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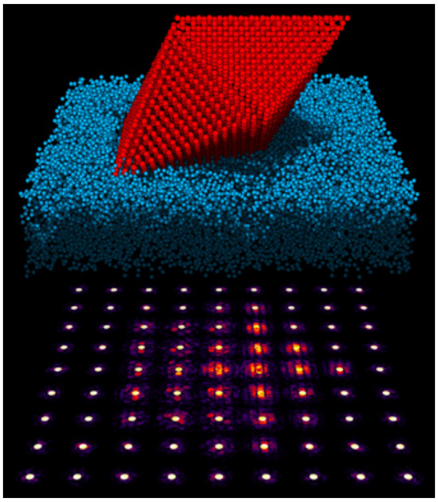
Highlights from Microscopy AND Microanalysis

Review Article

Four-Dimensional Scanning Transmission Electron Microscopy (4D-STEM): From Scanning Nanodiffraction to Ptychography and Beyond by C Ophus, *Microsc Microanal* | doi: 10.1017/S14319276190000497

Scanning transmission electron microscopy (STEM) is a flexible characterization tool used for many different imaging and spectroscopic measurements. The development of high-speed direct electron detectors has facilitated the widespread introduction of four-dimensional (4D)-STEM experiments, where a full 2D image of the STEM probe is recorded over a 2D grid of probe positions. These datasets are often extremely large, requiring both a large amount of digital storage and efficient computational analysis methods. However, tackling these challenges is worthwhile because of the large amount of structural information that can be recorded for a sample over many different length scales. In this paper, we review 4D-STEM experiments including mapping (of phase, orientation, and strain), virtual diffraction imaging, measurements of medium range order, position-averaged convergent beam electron diffraction, phase contrast imaging methods such as contrast ptychography, scanning confocal electron microscopy, structured phase plates, and others. We also discuss associated topics such as precession electron diffraction, computational analysis, electron scattering simulation, and detector development for 4D-STEM.



A simulated 4D-STEM dataset for a nanoparticle resting on an amorphous carbon substrate. The probes along the outer edge have passed only through the substrate, and therefore scatter weakly, so most of the intensity remains in the central beam. The probes passing through the nanoparticle show Bragg diffraction patterns, which can be used to measure the local crystal orientation and deformation.

Techniques and Biological Applications

Nanoindentation Properties and Finite Element Analysis of the Rostrum of *Cyrtotrachelus buqueti Guer* (Coleoptera: Curculionidae) by LH Li, C Guo, S Xu, YP Ma, and ZW Yu, *Microsc Microanal* | doi: 10.1017/S1431927619000242

Nanoindentation measurements and finite element analysis of mechanical properties of the rostrum of the outstanding driller weevil *Cyrtotrachelus buqueti* Guer are reported. Nanoindentation tests were used to measure the Young's modulus and hardness of the rostrum, with results for the "dry" samples being 13.89±0.75 GPa and 0.37±0.04 GPa, respectively. The values for "fresh" samples showed no clear difference from those of the "dry" ones. Moreover, field observations were conducted to determine the motion behavior of the rostrum. Micro-computed tomography (9 µm slices) was employed to obtain structural information about the rostrum, and a 3D model of the rostrum was created using the MIMICS design program. It was concluded that the rostrum of *Cyrtotrachelus buqueti* Guer provides an ideal biological template for the design of lightweight tube-shaped structures, which can be used in automobiles, aircraft, robotic arms, and other tube-like structures.

The weevil ***Cyrtotrachelus buqueti*** Guer is an outstanding driller that is able to effectively chew holes into and suck on bamboo. During the feeding process, the rostrum is subject to great pressure and high torque that changes with movement. These mechanical properties make it an ideal model to inspire new lightweight designs for long tubular structures.

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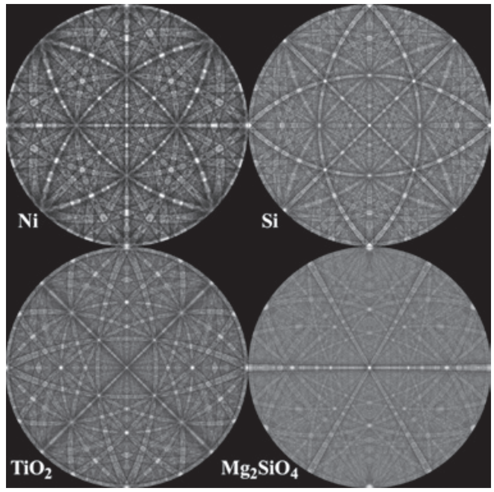
Microscopy AND Microanalysis

Techniques and Material Applications

Reflector Selection for the Indexing of Electron Back-Scatter Diffraction Patterns by SI Wright, S Singh, and M De Graef, *Microsc Microanal* 25(1) (2019) 1–7

The traditional Hough-based indexing algorithm for EBSD patterns requires a list of reflectors that will be considered as potential Kikuchi band labels. This list is usually generated using kinematical structure factor values for the crystal structure under consideration. The EBSD pattern, however, is generated by dynamical scattering of back-scattered electrons leaving the crystal, so that structure factor values are not necessarily representative values, in particular for complex unit cells. We have created a new reflector ranking algorithm, based on integrated intensities of individual bands in dynamically simulated master patterns (see Figure for example stereographic projections of master patterns). For elemental structures, the ranking closely follows the kinematical ranking. However, for more complex structures, the new ranking shows good agreement with a ranking obtained from experimental Kikuchi band intensities determined by means of the Hough transform. Hough-based indexing of a simulated forsterite data set showed an appreciable improvement in the median confidence index (from 0.15 to 0.35) when the new reflector ranking was used instead of the kinematical ranking.



20 kV master patterns (stereographic projections) for Ni, Si, TiO_2, and Mg_2SiO_4; in all patterns, the crystallographic **a** axis points horizontally toward the right, and the reciprocal **c*** axis is normal to the projections.