Plenary Lecture

PL04

Beyond Crystallography: Coherent Diffraction Imaging and Atomic Resolution Electron Tomography

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The discovery and interpretation of X-ray diffraction from crystals by von Laue, Henry and Lawrence Bragg about a century ago marked the beginning of a new era for visualizing the three-dimensional (3D) atomic structures in crystals. In 1999, the methodology of X-ray crystallography was extended to allow the structure determination of non-crystalline specimens, which is known as coherent diffraction imaging (CDI) or lensless imaging. In CDI, the diffraction pattern of a non-crystalline sample or a nanocrystal is first measured and then directly phased to obtain an image. The well-known phase problem is solved by combining the oversampling method with iterative algorithms. In the first part of the talk, I will present the principle of CDI and illustrate some applications using synchrotron radiation and X-ray free electron lasers (XFELs). In the second part of the talk, I will present a general tomographic method for determining the 3D local structure of materials at atomic resolution. By combining scanning transmission electron microscopy (STEM) with a novel data acquisition and image reconstruction method known as equally sloped tomography (EST), we achieve electron tomography at 2.4 Å resolution and observe nearly all the atoms in a multiply-twinned Pt nanoparticle. We find the existence of atomic steps at 3D twin boundaries of the Pt nanoparticle and, for the first time, image the 3D core structure of edge and screw dislocations in materials at atomic resolution. We expect this atomic resolution electron tomography method to find application in solid state physics, materials sciences, nanoscience, chemistry and biology.

***[1]** 1. K. S. Raines, S. Salha, R. L. Sandberg, et al., "Three-dimensional structure determination from a single view", Nature 463, 214-217 (2010), **[2]** 2. M. C. Scott, C.-C. Chen, M. Mecklenburg, et al., "Electron tomography at 2.4-ångström resolution", Nature 483, 444–447 (2012), **[3]** 3. C.-C. Chen, C. Zhu, E. R. White, et al., "Three-dimensional imaging of dislocations in nanoparticles at atomic resolution", Nature 496, 74–77 (2013)*

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