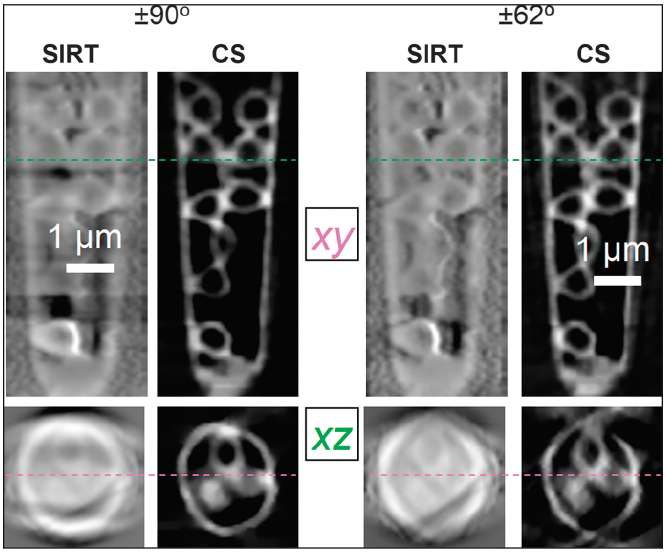
Highlights from Microscopy AND Microanalysis

Instrumentation and Software

Optimization of Three-Dimensional (3D) Chemical Imaging by Soft X-Ray Spectro-Tomography Using a Compressed Sensing Algorithm by J Wu, M Lerotic, R Leary, S Collins, Z Saghi, P Midgley, V Berejnov, D Susac, J Stumper, G Singh, and AP Hitchcock, *Microsc Microanal* 23(5) (2017) 951–56

Soft X-ray spectro-tomography provides 3D chemical mapping based on X-ray absorption properties. Radiation damage is intrinsic to X-ray absorption, so it is important to find ways to maximize useful information within a given dose. For tomography, using the smallest number of tilt series images that gives a faithful reconstruction is one such method. We show that compressed sensing (CS) methods applied to tomographic reconstruction provides faithful 3D reconstructions with a much smaller number of 2D projection images than required for conventional simultaneous iterative reconstruction technique (SIRT) reconstruction. We compare weighted back-projection, SIRT, and CS reconstructions applied to high-angle annular dark field scanning TEM (HAADF-STEM) and scanning transmission X-ray microscopy (STXM) tomography data sets. The effects of varying tilt angle increment and angular range on the tomographic reconstructions are examined. Optimization of the regularization parameter in CS reconstruction is explored and discussed. The comparisons show that CS provides improved reconstruction fidelity relative to SIRT, with increasing advantages as the number of tilt angles or the angular range is reduced.

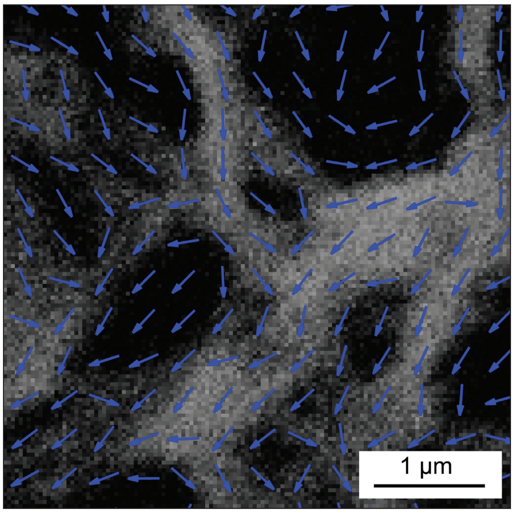


X-Y and *X-Z* slices from 3D distributions of polyacrylate in polystyrene microspheres inside a carbon nanopipette in water, derived from 23-energy C 1s STXM spectro-tomograms with (left) full (±90°, 46 angles) and (right) reduced (±62°, 16 angles) tilt angle ranges, processed by SIRT and CS.

Techniques and Biological Applications

Quantitative Studies of Endothelial Cell Fibronectin and F-Actin Co-Alignment in Response to Shear Stress by X Gong, X Zhao, B Li, Y Sun, M Liu, Y Huang, X Jia, J Ji, and Y Fan, *Microsc Microanal* 23(5) (2017) 1013–23

Exploring the relationship between the fibronectin (FN) and F-actin fiber alignment of endothelial cells (ECs) under mechanical stimuli is crucial to improve our understanding of the role that the extracellular matrix and cytoskeletal fiber alignment play in EC function and vascular graft development. Current studies are hampered by the lack of a reliable and sensitive quantification method of FN orientation. We have developed a feature enhancement method based on MATLAB to quantify FN and F-actin orientation. Our method divided the grayscale image converted from the original fluorescence images into a set of nonoverlapping blocks. The single local orientation in each block was defined by computing the orientation angle at the corresponding block center. Thus we obtained the locally constant direction of the unclear, broken, and irregular FN fibers. Our results demonstrated that FN and F-actin co-distributed and co-aligned parallel to the flow direction and that F-actin alignment played an essential role in regulating FN alignment in response to shear stress. These findings may provide new insight in vascular tissue engineering.



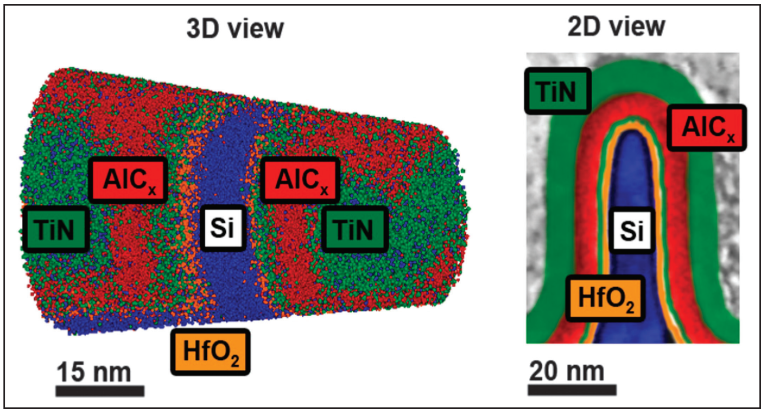
The fluorescence images were firstly divided into a set of non-overlapping blocks after grayscale transformation and normalization. The orientation vector (blue arrows) in each block was defined by computing the orientation angle at the corresponding block center with the least mean square estimation algorithm. A locally constant direction of fibers was thus obtained to represent an intrinsic property of the FN fibers, which is helpful to distinguish unclear, broken, and irregular fibers correctly.

Microscopy AND Microanalysis

Techniques

Three-Dimensional Nanoscale Mapping of State-of-the-Art Field-Effect Transistors (FinFETs) by P Parikh, C Senowitz, D Lyons, I Martin, TJ Prosa, M DiBattista, A Deavraj, and YS Meng, *Microsc Microanal* 23(5) (2017) 916–25

As transistor channel widths reach below 20 nm, device performance parameters, such as channel current density, can be affected by fluctuations in the channel width and fin wall roughness. This warrants the need for a deeper understanding of physical nanoscale features in individual transistors and their effects on device performance. Current scanning electron microscopy and mass spectrometry techniques do not provide the required resolution to probe the nanometer scale of the devices. Using atom probe tomography (APT) and scanning transmission electron microscopy energy dispersive x-ray spectroscopy (STEM-EDS), we provide a three-dimensional picture of commercial state-of-the-art 14 nm devices. Our techniques enable us to study the chemical composition of PMOS and NMOS fins in 3D, allowing for visualization of the fin and the individual gate dielectric layers. Differences in NMOS and PMOS, such as fin width, absence of Ge from NMOS fins, and thickness of the gate dielectrics, are consistent across both techniques. We believe APT is an important high-resolution 3D technique that will allow study of future transistor generations.



Left: Shows a 3D view of a NMOS fin with the Si fin and the gate dielectric layers; HfO2 and AlCx sandwiched between TiN layers obtained using APT. Right: 2D view of the NMOS fin using STEM-EDS.