Applications of Aberration-Corrected ScanningTransmission Electron Microscopy

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Abstract

As result of the imperfection of magnetic lenses, the resolution of the electron microscope is determined by spherical aberration, which is a consequence of the dependency of the electron focal length on its scattering angle. The characterization of nanoscaled materials can be enhanced by employing Aberration Corrected Electron Microscopy. By taking advantage of sub-angstrom image resolution, a new understanding of the behavior of matter at the nanoscale can be reached. In this work we study bimetallic nanoparticles owing to their extreme importance as catalysts. The addition of a second metal is known to produce much-improved catalysts. We have studied the structure, morphology and elemental distribution of Au/Pd bimetallic particles, displaying a three-layer structure using Aberration Corrected Electron Microscopy. It is well established that scanning-transmission electron microscopy images (STEM), acquired by high-angle annular dark field detector (HAADF) represent a scattering map of the sample. We matched the experimental intensities of atomic columns with theoretical models of the Au/Pd nanoparticle, and found that the surface layer of the nanoparticle contains kinks, terraces and steps at nanoscale. We suggest that the effect of adding a second metal induces the formation of such structures. This might very likely produce the improved catalytic activity. The internal structure of Au/Pd nanoparticles exhibiting the newly discovered three-layer core/shell morphology is composed of an evenly alloyed inner core, an Au-rich intermediate layer, and a Pd-rich outer shell. By exploitation of spatially resolved imaging and spectroscopic and diffraction modes of transmission electron microscopy (TEM), insights were gained on the composition of each one of the observed three layers (above figure), indicating a significant extent of intimate alloy among the monometallic elements.