Image-Based Nanocrystallography by Means of Transmission Electron Goniometry

Peter Moeck, Bjoern Seipel, and Krishnan Padmanabhan
Portland State University
Portland, OR

Wentao Qin
Motorola Technology Solutions/SPS
Chandler, AZ

Phil Fraundorf
University of Missouri at St. Louis

Because the crystallographic phase, defect content, and morphology of many materials change with the crystal size in the 1 to 10 nm range and the potential technological applications of nanoparticles are enormous, a need arises to determine the crystallography of nanoparticles individually. Direct-space, high-resolution, phase-contrast transmission electron microscopy (TEM) and atomic resolution Z-contrast scanning TEM combined with goniometry of direct/reciprocal lattice vectors offer the possibility of developing dedicated nanocrystallography characterization methods for such small nanoparticles. A tilt strategy for determining the lattice parameters of individual cubic nanocrystals from only two high-resolution electron phase-contrast images recorded in contemporary high-resolution TEMs (defined as having a point-to-point resolution of 0.2 nm or better) with a modest tilt range (of about ± 10 – 15° about two axes) is demonstrated. In future aberration-corrected TEM, more elaborate tilt strategies become possible and most nanocrystals with lower than cubic symmetry can be analyzed. Supported by dedicated nanocrystallography software and computer-controlled specimen goniometers with an additional degree of freedom to tilt the specimen, the crystallographic characterization of all kinds of nanoparticles (cubic and non-cubic) will become practical on a day-to-day basis. This poster presentation reviews this field and gives details on our summer project at the National Center for Electron Microscopy of the Lawrence Berkeley National Laboratory.