Diameter Dependence of Vertically-Aligned Single Walled Carbon Nanotubes for use as Counter Electrodes in Dye Sensitized Solar Cells

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Abstract:

Dye sensitized solar cells (DSSCs) are electrochemical devices that convert light into electrical energy and are viewed as sustainable alternative energy sources. In comparison to conventional Si-based solar cells, the manufacturing cost of DSSCs are substantially low but the highest reported efficiency is much lower; 30% for conventional solar cells and ~10% for DSSCs. Despite research and development efforts, there has been very little gain in overall efficiency of DSSCs over the past 10 years. An improvement in the fill factor, such as replacing the Pt counter electrode of DSSCs, could bring the efficiency of DSSCs to the level of conventional solar cells. Carbon nanomaterials such as vertically-aligned single walled carbon nanotubes (VA-SWCNT) have been shown to be viable candidates for this effort. Single-walled carbon nanotubes (SWNTs) have been intensively exploited for solar cell applications owing to their outstanding mechanical, electrical and optical properties. In our project, we will be changing the diameter of semiconducting SWNTs from 2 nm to 1 nm, resulting in the three-fold increase of the band gap. By changing the concentration of cobalt and molybdenum, we can change the diameter of the VA-SWCNT and in turn change the active surface area and series resistance of the DSSC. We fabricated VA-SWCNT using an alcohol-catalytic chemical vapor deposition method (ACCVD) and characterize them using Raman spectroscopy, absorption spectroscopy, and scanning electron microscopy (SEM).

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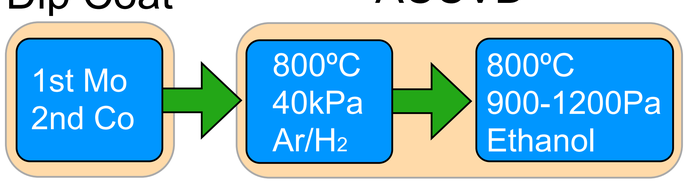
Introduction

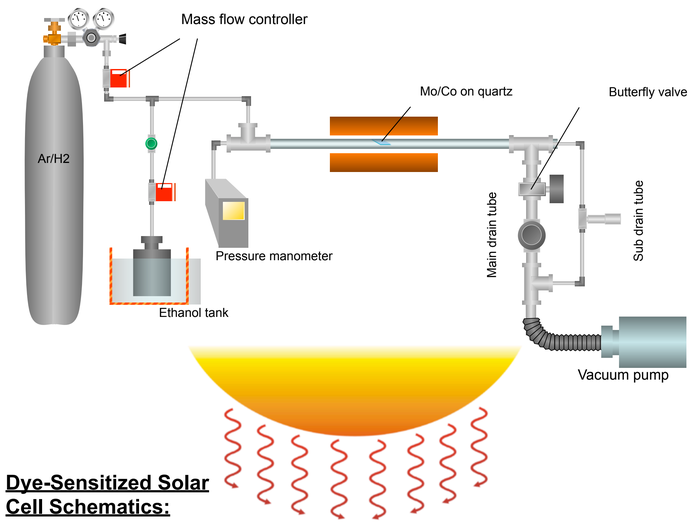
Goal: Observe effects of various diameters of vertically-aligned single walled carbon nanotubes (VA-SWCNT) on dye-sensitized solar cells (DSSC).
Motivation: VA-SWCNT have great electrical and optical properties. DSSC have low cost and high energy-conversion efficiency.

Procedures

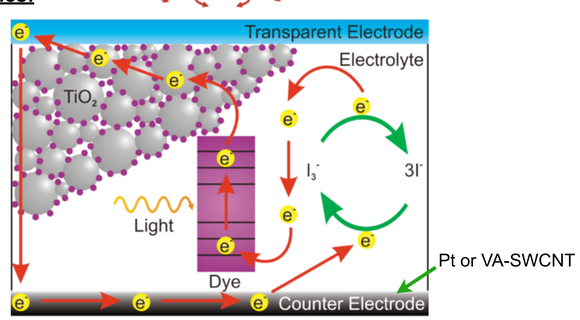
- Prepare quart and silicon substrates using dip coat method.
- Independent variable = cobalt concentration



ACCVD Schematics:



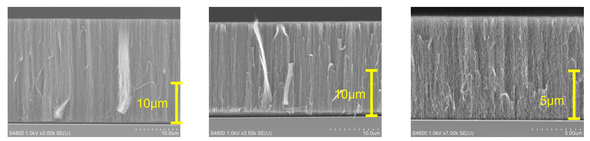
Dye-Sensitized Solar Cell Schematics:



Characterization & Results

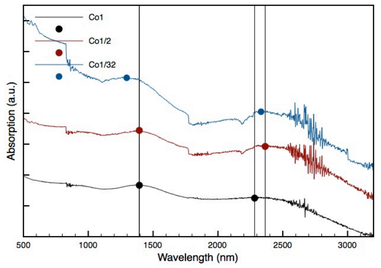
Characterization of VA-SWCNT:

1.SEM to determine the height of VA-SWCNT.

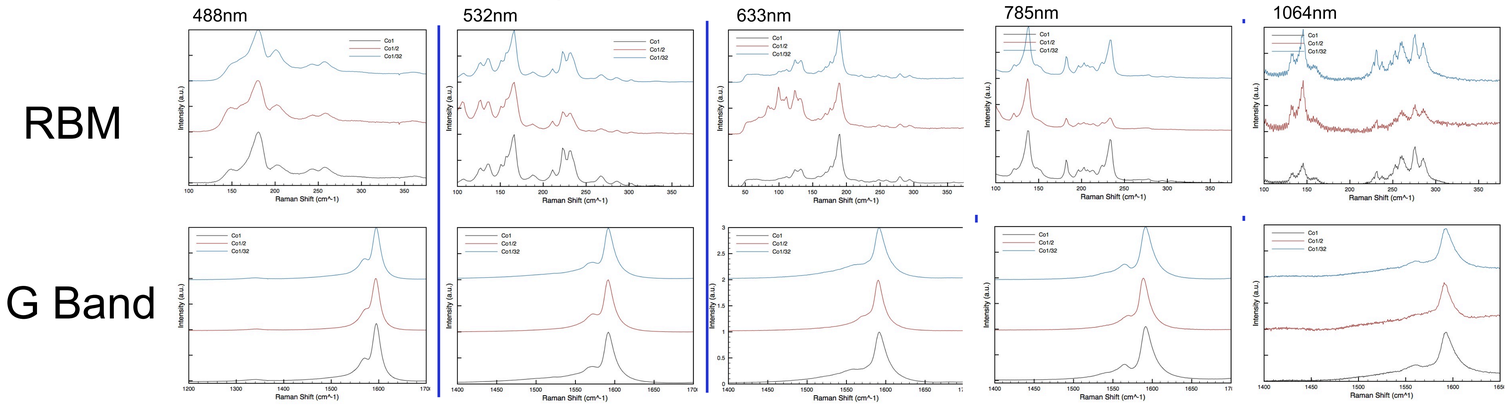


Co1 (26μm) Co1/2 (20μm) Co1/32 (11μm)

2.UV-vis-Absorption of VA-SWCNT to observe the shift of E11 peaks as concentration of Co changes.



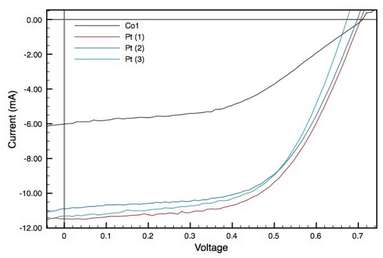
3.Raman Spectroscopy of VA-SWCNT at the Radial Breathing Mode (RBM) and G Band to characterize the multiple chiralities in each set of carbon nanotubes.



Dye-Sensitized Solar Cell Results:

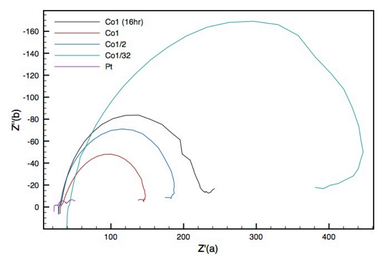
1.JV Curve shows differences between Pt and VA-SWCNT counter electrodes.

Current vs. Voltage



2.Impedance also demonstrate DSSCs differences of cobalt concentration.

Impedance



Conclusion

- CNT can replace Pt as counter electrode.
- Rate of VA-SWCNT may have also affected the power of DSSC.
- Impedance shows diameter dependence.
- Due to unstable chamber, more experiments need to be run.

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References & Acknowledgements

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