Prospects for Electron Holography of Nanoparticle Catalysts

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Off-axis electron holography is a transmission electron microscopy technique that can be used to record the phase shift of the electron wave that has passed through an electron-transparent specimen (1). The phase shift is sensitive to both the electrostatic potential and the magnetic induction in the specimen. The technique is now most commonly used to measure electrostatic potentials in semiconductor devices and magnetic fields in nanocrystals and thin films. However, to date it has rarely been applied to the characterization of supported metal nanoparticle catalysts.

Intriguingly, there have been several recent reports that the mean inner electrostatic potentials of sub-10-nm metal nanoparticles, measured using off-axis electron holography, are substantially higher than those measured from larger crystals (2-4). These reports are fascinating because they suggest that measurements of mean inner potentials, which are inherently sensitive to the structural and chemical states of the particle surfaces, may be used to provide information about the catalytic properties of the particles, including the possible influence of charge transfer between the particles and their substrates.

Here, we discuss some of the most important factors that affect electron holographic measurements of mean inner potentials of supported metal nanoparticles. These factors include the presence of reconstructions, adsorbates and/or changes in lattice parameter on the particle surfaces (5), the effect of dynamical diffraction on the measured phase shift, the accuracy with which the thicknesses of the particles in the electron beam direction can be measured, and charging of the particles and/ or their supports due to electron beam irradiation in the microscope. We discuss whether one or more of these factors can be used to explain the variations in mean inner potential with nanoparticle diameter that have been reported in the literature, and we assess the prospects for using electron holography to obtain useful information about the catalytic properties of the particle surfaces.

Separately, we show how electron holography can be used to measure the magnetic moments of individual ferromagnetic nanoparticles. Such measurements can, in principle, be used to follow the oxidation and reduction of magnetic catalyst nanoparticles during catalytic processes.

References

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