POPULATION ANALYSIS OF DIFFERENT CHIRALITIES IN THE (8,8) & (9,9) FAMILIES IN ARMCHAIR-ENRICHED SINGLE-WALLED CARBON NANOTUBE SAMPLES VIA RESONANT RAMAN SPECTROSCOPY

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Resonant Raman spectroscopy offers a nondestructive way to distinguish between the metallic and semiconductor nanotubes in mixed samples by determining the vibrational and rotational modes in molecules. Such optical characterization can be applied to many areas of nanotechnology, such as the creation of a wire spun only out of metallic carbon nanotubes, a material with far less electrical resistivity than that of copper. In order to identify the (8,8) & (9,9) family of nanotubes with resonant Raman spectroscopy, a tunable dye laser was pumped with an Nd: YAG laser. Different excitation wavelengths (570-615 nm) were scattered off of nanotube samples that had undergone density gradient ultracentrifugation (DGU). A charge coupled-device (CCD) camera was used to record the scattered light from the high resolution spectrometer. We see that the radial breathing modes in the Raman spectra indicate strong intensity of the armchair [i.e. (8,8)] and near-armchair [such as (9,6)] species within each metallic family. Additionally, the removal of other non-armchair species (both metallic and semiconducting) allows for the clean observation of a single-mode G-band peak, another hallmark of the presence of armchair nanotubes. Taken together, our results confirm that DGU strongly enriches toward large chiral angle, metallic nanotubes and specifically the armchairs (8,8) and (9,9).

Population Analysis of Different Chiralities in the (8,8) & (9,9) Families in Armchair-Enriched Single-Walled Carbon Nanotube Samples via Resonant Raman Spectroscopy

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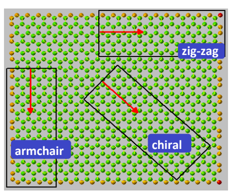
1. Objective

To produce a resonant excitation profile of RBM in SWNTs to determine the different chiralities in DGU samples

2. Introduction

Purpose of Metallic Nanotubes

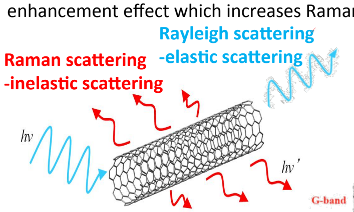
Construction of armchair quantum wire:
- A wire of **minimal** electrical resistance
- A wire consisting of armchair nanotube chiralities



SWNT Chirality
- HiPco
- Metallic-enriched through **density gradient ultracentrifugation**

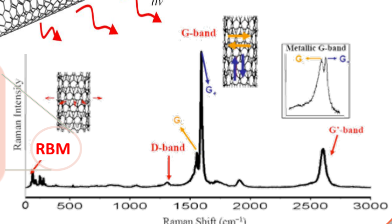
Resonant Raman Spectroscopy

Resonant raman-
enhancement effect which increases Raman scattering



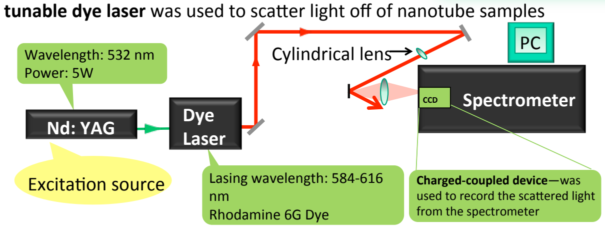
Raman Scattering
- Stokes scattering
- Anti-stokes scattering

Radial Breathing Mode: isotropic vibration in radial direction that specifies (n, m)



3. Methods

A **tunable dye laser** was used to scatter light off of nanotube samples



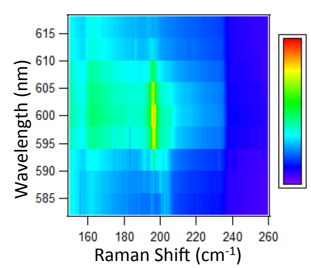
- Frequency calibration with neon lamp
- Intensity calibration with CCl_4

Analysis

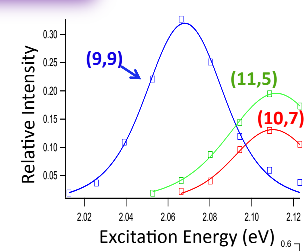
$$I_{Raman} = gN \times \left| \sum_{ij} \frac{M^{a,j}_{e\text{-}o} M^{a,j}_{e\text{-}ph} M^{ij}_{e\text{-}o}}{(E_{laser} - E_{ii} - i\gamma)(E_{laser} - E_{ii} - \hbar\omega_{ph} - i\gamma)} \right|^2$$

- Igor was used for peak analysis
- Peaks were fitted with a Lorentzian curve
- Cubic baseline subtraction

4. Results

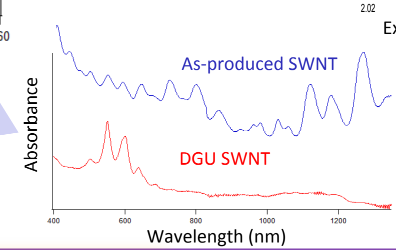


Resonance Excitation Map
Excitation map shows a 3D plot of the RBM peaks observed from the DGU sample

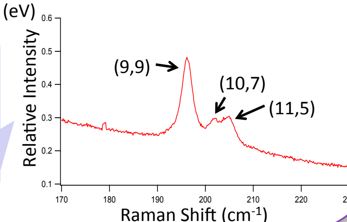


Resonance Excitation Profile
REP shows that a majority of the sample is dictated by the (9,9) SWNT chirality

Absorption Spectra
- Sharpening of metallic features (450-650 nm)
- Suppression of semiconductor features (650-1300 nm)



RBM Resonance Spectrum
RBM peak at 596 nm excitation



5. Conclusion

- Resonance profile was observed for (9,9), (11,5), and (10,7) chirality SWNTs
- Relative abundances of the (9,9), (11,5), and (10,7) chiralities in the sample were determined
- DGU metallically enriches samples with armchair SWNT

6. References

[1] E. H. Haroz, et al. *ACSNano*. 4, 4 (2010).
[2] http://academic.pgcc.edu/~ssinex/nanotubes/

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