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Multi-scale 3D characterization with dark-field x-ray microscopy

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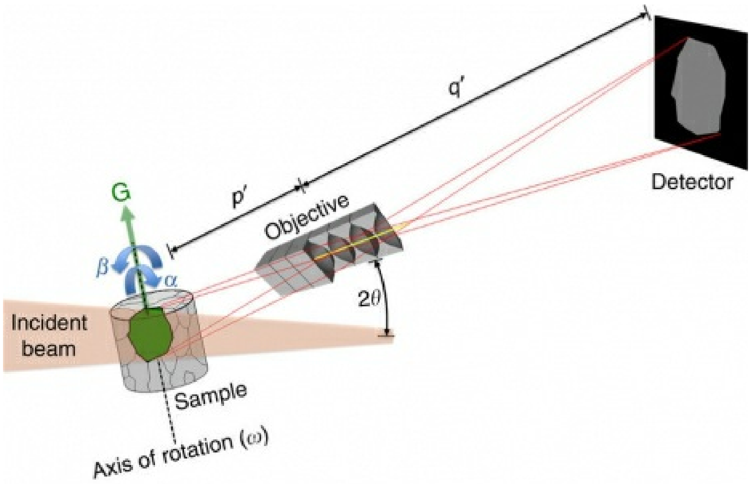
Grain boundaries, dislocations and domain walls create structural distortions that can strongly influence both local and global properties. Understanding how and over what range these distortions occur is crucial, but requires mapping strain and symmetry at the sub-micron scale without spurious effects from the sample geometry – a major challenge for many characterization techniques. Dark-field x-ray microscopy is a new way to map lattice strain and inclination in 3D. It is analogous to dark-field electron microscopy in that an objective lens magnifies diffracting features of the sample; however, the use of high-energy synchrotron x-rays means that these features can be large, deeply embedded, and fully mapped in seconds to minutes. Simple reconfiguration of the x-ray objective lens allows intuitive zooming between different scales down to a spatial and angular resolution of 70 nm and 0.001°, respectively. The technique is broadly applicable to crystalline matter, and is demonstrated here to map subtle, symmetry-lowering distortion fields around embedded domain walls, grain boundaries, and dislocations in ferroelectric crystals, ceramics and epitaxial films. These distortions extend much further than theoretical predictions – up to several μm – and result in significant strain inhomogeneity that lowers lattice symmetry throughout the majority of the material. This ability to directly characterize complex, multiscale phenomena in-situ is a key step toward formulating and validating multiscale models that account for the entire heterogeneity of materials.

[1] Simons, H., King, A., Ludwig, W., Detlefs, C., Pantleon, W., Schmidt, S., Stöhr, F., Snigireva, I., Snigirev, A., Poulsen, H. F., (2015), Nature Communications, 6098
[2] Simons, H., Jakobsen, A. C., Ahl, S. R., Detlefs, C., & Poulsen, H. F. (2016). MRS Bulletin, 41, 454-459



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