Perspective on the Use of Coherent Diffraction Imaging as a Tool for High Resolution Materials Characterization

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Coherent diffraction imaging (CDI) is an emerging technique that is currently used mainly in the field of physics. An opportunity is present for materials scientists to make use of this technique in order to solve current and future materials-centric problems. In addition to introducing the scope of the section in this article, the readers are also given backgrounds for the authors and how each paper fits together. Finally, a brief review of the inaugural symposium held at the TMS 2013 Annual Meeting is provided along with an invitation for the next symposium scheduled for 2015.

Although the concept of CDI has been around since the 1950s, experimental realization of this technique occurred only about 15 years ago. Through a combination of the oversampling method and iterative phase retrieval algorithms, high-resolution images can be obtained through the inversion of diffraction patterns from both crystalline and noncrystalline materials. This allows imaging and characterization through the use of x-rays to occur for a broad range of materials including nanoparticles, strained crystals, biomaterials, and cells. Unique characterization abilities such as three-dimensional strain mapping and nondestructive three-dimensional tomographic imaging highlight the emerging importance of CDI in the field of materials science. In this series of papers, current and potential applications of CDI techniques to solve problems in materials science are explored as a way to foster increased interaction between materials scientists and physicists, the predominant developers of CDI.

The first paper in this series is titled “From Grain Boundaries to Single Defects: A Review of Coherent Methods for Materials Imaging in the X-ray Sciences.” In this paper, Brian Abbey (La Trobe Uni-

versity, Melbourne, Australia, and Melbourne Centre for Nanofabrication, Melbourne, Australia) provides a broad overview of the various techniques within the field of CDI. Brief descriptions of the governing physics as well as limits of the techniques such as phase contrast tomography, plane wave CDI, ptychographic CDI, diverging beam CDI, reduced coherence CDI, coherent x-ray microbeam diffraction, and Bragg CDI are reported. The author also discusses current and potential uses for each technique within the materials science field. Dr. Abbey, in addition to the previously listed appointments, is also a member of the Micro Materials Characterization Beamline development team for the Australian Synchrotron.

The second paper in this series is titled “X-Ray Coherent Diffraction Imaging of Nanomaterials.” Ross Harder (Advanced Photon Source, Argonne, IL, USA) and Ian K. Robinson (University College London, London, England) explore the use of Bragg CDI to image structure in nanosized barium titanate crystals in conjunction with local strain measurements with high sensitivity. Harder manages the 34-ID-C beamline at the Advanced Photon Source and welcomes user proposals that will continue to push the envelope in CDI’s abilities and applications, especially in the field of strain mapping.

The final paper in this series is titled “Studies of Materials at the Nanometer Scale using Coherent X-Ray Diffraction Imaging.” Richard Sandberg (Los Alamos National Laboratory, Los Alamos, NM, USA), Zhifeng Huang, Rui Xu, Jose Rodriguez, and John Miao (all from the University of California Los Angeles, Los Angeles, CA, USA) explore the use of CDI in imaging materials as varied as biological cells and GaN quantum dot nanoparticles. The use of CDI is discussed in the context of both beamline-based CDI and table-top-source-based CDI. Sandberg’s primary research focus involves the development of table-top sour-

John Carpenter, chair of and JOM advisor for the Materials Characterization Committee of the TMS Extraction & Processing Division, and Richard Sandberg coordinated the topic Coherent X-ray Diffraction Imaging as a Characterization Tool in this issue.

ces for CDI making the technique more accessible. Professor Miao is responsible for the first experimental use of CDI in 1999, and his perspective on the growth of the field and its potential for crossover into the field of materials science is of great use.

Consistent with the editors' desire to create more interaction between the CDI field and the greater materials science community, a new symposium called Characterization of Materials through High Resolution Coherent Imaging was

introduced at the TMS 2013 Annual Meeting. Thirteen invited talks and ten submitted talks were presented over the course of 1.5 days. Response to the new symposium from the speakers, of whom a majority were physicists, and the predominantly materials-science-focused audience was overwhelmingly positive. The editors hope that this *JOM* section leads to collaborations that can be presented at another CDI symposium at the TMS 2015 Annual Meeting in Orlando, FL, USA.