Nanoengineering and electrochemical probing of carbon nanostructures in TEM

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1. Introduction

Uncovering mechanical, electrical and optical properties of a carbon nanomaterial, in particular on the individual nanostructure level, is of key importance once its smart integration into modern nanotechnologies is concerned. However, in many cases, these properties have been measured by means of the instruments without direct access to the material atomic structure, its crystallography, and existing defects. Therefore, the acquired results can hardly be linked to a particular morphology, structure, and defect networks. A wide scatter of data has commonly been observed between various samples and research groups. This has typically confused engineers and technologists and led to many uncertainties with respect to carbon nanomaterials' emerging applications.

2. Summary of results

I will demonstrate how diverse state-of-the-art *in situ* transmission electron microscopy (TEM) techniques can be effectively employed for a detailed property and function analysis of carbon nanomaterials, *e.g.,* individual nanotubes and graphene-like nanosheets [1-3]. Young's moduli, fracture strength and toughness, plasticity and electrical conductance may now be precisely determined inside TEM, while employing piezo-driven probes, sensors and nanomanipulators inserted into the microscope column (Fig. 1).

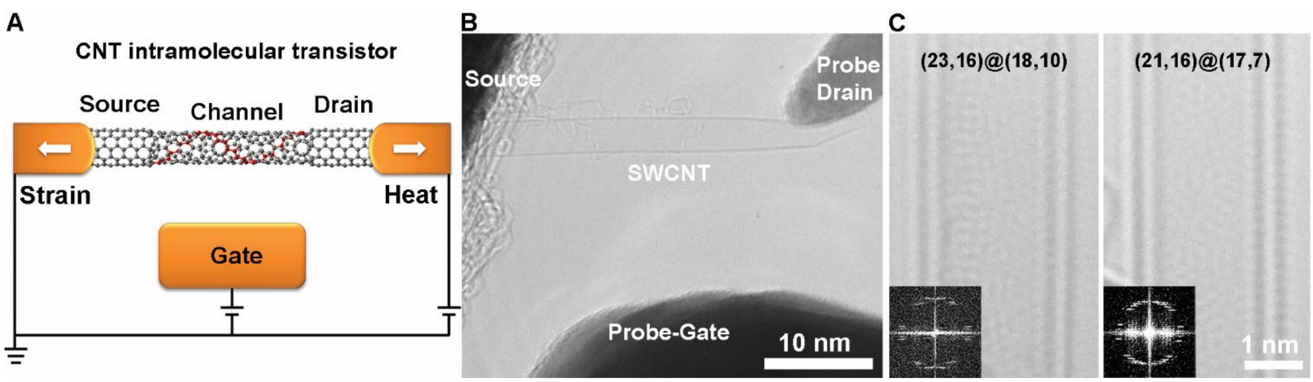

Fig. 1. Fabrication of a CNT intramolecular transistor. **(A)** Schematics of a CNT transistor with local chirality transformed by mechanical strain and Joule heating. **(B)** TEM image of a single-wall CNT transistor with a fixed source electrode, a probe as drain electrode, and another probe as gate. **(C)** Lattice-resolved TEM images and FFT patterns of a double-wall nanotube before and after chirality transition [3].

3. Acknowledgement

In situ TEM Project at QUT is supported through an Australian Research Council (ARC) Laureate Fellowship FL160100089 (2017-2022). The author is grateful to many colleagues at QUT, *i.e.,* Drs. Joseph Fernando, Konstantin Firestein and Chao Zhang, and the National Institute for Materials Science (NIMS), Tsukuba, Japan, *i.e.,* Drs. Daiming Tang, Ovidiu Cretu, Mingsheng Wang, Xianlong Wei and Naoyuki Kawamoto, for their key experimental contributions to multiple *in situ* TEM projects over the years.

4. References

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