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Direct FC-CVD Synthesis of SWNT Thin Films with Color and C₆₀-SWNT-Graphene Hybrids

Dec. 2 | Bldg. 101
Monday, 4 PM | Seminar Room on the 1st floor

Abstract: We discuss the floating catalyst chemical vapor deposition (FC-CVD) synthesis of single walled carbon nanotubes (SWNT)s, especially the tuning of the tube atomic structure i.e. (n,m) distributions and subsequently the thin film color. Ferrocene has been used as the catalyst nanoparticle precursor and CO, CH₄, C₂H₄, ethanol, methanol and toluene as the carbon precursors, with CO₂, H₂O, thiophene and H₂S as the respective additives to tune (n,m) distributions. By introducing various amount of CO₂ in FC-CVD with CO as the carbon source and in-situ ferrocene decomposition generated Fe catalyst nanoparticles, we directly synthesized and dry-deposited SWNT films with tunable (n,m) i.e. helicity distribution as well as tunable colors [1]. When operating the FC-CVD reactor at the ambient pressure and at 850 °C temperature with 0.25 and 0.37 volume percent of added CO₂, the SWNT films display green and brown colors, respectively. We ascribed various colors to suitable diameter and narrow (n,m) distributions, which were determined in detail using the electron diffraction. We will present results on using ethylene as the carbon source in nitrogen carrier gas with the addition of H₂O vapor to synthesize SWNTs with extremely narrow (n,m) distribution and directly deposit colorful films. Also, we will discuss studies on SWNT synthesis when using alcohols as carbon sources with thiophene as the growth promoter. When adding methanol with ethanol, we enhance the fraction of semiconducting tubes. Finally, we present interesting recent results on the simultaneous FC-CVD synthesis of fullerenes, graphene and SWNTs, as well as combining SWNTs and graphene for the transparent, conducting film [2].

References:

- [1] Y. Liao et al. *J. Am. Chem. Soc.* **140**, 31, 9797 (2018).
[2] Y. Liao et al., *ACS Nano* DOI: **10.1021/acsnano.9b05049** (2019).

Dr. Esko I. Kauppinen is the Vice-Dean at the Aalto University School of Science and Professor at the Department of Applied Physics. He has published more than 450 scientific journal papers e.g. in *Nature Nanotechnology* and *NanoLetters* with over 17 200 citations. He has given 130 invited conference talks and 230 talks at companies and universities. He is considered the world leading author in the carbon nanotube synthesis and thin film applications. He is the founder of the companies Canatu Oy (<http://www.canatu.com>), MetalCirc Oy (<https://www.metalcirc.com/>) and Teicos Pharma Oy (www.teicospharma.com). He is the first Finnish recipient of a UNESCO Nanosciences Medal, which he received 2018.

Special Seminar

You are cordially invited to attend!