Principles and Applications of Scanning Convergent Beam Electron Diffraction (SCBED) for Characterizing Complex, Multi-element Crystals

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CBED patterns provide rich structural information such as crystal symmetry, strain, atomic positions and vibrations, and crystal potential or charge density[1]. CBED patterns are formed using a focused electron probe at the specimen. Because of the convergent beam, the transmitted and diffracted spots broaden into disks, and the size of the disk determines the range of excitation errors (S_g) for each reflection. We can say CBED pattern displays a variation of intensity versus S_g, or rocking curve information, simultaneously in every diffraction order. The rocking curve information can thus be used for crystal symmetry determination and quantitative structure factor measurement. Moreover, the recorded higher order Laue zone (HOLZ) lines can be used to provide accurate measurement of crystal lattice parameters or electron acceleration voltage.

Scanning CBED (SCBED) is an extension of CBED. Previously, we have developed a scanning electron nanodiffraction (SEND) technique that uses the built-in TEM deflection coils to shift the beam. Using the deflection coils and a 2D digital detector, diffraction patterns (either NBD or CBED) can be recorded for every probe positions from a region of interest in the specimen[2]. Compared to conventional CBED, which records one diffraction pattern over one probe position, SCBED collects the full 4D data, in the form of two sets of coordinates: (x, y) in real space and the (k_x, k_y) in the reciprocal space. SCBED works like STEM, yet unlike BF-STEM, ADF-STEM or DPC-STEM which integrate scattered signals in detectors, we aim to make full use of the rocking curve information provided by CBED patterns. Removal of the inelastic background is critical for quantitative analysis of SCBED, which can be done by using an electron energy-filter with minimal distortions[3,4].

This talk will present a few "worked examples" of SCBED applications. Examples include characterization of lattice and polarization interactions and nanodomains in ferroelectric perovskites[5,6], as well as the detection of inhomogeneous lattice distortions in $Al_{0.1}CrCoFeNi$ high entropy alloys. New algorithms including symmetry quantification to analyze large dataset of CBED patterns quantitatively will also be discussed[7].

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[7] Supported by U.S. DoE, Office of Basic Energy Sciences under contract DEFG02-01ER45923.