

Characterization of the $\text{CoFe}_2\text{O}_4@ \text{MnFe}_2\text{O}_4$ Magnetic Particles Using Differential Phase Contrast in STEM

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Core-shell magnetic particles with magnetization properties have been extensively studied by various analysis tools [1-4]. The transmission electron microscope (TEM) and scanning transmission electron microscope (STEM) is a powerful tool to research the crystallographic and chemical properties [5]. Moreover, differential phase contrast (DPC) in STEM is an attractive function for characterization of magnetic or electric properties.

We present results using novel DPC technique to give information about magnetic domain contrast and its vector direction in core-shell magnetic particles. This technique uses sensitivity direction detectors to measure quantitatively the deflection of the electron beams when they are influenced by magnetic field [6-7]. Typically it uses a divided annular dark-field detector with four segments. If deflections of electron beam occur at any location in the specimen, it makes its own specific contrast reflecting components at that position. The in-plane field deflects the beam also cause a new contrast by subtracting perpendicular segments of a detector. In addition, we can show the vector direction of magnetic field by simulation with avizo software.

The core-shell $\text{CoFe}_2\text{O}_4@ \text{MnFe}_2\text{O}_4$ magnetic particles with the sizes of ~500nm were prepared by solvo-thermal method. The magnetic properties of these magnetic particles were characterized using STEM (Model TalosF200X) installed DPC detectors. The crystal structures were investigated using SAED pattern in TEM. The chemical compositions of magnetic particles were analyzed by EDS Spectrum, mapping using 4 SDD Super-X Detectors.

References:

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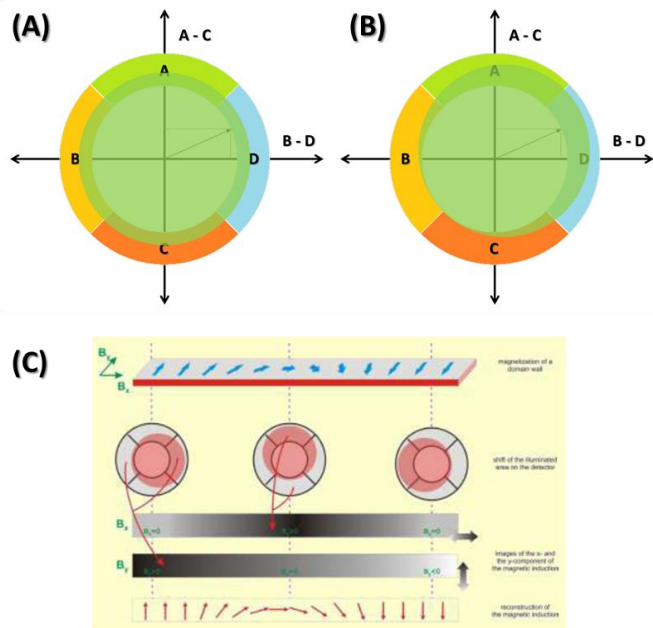


Figure 1. The shape of the beam deflected by the magnetic field. (A) undeflected (B) the beam deflected by the field (C) Schematic of contrast formation process due to the deflected beam

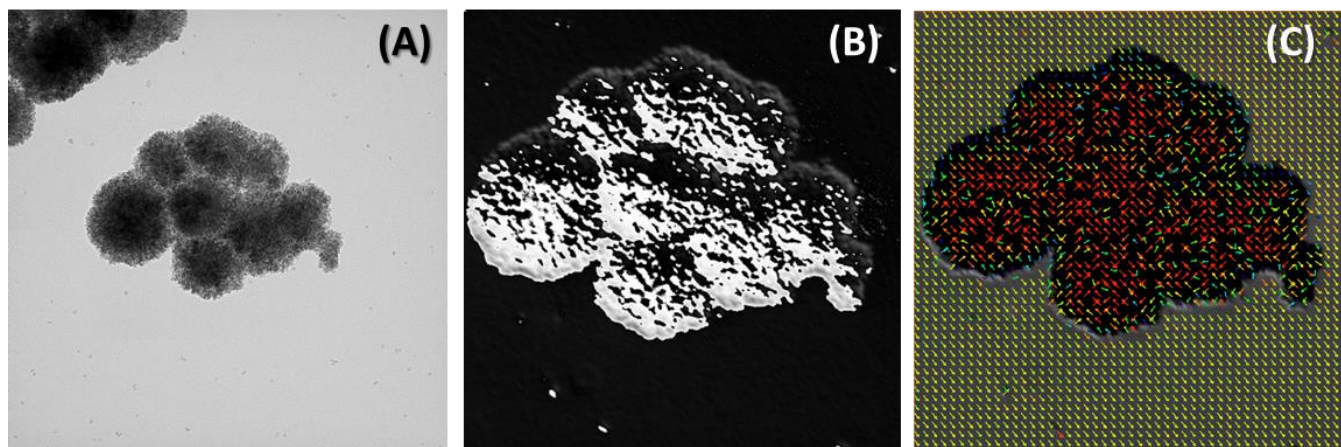


Figure 2. (A)TEM image of core-shell $\text{CoFe}_2\text{O}_4@ \text{MnFe}_2\text{O}_4$ magnetic particle (B) A-C segments image in DPC (C) Display the vector direction of magnetic field using Avizo