IN-SITU BRAGG COHERENT X-RAY DIFFRACTION DURING TENSILE TESTING OF AN INDIVIDUAL AU NANOWIRE

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Nanomechanical testing methods have drawn significant attention in both scientific and industrial research fields owing to unique deformation mechanisms in constrained volumes that underpin new property regimes. In-situ imaging equipment is now routinely employed to monitor the live evolution of material response during mechanical loading, with many of the testing developments tailored for electron microscopes (EMs). More recently, progress towards quantitative in-situ testing at synchrotron beamlines[1–3] enabled by innovations in source brightness, focusing optics, and large size detectors has been made. Novel techniques such as Bragg coherent X-ray diffraction promise 3D information with phase information related to displacement fields (elastic strain, defects) within the material. However, despite the rich information that can be collected, many challenges arise in the realization of in-situ imaging of single nanostructures using such methods, including meticulous sample preparation and complex data analysis in retrieving phase information.

In this work, we present the first successful systematic single nanowire tensile test while simultaneously recording 3D Bragg peaks using coherent X-rays. Defect free single crystalline <110> oriented Au nanowires were grown by physical vapor deposition[4] and a 100 nm nanowire was harvested from the substrate and transferred to a nanotensile stage within a microelectromechanical system chip, which can be mounted to a coherent X-ray beamline. 3D Bragg peaks were recorded with nanofocused beam combined with 2D detector at each displacement step to discuss the evolution of strain and rotation of the nanowire during the tensile test. The movement of the peak sensitively depicted evolution of the deformation of the nanowire. In addition, the 3D Bragg coherent X-ray diffraction followed by phase retrieval has shown to reveal the internal strain state of nanostructure[5] and this advanced technique is expected to reveal unique surface effects that mediate the overall mechanical performance of nano-scaled materials.

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