Optical studies of the growth kinetics of individual carbon nanotubes

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Abstract

Carbon nanotubes (CNTs) due to their unique properties are promising materials for electronic and optical applications. However, several unsolved problems stand on the way toward their practical usage, especially the direct synthesis of CNTs with desired chirality and structure. To address this question, our team developed optical methods to image individual CNTs in real growth conditions (at ambient pressure, on a substrate) and relate their growth kinetics with their chirality. More precisely, we grew horizontally-aligned carbon nanotubes on quartz substrate by chemical vapour deposition (CVD)1 varying the temperature and precursor pressure during the synthesis. Such a substrate-aligned growth allows us to collect in situ optical images of nanotubes by a unique optical setup2. This imaging technique provides crucial information about the nanotube growth kinetics such as their growth rate, lifetime and nucleation time with high temporal resolution (down to 10 ms). Further Raman analysis of grown CNTs3 completes our set of data with information about the nanotube chirality and defectiveness thus allowing us to correlate nanotube structure and growth kinetics. The Raman analysis of CNTs on quartz substrate is known to be complicated by radial deformation and axial strain but our study revealed that a careful analysis of these information-rich secondary Raman features (beside the classical RBM frequency and G-band shape) can be used to precisely assign the CNT chirality. This allowed us to precise the relation relating the RBM frequency and the CNT diameter for CNTs grown on quartz.

References

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