Towards tunable growth of SWCNTs by floating catalyst chemical vapor deposition using inline Raman spectroscopy

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Realizing stricter control over single-walled carbon nanotube (SWCNT) properties and architectures during large-scale synthesis is key to enabling many emerging applications. However, many challenges must be overcome in order to make substantial progress towards this goal. To this end, we have invented a non-destructive and scalable process for real time monitoring of SWCNTs produced by floating catalyst chemical vapor deposition (CVD) reactor using Raman spectroscopy. Reaction parameters (e.g. temperature, precursor and gas feed rates) are varied, and SWCNTs are collected on a filter at the exhaust end. Immediately following deposition, the filter, which is housed in a motorized spool, is advanced and analyzed with a fiber optic Raman probe. The resulting spectrum can be correlated to important characteristics such as yield, quality and physical properties (length, diameter etc.) of the SWCNTs. Furthermore, this feedback can be used as the input for optimizing CVD process conditions autonomously using machine learning algorithms. Using this system, we have been able to evaluate a panel of reactant additives that can be used to tune the diameter, yield and quality (defect density) of SWCNTs.