Structural Evolution in core-shell nanoparticles: Implication in Nanomagnetism and Catalysis

Xiao-Min Lin

Center for Nanoscale Materials, Argonne National Laboratory,
James Franck Institute, University of Chicago

Abstract

The structural and chemical complexity on nanometer scale can have a profound influence on the physical and chemical properties of materials. I will illustrate this phenomenon through two examples. In the first case, I will focus on a recent magnetic study of chemically synthesized Fe@Fe$_3$O$_4$ core-shell and iron oxide hollow shell nanoparticles. The ability to obtain highly monodisperse magnetic nanoparticles through chemical synthesis has created new opportunities to investigate exchange bias (EB) phenomenon in these systems. I will show that the EB effect in these systems is directly related to the amount of aligned frozen spins at the interface between core and shell, and can be manipulated through applied cooling field, measuring temperature as well as magnetic cycling history. Interesting, a gradual oxidation of the sample in air can lead to a dramatic structural change at the interface, and ultimately leads to magnetic decoupling between core and shell. In a second case, I will discuss the kinetic pathway of palladium nanoparticle sulfidation process with the addition of excess amount of octadecanethiol at different temperatures. With increasing temperatures, polycrystalline Pd-oleylamine nanoparticles gradually become amorphous PdS$_x$ nanoparticles, with sulfur atomic concentration eventually saturating at Pd/S=66/34 at 200°C. Combining electron microscopy and X-ray Absorption Spectroscopy, we found that the sulfur diffusion into the nanoparticle depends strongly on the temperature and likely first go through the grain boundaries of the nanoparticle. Elucidating the exact reaction pathway, the degree of sulfidation, the chemical stoichiometry and the temperature dependence of this sulfidation process may prove to be important in understanding many Pd based catalytic reactions.