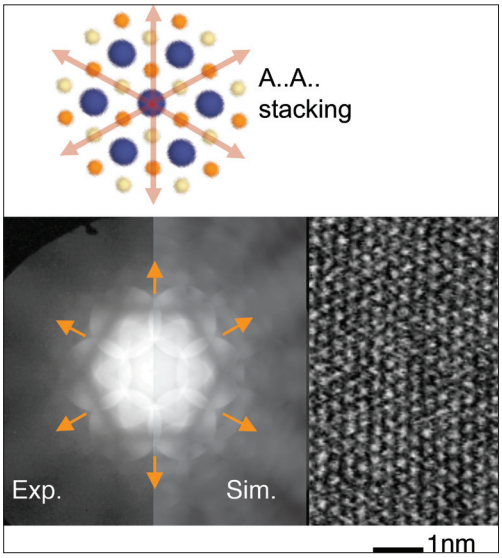
Highlights from Microscopy AND Microanalysis

Techniques and Material Applications

Thickness and Stacking Sequence Determination of Exfoliated Dichalcogenides (1T-TaS2, 2H-MoS2) Using Scanning Transmission Electron Microscopy by R Hovden, P Liu, N Schnitzer, AW Tsen, Y Liu, W Lu, Y Sun, and LF Kourkoutis, *Microsc Microanal* | doi: 10.1017/S1431927618012436

Layered transition metal dichalcogenides (TMDs) have accrued considerable interest due to their promise for future electronic and optoelectronic technologies. Approaching the 2D limit, thickness and local topology greatly influence macroscopic material properties. Toward developing an understanding of the unique behavior of TMDs, it is necessary to characterize the number of atomic layers and their stacking sequence in a sample. Pairing experimentally recorded high-angle annular dark-field (HAADF) STEM images and position averaged convergent beam electron diffraction (CBED) patterns with quantum mechanical multislice scattering simulations, the thickness and stacking of TMDs can be measured directly. Notably, CBED measurements are insensitive to amorphous surface material and do not require the lattice to be resolved in real space, enabling accurate and high throughput structural characterization. We demonstrate the determination from CBED of crystal thickness in exfoliated 1T-TaS_2 and 2H-MoS_2 to within a single layer for ultrathin <~9 layers and ±1 atomic layer (or better) in thicker specimens, while also revealing information about stacking order.

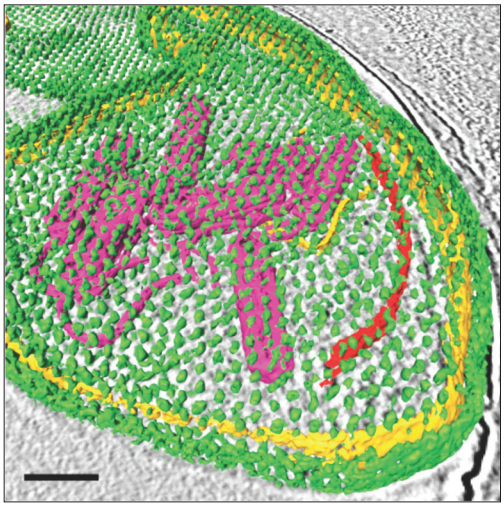


CBED patterns (*left*) and HAADF STEM image (*right*) reveal thickness and stacking order in regions of 1T-TaS_2 crystal. The 6-fold symmetry of A..A.. stacking is reflected in the CBED pattern (orange arrows). Sample thickness is 35 ± 1 u.c as determined by comparison to simulations.

Techniques and Biological Applications

Biological Applications at the Cutting Edge of Cryo-Electron Microscopy by RS Dillard, CM Hampton, JD Strauss, Z Ke, D Altomara, RC Guerrero-Ferreira, G Kiss, and ER Wright, *Microsc Microanal* | doi: 10.1017/S1431927618012382

Cryo-electron microscopy (cryo-EM) is a powerful tool for macromolecular to near-atomic resolution structure determination in the biological sciences. The specimen is maintained in a near-native environment within a thin film of vitreous ice and imaged in a transmission electron microscope at cryogenic temperatures. The images can then be processed by a number of computational methods to produce three-dimensional information. Recent advances in sample preparation, imaging, and data processing have led to tremendous growth in the field of cryo-EM by providing higher-resolution structures and the ability to investigate macromolecules within the context of the cell. We review developments in grid preparation methods and substrates, such as affinity capture systems, vitrification devices, and gold grids; improvements in detectors that have significantly contributed to the expansion of cryo-EM resolution capabilities; contrast enhancement using phase plates; and cryo-correlative light and electron microscopy, which allows us to combine spatio-temporal information from fluorescence microscopy with structural information from cryo-EM. We have included specific biological applications to illustrate these advances.



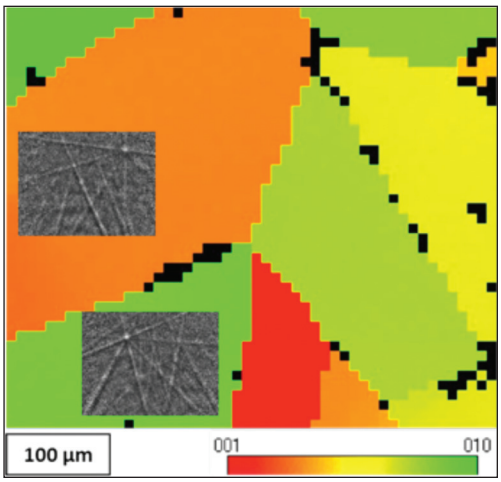
Three-dimensional segmentation of ϕCbK bacteriophages assembling within a lysing *Caulobacter crescentus* cell. Cells were infected with ϕCbK, plunge frozen, and imaged by cryo-electron tomography using Zernike Phase Contrast phase plates, which provide higher contrast to reveal internal features. The bacterial hexagonal surface layer is shown in green, outer membrane in gold, inner membrane in red, and assembling ϕCbK phages in magenta. Scale bar is 100 nm.

Microscopy AND Microanalysis

New Technique Development

Methods for Conducting Electron Backscattered Diffraction (EBSD) on Polycrystalline Organic Molecular Thin Films by K Abbasi, D Wang, MA Fusella, PB Rand, and A Avishai, *Microsc Microanal* | doi:10.1017/S1431927618000442

Electron backscattered diffraction (EBSD) is a technique regularly used to obtain crystallographic information from inorganic samples. When EBSD is acquired simultaneously with EDS data, a sample can be thoroughly characterized both structurally and compositionally. For organic materials, coherent Kikuchi patterns do form when the electron beam interacts with crystalline material. However, such patterns tend to be weak because of the low average atomic number of organic materials. This is compounded by the fact that the patterns fade quickly and disappear completely once a critical electron dose is exceeded, inhibiting successful collection of EBSD maps from them. In this study, a new approach is presented that allows successful collection of EBSD maps from organic materials; here the extreme example of a hydrocarbon organic molecular thin film is presented, which opens new avenues of characterization for crystalline organic materials.



EBSD patterns can be achieved from polycrystalline organic molecular thin films using the proposed approach. These patterns can be then used to produce crystallographic orientation maps. Each grain has a specific orientation. Two of the grains are shown with their respective EBSD patterns.

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