Characterizing low-dimensional materials by using advanced electron microscopy

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Cretu Ovidiu
Atomic Structure and Physics Field / Electron Microscopy Group
CRETU.Ovidiu@nims.go.jp | https://samurai.nims.go.jp/profiles/cretu_ovidiu

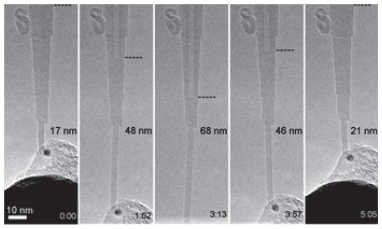
Background

Atomic-scale defects determine the properties of current materials. Despite the excellent structural data available for these objects, their effect on the material is in most cases determined indirectly, or predicted based on theoretical calculations.

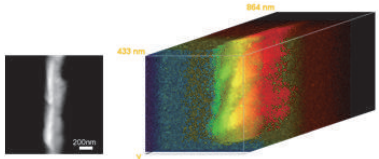
Aim

The goal of this research is to relate the atomic-scale structure and chemical properties of defects in low-dimensional materials to their performance. This will be achieved through a combination of state-of-the art microscopy techniques and innovative in-situ experiments using specialized sample holders.

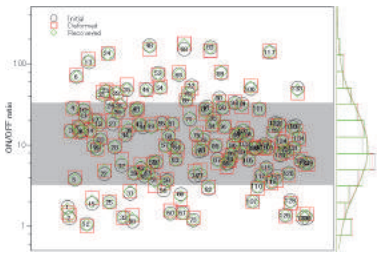
Advanced Research Topics



1) Carbon nanotube telescoping: the exposed core of a nanotube can be contacted with a metallic probe and reproducibly pulled out then re-inserted, while measuring electrical properties at each movement step. Due to the low friction between the nanotube walls, a large number of cycles can be performed, highlighting the stability of these structures, which represent the ultimate flexible contacts.



2) Luminescence center mapping in CdS: optical data can be acquired from individual nanowires by positioning a fiber close to the sample, through cathodoluminescence. This method reveals the distribution of centers with nanometer-precision, allowing us to associate them with various intrinsic defects.



3) Optoelectronic measurements on CdS: the electrical properties of individual nanowires are probed before, during and after mechanical deformation, while irradiated with a light source. This complex experiment involving 3 simultaneous stimuli reveals details such as their optical ON/OFF ratios and wavelength-dependent photocurrent generation.

Publications

- O. Cretu, C. Zhang, D. Golberg, Appl. Phys. Lett. 110, 111904, 2017
- C. Zhang, O. Cretu, et.al., Nano Lett. 16, 6008-6013, 2016
- K. Moore, O. Cretu, M. Mitome, D. Golberg, Carbon 107, 225–232, 2016

Summary

- In-situ experiments are performed on individual nanoscale objects inside a microscope.
- The measured properties of these objects are correlated with their structure, obtained by observing them at high magnification.

Research outcome

- Our methods allow us to measure properties of individual nanostructures which would not be accessible otherwise.
- The techniques developed in these studies can be readily extended to other materials.