CHARACTERIZING LOCAL STRAIN TENSORS, CRYSTALLOGRAPHIC ORIENTATIONS AND DEFECTS USING SUB-MICROMETER X-RAY BEAMS, AND COMPARISON WITH CONVENTIONAL LINE PROFILE ANALYSIS

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When fcc metals such as copper are plastically deformed, the stored dislocations self organize to form three dimensional cellular structures composed of cell walls with high dislocation density surrounding cell interiors with much lower dislocation density. Since dislocations interact primarily through their stress fields, the mesoscopic distribution of stresses within a cellular dislocation structure plays a critical role in the work hardening process, and this topic has received considerable attention in the literature over the past few decades. The most common approach for estimating these stresses was originally suggested by Mughrabi [Acta Metall. **31**, 1367 (1983)]. Here, a broadened asymmetric line profile is decomposed into two symmetric sub-profiles, corresponding to dislocation cell walls and cell interiors. The cell wall and cell interior elastic strains (and thus stresses) can then be determined from the sub-peak positions and the dislocation densities can be estimated from the sub-peak widths and shapes using approaches developed by Krivoglas, Wilkens, and others. Unfortunately, since the line profiles are a volume average over a severely heterogeneous dislocation microstructure, this general approach is highly model dependent. Validation of this methodology requires extensive quantitative diffraction data from *individual* cell interiors and cell walls in heavily deformed specimens.

The use of depth resolved, sub-micrometer X-ray beams for studying dislocation structures in plastically deformed metals has come a long way over the past five years. Thus, in our earliest work, we measured elastic strains (and thus stresses) within individual, isolated dislocation cell interiors [see L.E. Levine *et al*., Nature Mater. **5**, 619 (2006)]. These spatially resolved measurements found large elastic strains that are compressive in the unloaded tension samples and tensile in the unloaded compression samples. These results are qualitatively consistent with Mughrabi's model. However, the strains also exhibited large cell-to-cell variations that have important implications for theories of dislocation structure evolution, dislocation transport, changes in mechanical properties during reverse loading (Bauschinger effect and fatigue) and the extraction of dislocation structure parameters from X-ray line profiles. More recent experiments measured diffraction line profiles from numerous individual cell interiors and adjacent cell walls, allowing complete stress distribution functions to be determined. Of particular interest to the line profiling community, these spatially resolved diffraction measurements provide a welcome opportunity to directly test analysis methods for interpreting asymmetric line profiles from macroscopic sample volumes. In this talk, I will compare the results of a sub-profile analysis of an asymmetric line profile from plastically deformed Cu with corresponding microbeam measurements from a statistically robust sampling of cell walls and cell interiors. If time permits, I will also describe our recent progress in measuring both the crystallographic orientation and the complete elastic strain tensor from spatially resolved, sub-micrometer sample volumes within deformed metal specimens.