Magnetic Clusters in Nanotube

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Introduction

In the finite size regime materials can exhibit phases that are different from the stable phase in the bulk, depending on the size of the material. It's known that iron exists in different allotropic forms, where at ambient conditions the most stable phase is ferromagnetic body-centered cubic α-Fe, and the face-centered cubic γ-Fe is thermodynamically unstable and not ferromagnetic [1, 2]. However, theoretical studies have predicted the existence of two different magnetic states in γ-Fe, i.e. a ferromagnetic (or high-spin) and an antiferromagnetic (or low-spin) state, depending on the inter-atomic distance in the fcc Fe lattice [3]. In the past attempts have been made to stabilize γ-Fe at room temperature, resulting in ferromagnetic fcc Fe confined to thickness of only few monolayers [4]. We have found that iron catalyst nanoparticles trapped in carbon nanotubes (see Fig. 1) are indeed ferromagnetic γ-Fe at room temperature.

The unusual magnetic moment of γ-Fe nanoparticles observed using room temperature magnetic measurements (see Fig. 2) and Mössbauer spectroscopy (see Fig. 3) is explained by a lattice expansion due to insertion of carbon atoms into the interstitial sites. According to the Mossbauer data analysis, there exist two different magnetic moments of iron in the γ-Fe nanoparticles, presumably due to their atomic environments, namely whether they have a carbon atom in the nearest neighbor or not. The First principles calculations corroborate that ferromagnetism observed here is related to both lattice distortion and charge transfer between Fe and C. Detailed analysis of the structure and magnetic properties of the magnetic clusters will be discussed.

References

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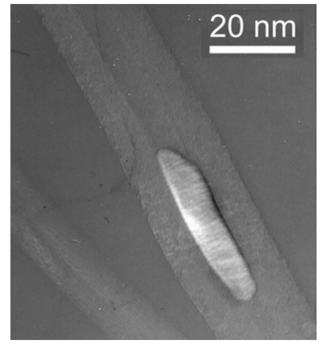

Fig. 1 Transmission electron micrograph of an iron nanoparticle in carbon nanotube.

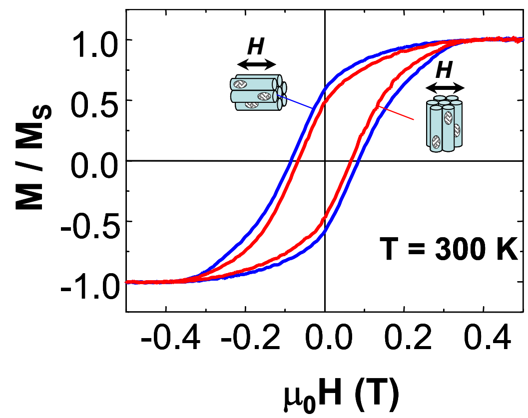

Fig. 2 Magnetic hysteresis loop for iron nanoparticles in carbon nanotubes.

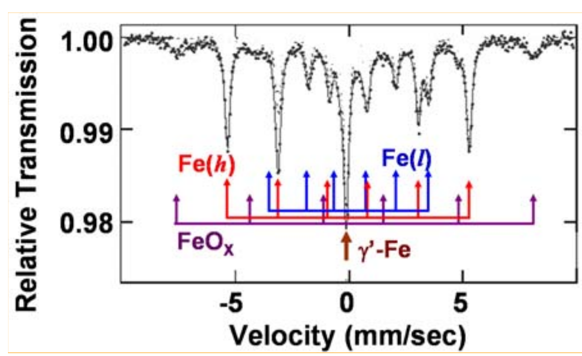

Fig. 3 Mössbauer spectrum of iron nanoparticles in carbon nanotubes.