X-RAY MICRODIFFRACTION TECHNIQUES FOR MEASURING LOCAL MICROSTRUCTURE AND STRAIN DISTRIBUTIONS

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The physical properties of materials are generally determined by local structural and chemical inhomogeneities such as grain morphologies, precipitates or residual stress distributions. Spatially-resolved, nondestructive, quantitative measurements of such inhomogeneities can now be obtained using microdiffraction and microfluorescence techniques at high-brightness synchrotron facilities. At the XOR-UNI beamline at the Advanced Photon Source (APS), we have developed a polychromatic scanning microbeam capability with submicron spatial resolution in three-dimensions (3D). This structural probe provides real-space maps of the local crystal structure, orientation and strain tensor, and hence provides a new tool for understanding the role of mesoscale defects in determining materials behavior.

In this approach, broad-spectrum (~8-22 keV) undulator radiation is focused using a pair of achromatic Kirkpatrick-Baez (K-B) reflecting mirrors. Beam diameters of ~500 nm FWHM are now typical, and 90 nm focus has been demonstrated. The small beam size provides spatial resolution in two dimensions. Resolution in the third dimension (along the incident x-ray beam path) is accomplished by a scanning-wire differential aperture technique which uniquely determines the depth dependence for scattered x-rays [1]. Computer analysis of depth-resolved, white-beam Laue diffraction patterns yields the crystal structure, orientation and deviatoric strain tensor for each ~micron-sized local volume element in the sample. In addition, monochromator scans can be employed to determine the absolute strain tensor. Thus, a four-dimensional scan (x-y sample positions, wire, and energy) provides a full, quantitative 3D map of the microstructure inside a bulk sample. This microdiffraction technique has been applied in studies on a variety of 1D, 2D and 3D materials systems and processes, including nanostructures, thin films, grain growth and deformation microstructures. We will illustrate local strain mapping in epitaxial films and in directionally-solidified, phase-separated eutectic manganite systems.

[1] B.C. Larson *et al*, Nature **415**, 887 (2002).

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