920 CD
DOI: 10.1017/S1431927606067651

Microsc Microanal 12(Supp 2), 2006

Strain-resolved Polychromatic X-ray Microdiffraction

G.E. Ice, B.C. Larson, J.W.L. Pang, W. Liu*, and R. I. Barabash

Oak Ridge National Laboratory, Metals and Ceramics Division, MS-6118 1 Bethel Valley Road Oak Ridge TN 37831-6118

*Advanced Photon Source, Sector 34, Argonne National Laboratory, 9700 S. Cass Ave. Argonne Il 60439.

Polychromatic microdiffraction is a powerful method for characterizing the three-dimensional (3D) phase, local orientation and deviatoric-elastic-strain distributions in crystalline materials.[1,2] Measurements can be made on sub cubic micron volumes and on single-crystal, polycrystalline and deformed materials. The method is well suited to near-surface characterization, but can also probe 3D distributions mm's below the surface in low Z materials. Spatial resolution transverse to the incident beam is determined by the beam size. Spatial resolution along the beam is obtained by a method called differential aperture x-ray microscopy. [2]

Samples with small or highly deformed grains are the most challenging, because the local crystallographic orientation changes rapidly with position. For these samples, various strategies can improve strain resolution. For example, spatial resolution can be significantly improved by the use of more advanced focusing optics [3] and as spatial resolution improves, the local volume probed by the beam, can be accurately modeled by a crystal with a uniform defect density. We have recently demonstrated [4] the capability of forming polychromatic hard x-ray beams below 100 nm (Fig. 1) and with better vibration control and higher precision alignment control there is evidence that beams below 30 nm may be possible with optics already in hand. [5]

Another way to improve the strain resolution in deformed materials is to use energy scans to accurately determine the 2d spacing independent of deformation. With energy scans, a Laue reflection that is badly streaked due to the presence of lattice rotations within the crystal is resolved into a series of much sharper spots that move in angle as a function of energy. This approach allows the 2d spacing and local orientation of the Bragg planes to be unambiguously determined. In principle, the full strain-tensor distribution can be built up by studying the energy/angle/ sample volume dependence of many Laue reflections. Although this process is currently very time consuming, the development of much faster area detectors and the development of area detectors with good energy resolution will make such methods routine in the near future.

Applications of microdiffraction to such diverse and long-standing materials issues as 2D and 3D grain growth, deformation and the mesoscale structure of cracks are currently underway.

1. J.S. Chung and G.E. Ice, *J. Appl. Phys*. **86** 5249-5256 (1999).
2. Larson, B. C., Yang, W., Ice, G. E., Budai, J. D. and Tischler, J. Z. (2002) *Nature,* **415,** 887-890.
3. C. Liu, Lahsen Assoufid, R. conley, A. Macrander, G.E. Ice and J.Z. Tischler, *Opt. Eng*. **42** 3622 (2003).

4. W. J. Liu, G.E. Ice, J.Z. Tischler, A. Khounsary, C. Liu, L. Assoufid, A.T. Macrander Rev Sci. Inst. **76** 113701 (2005).
5. Ali Khounsary, Argonne National Laboratory private communication.
6. Research sponsored by the U.S. Department of Energy under contract DE-AC05-00OR22725. The UNICAT facility at the APS is supported by the U.S. DOE under Award No. DEFG02-91ER45439.

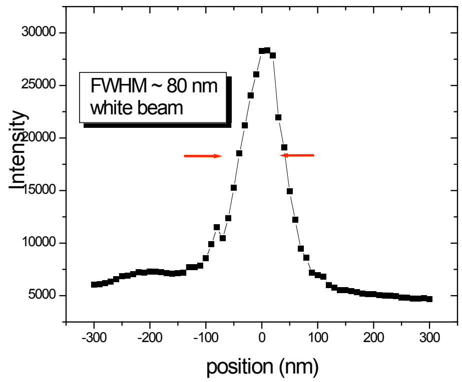

Fig. 1. Focused x-ray beams below 70 nm have been demonstrated with prospects to approach 30 nm beams in the near future.

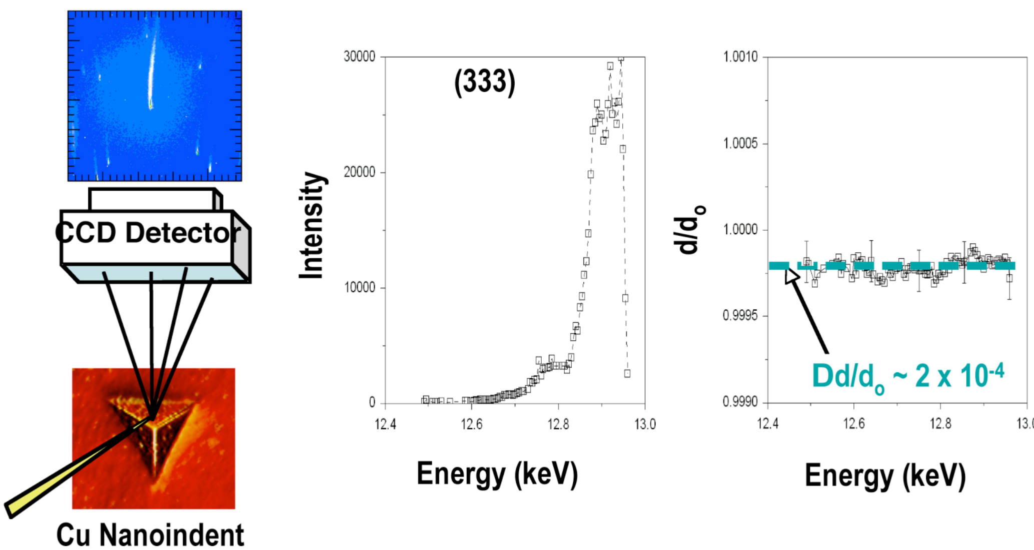

Fig. 2. The deformed metal of a Cu single crystal after indentation causes dramatic streaking in the Laue pattern. Although the streaking can in principle be due either to a strain gradient in the material or due to lattice rotations due to the presence of geometrically necessary dislocations, energy resolved measurements find that the 2d spacing is nearly unchanged and the streaking is due almost entirely to lattice rotations.

https://doi.org/10.1017/S1431927606067651 Published online by Cambridge University Press