron of 1.0 μ_B.

Significant intergrain magnetoresistance of over 12 % in 2 kG was also observed at room temperature in highly monodispersed ($\sigma \approx 5$ %) single crystalline nanoparticles of 12 nm size. According to our knowledge, this is the highest magnetoresistance value reported at room temperature for the magnetic nanoparticles. Superparamagnetic-like behavior was also observed in pressed pellets of magnetite at room temperature. The enhanced magnetoresistance and the superparamagnetic-like behavior could arise from the subtle interplay between the intrinsic properties, size distribution of the nanoparticles, finite-size effects and the interparticle interactions.[2] Our results show clearly that finite-size effects dominate the magnetic behavior of individual nanoparticles, increasing their relevance as the particle size decreases.

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5. References

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