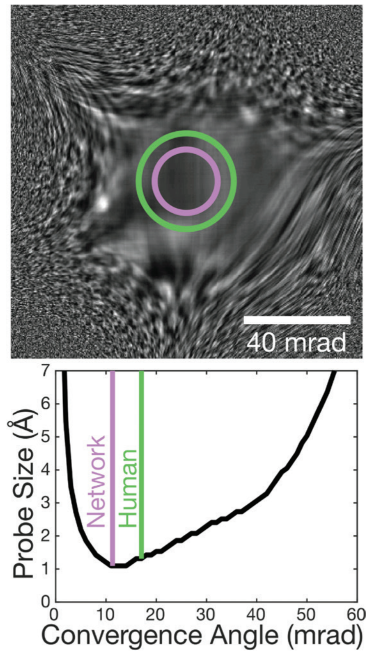
Techniques Development

Optimal STEM Convergence Angle Selection Using a Convolutional Neural Network and the Strehl Ratio by N Schnitzer, SH Sung, and R Hovden, *Microsc Microanal* | doi:10.1017/S1431927620001841

Selection of the correct convergence angle is essential for achieving the highest resolution imaging in scanning transmission electron microscopy (STEM). Use of poor heuristics, such as Rayleigh's quarter-phase rule, to assess probe quality and uncertainties in measurement of the aberration function result in incorrect selection of convergence angles and lower resolution. We show that the Strehl ratio provides an accurate and efficient way to calculate criteria for evaluating probe size. A convolutional neural network trained on the Strehl ratio is shown to outperform experienced microscopists at selecting a convergence angle from a simulated electron Ronchigram (Figure). Generating tens of thousands of simulated examples, the network is trained to select convergence angles yielding probes on average 85% nearer to optimal size at millisecond speeds. Assessment on experimental Ronchigrams with intentionally introduced aberrations suggests that trends in the optimal convergence angle are well modeled, but high accuracy requires extensive training datasets. This near immediate assessment of Ronchigrams using the Strehl ratio and machine learning, highlights a path toward rapid, automated alignment of aberration-corrected electron microscopes.

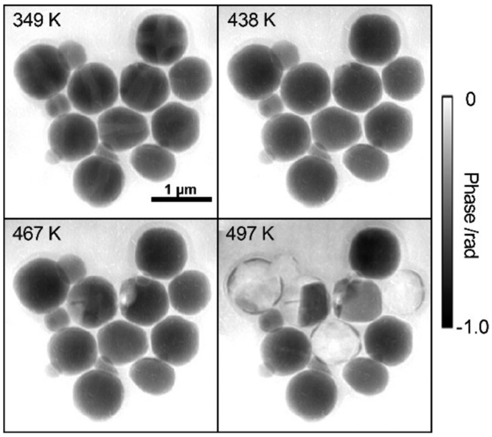


Convergence angles selected by the convolutional network and a microscopist for a simulated electron Ronchigram and the corresponding probe sizes.

Material Applications

Nanoscale Visualization of Phase Transition in Melting of Sn–Bi Particles by *in situ* Hard X-ray Ptychographic Coherent Diffraction Imaging by N Ishiguro, T Higashino, M Hirose, and Y Takahashi, *Microsc Microanal* | doi:10.1017/S1431927620024332

The phase transition in the melting of Sn–Bi eutectic solder alloy particles was observed by *in situ* hard X-ray ptychographic coherent diffraction imaging with a pin-point heating system. Ptychographic diffraction patterns of micrometer-sized Sn–Bi particles were collected at temperatures from room temperature to 540 K. The projection images of each particle were reconstructed at a spatial resolution of 25 nm, showing differences in the phase shifts due to two crystal phases in the Sn–Bi alloy system and the Sn/Bi oxides at the surface (Figure). By quantitatively evaluating the Bi content, it became clear that the non-uniformity of the composition exists in the particle when the particles are synthesized by the centrifugal atomization method. This knowledge is useful for optimizing the gas atomization process for Sn–Bi alloy particles. We believe that the present system provides a novel opportunity for studying and monitoring changes in the nanoscale structure, chemical composition, and morphology of bulk materials, such as catalysts, batteries, rubbers, and magnetic materials.



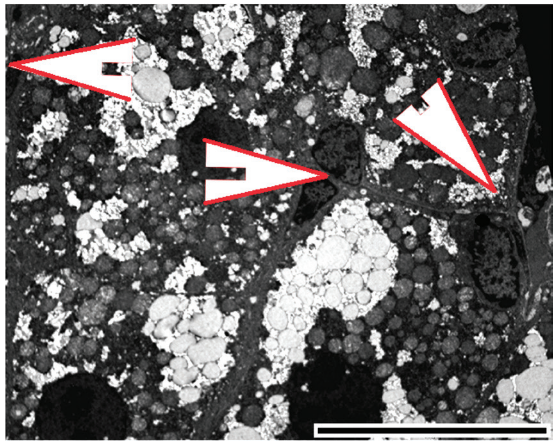
Phase images of Sn–Bi Particles by *in situ* hard X-ray ptychographic coherent diffraction imaging, showing remarkable phase shift due to two different crystal phases in the Sn–Bi alloy system and the Sn/Bi oxides at the surface.

Microscopy and Microanalysis

Biological Applications

Effect of Betaine on Liver Tissue and Ultrastructural Changes in Methionine–Choline Deficient Diet-Induced NAFLD by M Vesković, M Labudović-Borović, D Mladenović, J Jadžić, B Jorgačević, D Vukićević, D Vučević, and T Radosavljević, *Microsc Microanal* | doi:10.1017/S14319227620024265

A methionine–choline-deficient (MCD) diet is widely used for the development of nonalcoholic fatty liver disease (NAFLD) and nonalcoholic steatohepatitis (NASH) in animal models (Figure). The histopathological identification of NASH involves steatosis, hepatocellular injury in the form of ballooning predominantly located in acinar zone 3, lobular inflammation, and perisinusoidal fibrosis due to collagen deposition in the space of Disse. Ultrastructural modification of hepatocytes such as changes in the number of autophagosomes or changes in mitochondrial structure and nuclear chromatin may represent important early signs of altered hepatocellular function. Betaine reduces the degree of steatosis and inflammation and the size of mitochondria in MCD-induced NAFLD potentially by its antioxidant and anti-apoptotic effects. Betaine also stimulates autophagy by the activation of the Akt/mTOR signaling pathway with an increase in the number of hepatocyte autophagosomes. Induction of lipophagy in NAFLD may lead to the removal of accumulated lipids from hepatocytes that may represent an additional hepatoprotective mechanism of betaine.



Effects of betaine on liver ultrastructural changes in the MCD group in mice with NAFLD. Extensive microvesicular fatty change; numerous hepatic stellate cells/myofibroblasts (white arrowheads). Bar = 20 µm.