Highlights from Microscopy AND Microanalysis

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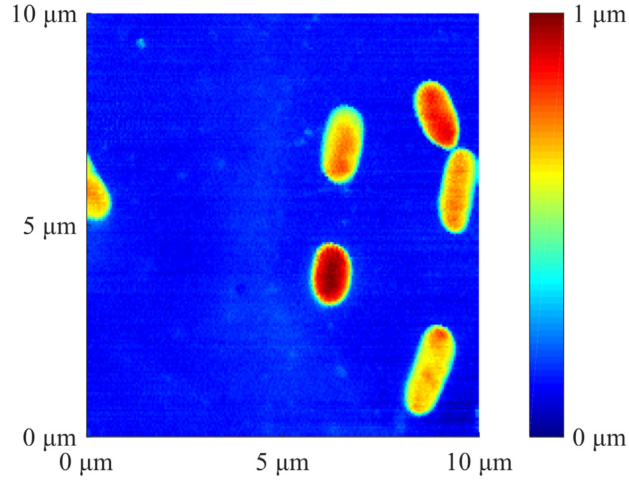
Biological Applications

Accurate Morphology Characterization Using Atomic Force Microscopy via Vertical Drift Correction and Illusory Slope Elimination by Y Wu, Y Fang, Z Fan, and C Liu, *Microsc Microanal* | https://doi.org/10.1017/S1431927621012599.

As common error sources, vertical drift and illusory slope severely impair atomic force microscopy (AFM) imaging quality. To address this issue, a robust algorithm is proposed to synchronously correct the image distortion caused by vertical drift and slope, thus achieving accurate morphology characterization. Specifically, to eliminate the damage of abnormal points and feature areas on the correction accuracy, the laser spot voltage error acquired in the AFM scanning process is first utilized to preprocess the morphology height data of the sample to obtain the refined alternative data suitable for line fitting. Subsequently, a novel line-fitting algorithm based on sparse sample consensus is proposed to accurately simulate vertical drift and slope in the cross-sectional profile of the topographic image, thereby achieving effective correction of the image distortion. In the experiments and applications, a nanoscale optical grating sample and a biological cell sample are adopted to perform topography imaging and distortion correction, which verify the ability of the proposed algorithm to promote AFM imaging quality (Figure).

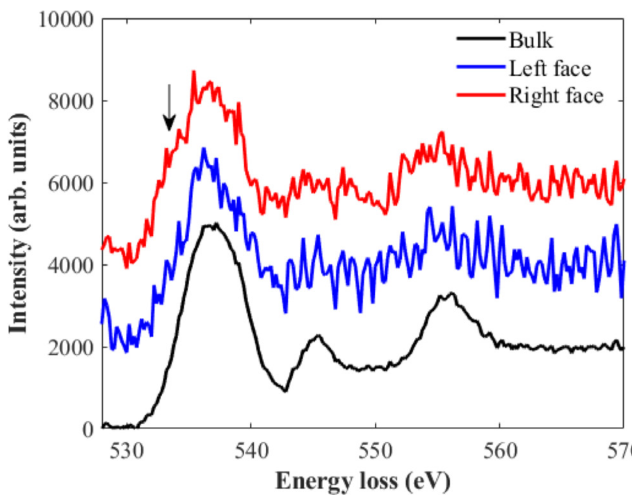


Topographic image of the *Escherichia coli* sample corrected by the proposed method. The color of the substrate in the image is basically the same, which demonstrates that the sample surface is flat and level. Moreover, the color of the corrected cell area is also more uniform, indicating that the height change of the cell topography is smoother.

Materials Applications

Surface Core Hole Electron Energy-Loss Fine Structure in MgO: Experiment and Theory by BG Mendis, *Microsc Microanal* | https://doi.org/10.1017/S1431927621012691.

The fine structure in electron energy loss spectroscopy (EELS) core edges is used to “fingerprint” the bonding environment and electronic structure of a solid. With a focused electron beam, local electronic structure changes, such as at an interface, can be measured. Often, however, EELS edges are distorted by the core hole, that is, the positive charge left behind in the ionized atom. Core hole screening by electrons in the solid will be different for EELS spectra acquired at an interface compared to the bulk material. This is evident in O K-EELS spectra acquired from the interior and free surface of MgO smoke cubes. The latter shows extra intensity at the edge onset (Figure). An electrodynamic model is used to calculate core hole screening in the bulk and free surfaces of MgO. It is shown that the pre-edge intensity is largely due to reduced core hole screening, rather than surface electronic states. This demonstrates the importance of the local dielectric environment on the measured EELS edge shape.



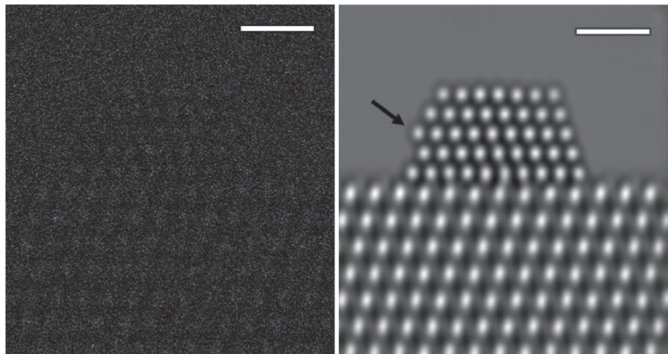
O K-EELS edge shapes acquired from the interior (“Bulk”) and free surfaces (“Left/Right face”) of a MgO smoke cube. The latter shows extra intensity at the edge onset (arrowed feature), largely due to reduced core hole screening at the free surface.

Microscopy AND Microanalysis

Techniques Development

Developing and Evaluating Deep Neural Network-Based Denoising for Nanoparticle TEM Images with Ultra-Low Signal-to-Noise by JL Vincent, R Manzorro, S Mohan, B Tang, DY Sheth, EP Simoncelli, DS Matteson, C Fernandez-Granda, and P Crozier, *Microsc Microanal* | https://doi.org/10.1017/S1431927621012678.

A supervised convolutional neural network has been developed to denoise atomic-resolution transmission electron microscope (TEM) images. The dataset, consisting of a CeO_2-supported Pt nanoparticle, has been recorded using a direct electron detector, where the signal of the extremely fast acquisitions is limited by Poisson noise. The proposed network, trained over a wide range of simulated TEM images, has been demonstrated to outperform state-of-the-art denoising methods on both simulated and experimental data (Figure). An extensive analysis of the different factors contributing to the performance of the network has been described, including the features and geometry of the TEM images and the size of the network's receptive field. Finally, to verify the performance, we have designed an approach based on the log-likelihood ratio test that provides a quantitative measure of the agreement between the noisy observation and the atomic-level structure in the network-denoised image. The development of such machine learning-based tools for TEM image denoising opens up the possibility of characterizing time-resolved and beam-sensitive materials.



A representative noisy simulated image along with a denoised image output by the network. After denoising, a spurious atomic column appears at the arrowed site, which shows a large negative value in the likelihood map. Scale bar = 1.0 nm.