Experiment Brief

OneView Camera

Title

Torsional deformation in subnanometer MoS interconnecting wires.

Gatan instrument used

OneView® IS camera is the fastest and highest performance fiber coupled CMOS camera, displaying and saving 16 MP images to disk at up to 25 fps to observe dynamic details in *in-situ* TEM experiments.

Background

With development of new 2D materials, there is emerging interest in production of interconnecting nanowires that strongly bond to the edge of 2D sheets, rather than weakly adhere to the surface. While there have been some theoretical studies of the atomic structure of nanowires during torsional deformations, there is little experimental work on probing the rotational twists, such as torsional effects, on the crystal structures of suspended nanowires.

Materials and methods

The MoS_2 specimen was heated to 400 °C and MoS wires were formed *in situ* by constant electron beam irradiation of the monolayer using an 80 keV electron beam in an aberration-corrected transmission electron microscope. After the MoS wires formed, they were stable for sufficient time to collect more than 1000 frames over several minutes.

The OneView camera was used at 4k x 4k resolution and up to 10 fps to track the real time atomic level torsional dynamics of subnanometer wires of MoS interconnecting monolayer regions of MoS_2 (free from carbon residue to eliminate its effect on nanowire formation).

After careful study of high resolution and excellent signal-to-noise ratio TEM images, the researchers found that the MoS crystal structure rotation was driven by changes to the attachment of one end of the suspended MoS wire or in the number of unit cells that make up the wire length. An example of such changes is shown in Figure 1, where a lattice segment was lost while no changes were observed at the anchoring sites. This effectively shortened the wire and introduced torsional rotation in the wire and was followed by loss of another segment in the wire length to return it back to the original orientation.

In addition, it was shown that while elastic torsional flexibility of the MoS wires helped their self-adapting connectivity during the structural changes, plastic torsional deformation could also occur for those wires that contained defects in their crystal structure (generation of defects helps relieve the torsional strain). These results reveal important insights related to the competing processes of shearing and crystal rotation to compensate for induced torsional strain in the system.

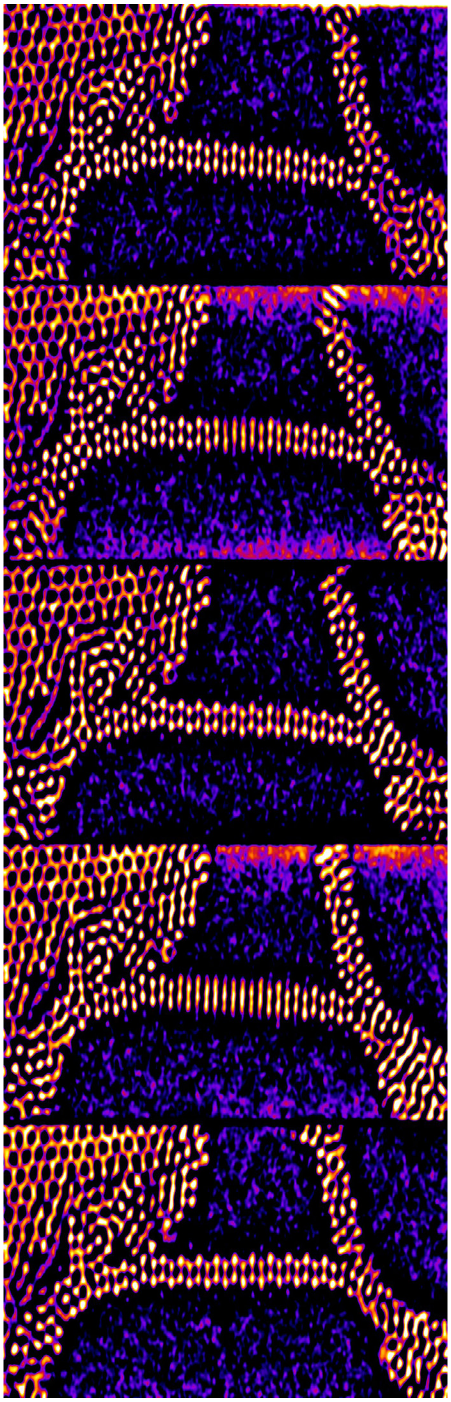

Figure 1. The figure shows a time series of aberration-corrected TEM images of a MoS nanowire changing length and undergoing torsional rotations that cause blurring of the lattice contrast in the middle section of the wire.

Summary

Using the OneView camera's fast frame rate with high sensitivity, dynamic results reveal changes in the MoS structure and made it possible to show that subnanometer MoS interconnecting wires exhibit both bending flexure and rotational "elastic" torsion.

Credit(s)

A special thanks to Dr. A. L. Koh (Stanford University) and Dr. J. H. Warner (University of Oxford).

EB-OneView-Torsional-CA-FL2-NOV20