High Resolution 3D X-ray Microscopy in the Laboratory

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3D X-ray microscopy has emerged as a powerful imaging technique that obtains information from a range of materials under a variety of conditions and environments. Recently, laboratory-based X-ray sources have been coupled with high resolution X-ray focusing and detection optics from synchrotron-based systems to acquire tomographic datasets with resolution down to 50 nm for nanoscale investigation and <700 nm for submicron investigation across a great span of sample dimensions. This talk will explore both the details of the optics involved in such a laboratory-based X-ray microscopes but also several important applications examples of how X-ray tomography has been used as a complement to destructive techniques.

Observing the evolution of microstructure buried deep within a sample on the identical region of a single sample can rapidly benefit materials modeling techniques, by avoiding the requirement to extrapolate based on statistical samplings from a large number of like specimens. This is largely a unique capacity of X-ray tomography and several examples of in situ and ‘4D’ experiments will be presented, including crack propagation in ceramics, porosity and permeability characterization, deformation of polymer foams under load and the evolution of defects in battery anode materials in lithium ion batteries. Soft materials, ranging from polymers to biological tissue, consistently pose challenges in generating contrast by several techniques, X-ray absorption included. We demonstrate the application of both phase propagation and Zernike phase contrast techniques on such materials. Finally, the workflow employing 3D & 4D X-ray microscopy as a complementary step prior to complementary high-resolution 2D and 3D techniques will be discussed.

References:


