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Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

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Submission Details

Submission Type / Conference Track: Abstract Submission

In-situ ETEM Study of Nucleation and Growth Termination Mechanism of Single-Wall Carbon Nanotubes

Lili Zhang¹, Jens Kling¹, Maoshuai He², Thomas W. Hansen¹, Hua Jiang³, Esko I. Kauppinen³, Jakob B. Wagner¹

Organization(s): 1: Technical University of Denmark, Center for Electron Nanoscopy, Fysikvej 307, 2800 Kgs. Lyngby, Denmark; 2: Shandong University of Science and Technology, School of Materials Science and Engineering, 266590 Qingdao, People’s Republic of China; 3: Department of Applied Physics, Aalto University School of Science, P.O. Box 15100, FI-00076 Aalto, Finland

Submitted by: Lili Zhang (Technical University of Denmark, DK), ID: 1030

Presenting Author: Zhang, Lili llqingk@gmail.com

Topics: NT17: Synthesis and Processing

Keywords: single-wall carbon nanotube, catalytic nucleation and termination mechanism, multiple nucleation, in-situ, transmission electron microscopy

Abstract

The promising application of single-wall carbon nanotubes (SWCNTs) in nano-electronics, strongly depends on the controllability of their atomic structures. Much effort has been devoted to designing novel catalysts and optimizing synthesis parameters. In this respect, it is critical to reveal the roles of catalysts and carbon source on the SWCNT structures, which requires the in-depth understanding the growth mechanism of SWCNTs, especially at the initial and final growth stages. However, the detailed microscopic secrets of SWCNT nucleation and growth cessation are still lacking. Here we present direct experimental evidence on the nucleation [1] and termination [2] of SWCNTs by using environmental transmission electron microscopy (ETEM) [3]. We demonstrate the long-lasting activity of catalysts based on the fact of multiple nucleation from the same particle. Insufficient active carbon species and a certain amount of stresses exerted at the tube-catalyst interface are proposed as the main cessation reasons in this study. Therefore, special attention should be paid to the stability of carbon supplies and the growth environments in future studies. Additionally, crystalline metal catalysts with low carbon solubility were also comparably studied, further confirming the above conclusion. All of these nucleation and termination mechanisms support many phenomena of CNT growth and provide valuable insights which enables further control over the structure of SWCNTs individually or on a macroscale.

Reference