Materials Science Using Submicron-Resolution Polychromatic X-ray Diffraction

J. D. Budai, B. C. Larson, G. E. Ice, N. Tamura, J.-S. Chung, W. Yang, K.-S. Chung, J. Z. Tischler, D. P. Norton, Oak Ridge National Laboratory*, Oak Ridge, TN; W. P. Lowe, E. L. Williams, Howard University, Wash. DC

The availability of intense, focused x-ray microbeams has enabled new classes of materials investigations with submicron spatial resolution. Our approach is based on the analysis of white-beam Laue diffraction patterns and consequently requires only sample translations rather than rotations. Polychromatic x-rays are focussed using a pair of elliptical Kirkpatrick-Baez mirrors, and beam diameters of ~0.5 micron FWHM have been achieved. Laue patterns are collected using a CCD area detector and analysis provides real-space maps of the phase, grain orientations (texture), and the local stress/strain tensor. Recent developments using a new technique have demonstrated submicron position resolution along the path of the incident beam, i.e. <1 micron resolution in all 3 dimensions.

We have initiated fundamental microdiffraction studies of several classes of polycrystalline and deformed materials. This talk will present results from a study of the epitaxial growth of oxide multilayer films on rolling assisted biaxially-textured substrates (RABiTS), materials which are under active development for superconducting wire applications. Grain-by-grain microdiffraction provides a combinatorial study of the orientation and strain of a large number of different vicinal grains grown on a single sample. At high growth temperatures, we find that successive layers are not strictly epitaxial; rather, each heteroepitaxial layer exhibits a crystallographic tilt consistent with a model combining elastic deformation at step ledges with the effects of misfit dislocations. In contrast, growth at low temperatures yields more closely aligned layers, revealing that reduced kinetics suppress the high temperature mechanisms.

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