

Direct observation of carbon nanotubes growth

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A complete and atomic level understanding of the nucleation of carbon atoms on metal catalysts during chemical vapor deposition (CVD) process is required for the controlled fabrication of carbon nanotubes. This can be achieved through time-resolved *in-situ* ultra-high vacuum transmission electron microscopy (UHVTEM) studies and density functional theory (DFT) calculations. [1-3] In this presentation, I will give the initial nucleation process of carbon atoms on metal surfaces, as well as the growth sequence of single-walled and multi-walled carbon nanotubes. The SWNTs preferentially grow on smaller sized catalyst (diameter ≤ 6 nm) through base-growth mechanism, while larger Ni catalyst results in MWNTs formation. It is showed that the catalytic growth of nanotubes involves the *adsorption – incubation - catalyst shape transition – nucleation - growth* process steps. Graphene layers do not form spontaneously as the coverage of carbon-adsorbates increase. It occurs only after a shape transition of Ni catalyst has resulted. The Ni catalyst particle shape transition must occur for facile nucleation of graphene as it alters the potential energy surface of the reaction and provides an alternative pathway with a lower activation energy barrier for nucleation and growth.

References

- [1] M Lin et al., Nano Lett. 6 (2006) 449.
- [2] M Lin et al., Nano Phys. 7 (2007) 2234.
- [3] S Helveg et al., Nature. 427 (2004) 426.

