Coherent X-ray Diffraction imaging of strain in a single ZnO nanorod

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Abstract. Nanoscale structures can be highly strained because of confinement effects and the strong influence of their external boundaries. This results in dramatically different electronic, magnetic and optical material properties of considerable utility. Third-generation synchrotron-based Coherent X-ray Diffraction (CXD) has emerged as a non-destructive tool for three dimensional (3D) imaging of strain and defects in crystals that are smaller than the coherence volume. Prior to this work, measurements have been possible only at a single Bragg point of a given crystal because of the limited ability to maintain alignment; it has therefore been possible to determine only one component of displacement and not the full strain tensor. Here we report key advances in our fabrication and experimental techniques, which have enabled diffraction patterns to be obtained from six Bragg reflections of the same ZnO nanocrystal for the first time. All three Cartesian components of the ion displacement field, and in turn the full nine-component strain tensor, have thereby been imaged in three dimensions.

This talk will describe the CXD measurements method and the computational solution of the phase problem, which takes advantage of the fact that the continuous diffraction pattern of a nanocrystal can be "oversampled" with respect to the spatial Nyquist frequency. This leads naturally to the idea of a "support" constraint, which solves the phase problem. Under these conditions the inversion of CXD data to images is fairly routine and usually gives a result. The strain information is encoded in the spatial phase distribution of the resulting image. The observed phase at each point within the 3D object is the projection of the local displacement (wrt a reference lattice) onto the momentum-transfer vector, Q. In this way, three or more non-coplanar Q-vectors determine the vectorial displacement field and the spatial derivative gives the local rotation and strain tensors.

Suggested type of contribution: [X] INVITED Oral   [ ] Poster   [ ] no preference.

Topic: mark your preference [1] and second choice [2]

A - Experimental methods
[ ] A1 - Traditional laboratory techniques
[1] A2 - Strain mapping
[ ] A3 - In situ analysis
[ ] A4 - New and advanced techniques

B - Theory and Methodology
[ ] B1 - Residual stress modelling and computation (micro- and macro-scale)
[2] B2 - Microstrain studies
[ ] B3 - Texture-stress relationships
[ ] B4 - Grain interaction mechanisms and elasto-plastic behaviour of materials
[ ] B5 - Multiscale modelling and scale bridging aspects

C - Applications
[ ] C1 - Residual stresses in thin films, coatings, multiphase materials and composites
[ ] C2 - Behaviour of components with residual stresses
[ ] C3 - Generation of residual stresses by manufacturing and processing of materials
[ ] C4 - Residual stresses and phase transformations
[ ] C5 - Residual stresses and design
[ ] C6 - Residual stress relaxation