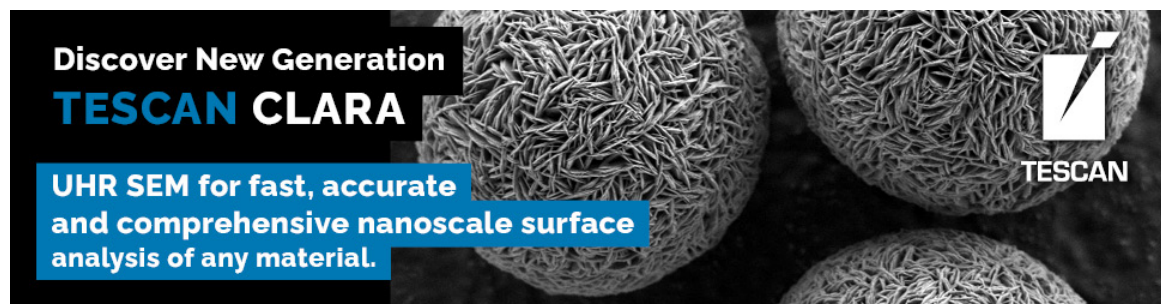


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Meeting-report

Principles and Applications of 4D-STEM Diffraction Imaging for Characterizing Complex Crystalline Materials

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Recent advances in four-dimensional (4D-) scanning transmission electron microscopy (STEM) imaging have enabled micron-scale mapping of structures with sub-nanometer resolution, or resolution beyond the diffraction limit [1, 2]. 4D-STEM works like STEM, yet unlike bright-field (BF-)STEM, annular dark-field (ADF-)STEM or differential phase contrast (DPC-)STEM which integrate scattered signals in detectors, we aim to make full use of the structural information provided by the diffraction patterns. These advances take advantage of flexible electron optics and fast direct electron detectors [3, 4] to collect two-dimensional (2D) diffraction patterns (k_x, k_y) at each probe position over a 2D region in real space (x, y), resulting 4D datasets [5]. Thus, by analyzing the diffraction patterns, structural information about materials can be obtained such as lattice disorder, symmetry, strain, electric or magnetic fields.

Various structural information can be extracted from different parts of diffraction patterns recorded by 4D-STEM. For example, variations in Bragg scattering angles can be used to determine crystallographic orientations and projected 2D strain, while the angular deflection and change in CBED disk shape can be used for measuring electric or magnetic field across the sample. To deal with large 4D datasets, data analysis algorithms are needed. Depending on the information extracted, the algorithms can range from a simple intensity center-of-mass analysis, iterative peak fitting, to sophisticated machine learning methods [6]. In addition, quantitative comparison between calculated and experimental diffraction patterns can be obtained by using multiple scattering simulations, which further aids data interpretation.

This talk will present a few “worked examples” about what we have learned about 4D-STEM diffraction imaging and their applications in understanding the structure-property relationships in complex crystalline materials. Emphasis will be on strategies to optimize the acquisition and analysis of 4D-STEM, common artifacts in interpreting the data will be discussed [7].

References

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