New Applications in Energy Research Enabled by a Triple Beam, Dual Chamber FIB with Isotropic Tomographic Voxels

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Energy materials research relies heavily on a deep understanding of material and device microstructure to make advancements. Moreover, because these materials exist in complex devices constructed of many materials and interfaces between them, the critical information is often buried beneath the surface of a material specimen or encapsulated in a closed-form device. Furthermore, the final devices derive their performance from the nanoscale 3D arrangement and microstructures of the constituent materials involved. Recently, a commercial focused-ion beam scanning electron microscope was developed with an integrated fs-laser mill attached to the load lock of the microscope, opening the door to new and more powerful analysis approaches in energy materials research. Applications include rapid access to deeply buried structures for high resolution imaging and analytics, large area cross-section preparation, and massive material ablation for sample preparation of structures for, e.g. FIB-SEM tomography, TEM, APT, or X-ray nanoCT. Additionally, each of these may be correlatively guided by prior imaging with techniques like 3D X-ray microscopy to enable targeted analysis and preparation. By combining the laser mill with leading technologies for 3D FIB-SEM tomography with true isotropic voxels, this platform enables comprehensive quantitative analysis of energy materials at the nanoscale. We illustrate these concepts with a number of application examples and use cases demonstrating the utility of the approach.