The evolution of species in carbon nanotube ensembles during chemical vapor deposition and gas phase destruction

P. Finnie[1,2], P. Vinten[2,1], A. Li-Pook-Than[2,1],
P. Marshall[1], J. Lefebvre[1]
[1]National Research Council Canada
1200 Montreal Road, Ottawa, ON, Canada K1A 0R6
[2]Department of Physics, University of Ottawa
150 Louis Pasteur, Ottawa, ON, Canada K1N 6N5

Key characteristics of as-grown ensembles of carbon nanotubes in general include their species distributions (*i.e.* diameters, chiralities) and their crystallinities. These parameters for *as-grown* nanotubes are very sensitive to synthesis parameters and they can also be manipulated by post-growth processing by exposure to ambient gas. How nanotube ensembles evolve under controlled reactor conditions is very reproducible and intricate on a fine scale, but the origins of this evolution are still not fully clarified. Here, we use *in situ* and *ex situ* optical approaches to track the evolution. We explore how simple energetic models connect to this data and suggest new explanations.

Here carbon nanotube forests and surface nanotubes are synthesized by chemical vapor deposition using acetylene sources and cobalt nanoparticle seeds, among other combinations. We use *in situ* optical imaging to track forest growth in real time and *ex situ* Raman spectroscopy to characterize the nanotube distributions post-growth. We relate the observed results to simple growth models.

We also perform experiments in which nanotubes are destroyed by etching with the gas ambient. Etching can be viewed as an inverse process to chemical vapor deposition, and its effects can likewise be finely tuned. Using *in situ* Raman spectroscopy we investigate the time evolution of nanotube destruction via gas phase etching. These experiments reveal an intricate dynamical evolution and provide additional means to manipulate species distributions as well as crystallinity.