Application of non-destructive 3D orientation mapping for study of plastic deformation in micro- and nano-grained metals.

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In metals undergoing plastic deformation predominantly by dislocation glide the evolution of texture as a result of crystal lattice rotations resulting from constrained deformation provides a characteristic measure of the deformation process. A complete picture of these rotations requires spatially-resolved 3D orientation mapping in a non-destructive manner to allow changes in lattice orientation both between, and within, individual grains to be followed. Three examples of such measurements will be given in this presentation, covering plastic deformation of samples with average grain size either in the near-micrometer regime or of tens of nanometers. At the micron-scale a white-beam Laue microdiffraction technique using high brightness synchrotron radiation has been used to collect the diffraction signal from within a 3D volume with a sub-micrometer spatial resolution in each dimension. Analysis of data collected during tensile loading of aluminium with near-micrometer average grain size provides information on the percolation of plastic slip in the elastic-plastic regime. Tracking the evolution of crystal lattice orientations within grains in the same material to larger strains during tensile loading reveals a pattern of heterogenous plastic deformation, where the average grain rotations conform largely to those expected from advanced crystal plasticity models, showing some differences to the pattern of rotations obtained from 2D surface-based observations using electron backscatter diffraction measurements. For following grain rotations at the nanoscale a transmission electron microscopy method for 3D orientation mapping has been used, in combination with reciprocal space imaging during *in-situ* nano-pillar compression, to explore the changes in lattice orientations of nano-grained nickel with average grain size of approx. 20 nm. Unexpected lattice rotations are observed, where these are attributed to lattice-rotations upon unloading, driven by large back-stresses within the nanograined sample. The potential for application of this nanoscale 3D orientation mapping technique for other problems will also be discussed.

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