Multi-length-scale x-ray computed tomography with sub-50 nm resolution for non-destructive 3D visualization and analysis

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Full-field transmission x-ray microscopy is an established imaging technique for visualization of the interiors of optically-opaque samples. The high penetration depth of x-rays coupled with methods of computed tomography enable non-destructive 3D analysis with very high resolution.

Traditionally, the projection-imaging approach has been employed, where resolution is typically limited by the size of the x-ray source spot. This often leads to restrictions on sample dimensions for high-resolution tomography. By increasing the resolution of the detector, however, these mechanical parameters may be relaxed, enabling ~1 μm resolution for large samples, often with little or no sample preparation.

By employing x-ray optics paired with a similar high-resolution detector, higher spatial resolution may be achieved. Using a Fresnel zone plate imaging objective with 35 nm outmost zone width and a detector with 16 nm pixel size, sub-50 nm spatial resolution has been routinely achieved. Due to the independence of source geometry, such resolution may be realized with either a laboratory or a synchrotron x-ray source.

Here, a multi-length-scale x-ray computed tomography (XCT) system will be presented utilizing both of the techniques described. Application examples ranging from biological research to materials science and the semiconductor industry will be demonstrated.