Defects and Thin-films Analysis using Four-Dimensional Scanning Transmission Electron Microscopy

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Keywords: Electron crystallography, diffraction imaging, defects and thin-films

The study of order and disorder is a fundamental theme in crystallography and its applications in materials science and condense matter physics. Examples include doping of semiconductors, advanced alloys with complex compositions, nanocrystalline and amorphous materials for energy and environmental technologies. These materials feature minute, significant and strong departures from perfect crystallinity, and their crystallographic analysis is a challenge.

Transmission electron microscopy (TEM) has played a predominant role in the discovery of disorder within order or order within disorder, from atomic resolution imaging of crystal defects and fluctuation analysis of short- and medium-range ordering in amorphous solids. However, large gaps remain in our ability for the interrogation of significantly and strongly disordered materials. Here we introduce the concept of cepstral STEM (scanning TEM) for filling these gaps [1-5]. The basic idea is to collect large amounts of nanodiffraction patterns using scanning electron nanodiffraction (SEND) and Fourier transform the logarithmic intensities into cepstral patterns to detect the harmonics captured by diffraction and use the quefrency signals for imaging and structural analysis (Fig. 1). This talk will detail this method and demonstrate its effectiveness through applications to defect analysis in semiconductors, structure determination of high entropy alloys and analysis of silicon anode in lithium batteries.

Figure 1. Cepstral STEM for imaging silicon anode. (a) Starting cepstrum stack computed from SEND dataset with (b) corresponding radial cepstrum profile. Image reconstruction of (c) amorphous material and (d) crystalline material.


Work supported by DMR-2226495 from the Metals and Metallic Nanostructures Program (MMN) within the Division of Materials Research, National Science Foundation.