PREPARATION OF SINGLE-WALLED CARBON NANOTUBE SAMPLES FOR MICROPHOTOLUMINESCENCE

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This study investigates whether or not poly(methyl methacrylate) (PMMA) increases the photoluminescence (PL) signal emitted from individual single-walled carbon nanotubes (SWCNTs). PL from SWCNTs displays blinking rather than a constant signal over time, thereby reducing the total signal collected. Increasing the PL signal is a necessary step for the design of opto-electronic devices and should provide a better understanding of the blinking mechanism in 1-D systems. The effect of PMMA on the PL of SWCNTs has been reported only once[†]. We want to take advantage of this fundamental study in order to increase the signal collected, while decreasing the collection time of our PL setup by spin-coating our substrates with PMMA. A reliable SWCNT deposition procedure is a necessary preliminary step. Usually to make samples of SWCNTs; however, this process leads to unwanted amalgamation of SWCNTs around the electrodes. To avoid this problem, we deposit SWCNTs on a SiO_2 sample and characterize it. Drop-dry deposition is used and samples are imaged with an Atomic Force Microscope (AFM), to confirm that SWCNTs are correctly individualized on the substrate. The micro-PL is observed using a separate set-up before and after spin-coating the sample with PMMA. We propose a repeatable and reliable procedure to spin-coat PMMA on a sample of individual SWCNTs to increase their optical emission properties.

[†] Ai, N., et al. Suppression of Blinking and Enhanced Exciton Emission for Individual Carbon Nanotubes. **ACS Nano**. Online Publication. (2011)

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Introduction

- Increasing photoluminescence (PL) signal is necessary for the design of opto-electronic devices and should provide deeper understanding of the blinking mechanism in 1-D systems.
- Polymethyl methacrylate (PMMA) has been proposed to increase the PL signal emitted from individual single-walled carbon nanotubes (SWCNTs).†
- We propose a repeatable and reliable procedure to spin-coat PMMA on a sample of individual SWCNTs to increase their optical emission properties.

Sample Preparation: Drop-Dry Deposition of HiPCo SWCNTs

Deposition Procedure:

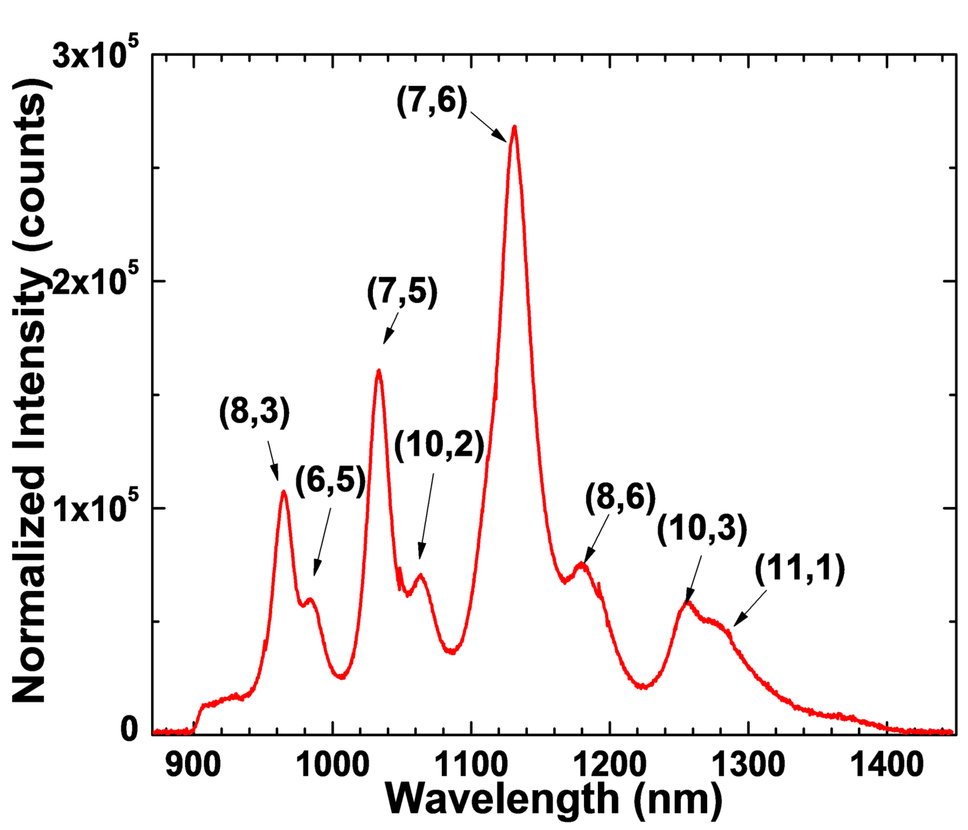
1.

2. Droplet is washed off with DI water and IPA to reduce capillary action of the water.
3. Sample is blown dry.

Experiment Details: HiPCo SWCNTs

- SWCNTs suspended in DCO surfactant
- Diluted: 30% SWCNTs

- PL spectrum of the suspension used for deposition and assigned chirality of nanotubes. (660nm laser diode excitation)

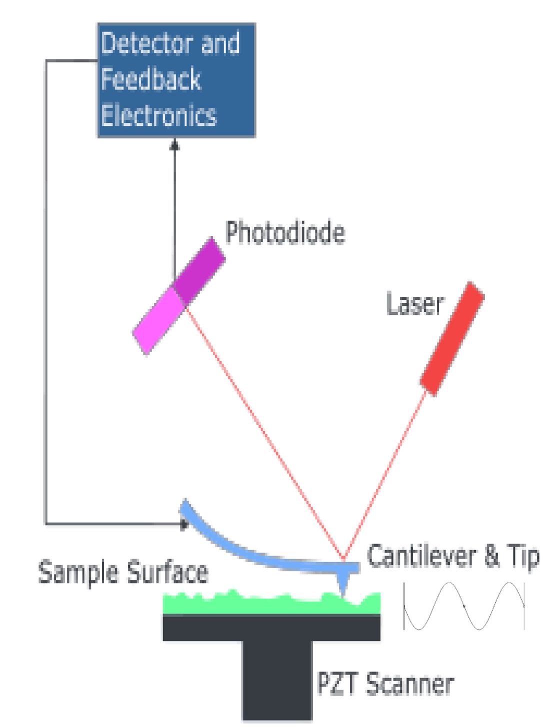


Atomic Force Microscopy (AFM) Imaging

- Used to confirm that SWCNTs are correctly individualized on the substrate.

AFM Operation: (tapping mode)

- AFM cantilever is excited by a piezo-electric stack, causing tip oscillation near resonant frequency.
- Tip is deflected upon encounter with the surface. Tip is maintained at constant height during sample scanning.
- A reflected laser beam reveals changes in oscillation frequency and amplitude, providing material characteristic information.



AFM Images of samples after deposition:

Image 1: Height channel, 5 x 5 μm scan

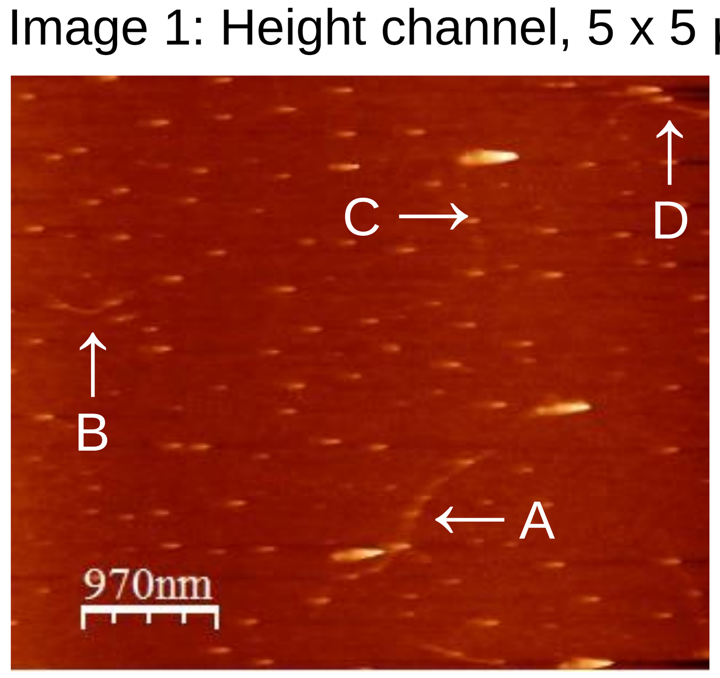


Image 2: Amplitude channel, 1 x 1 μm

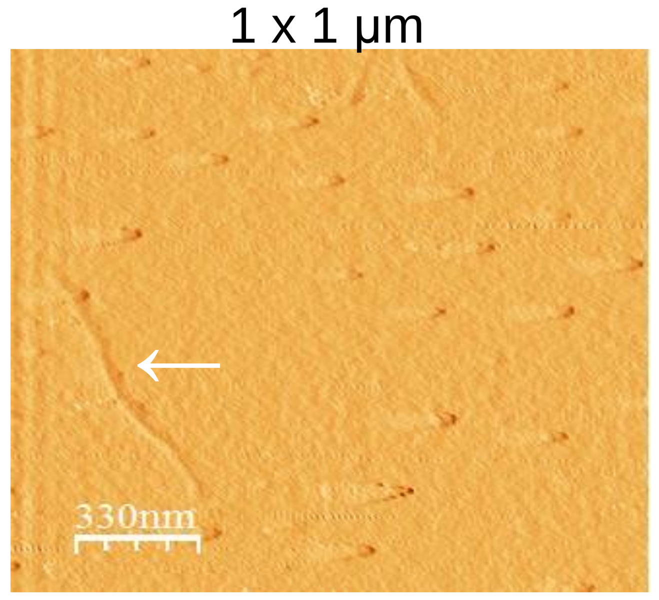
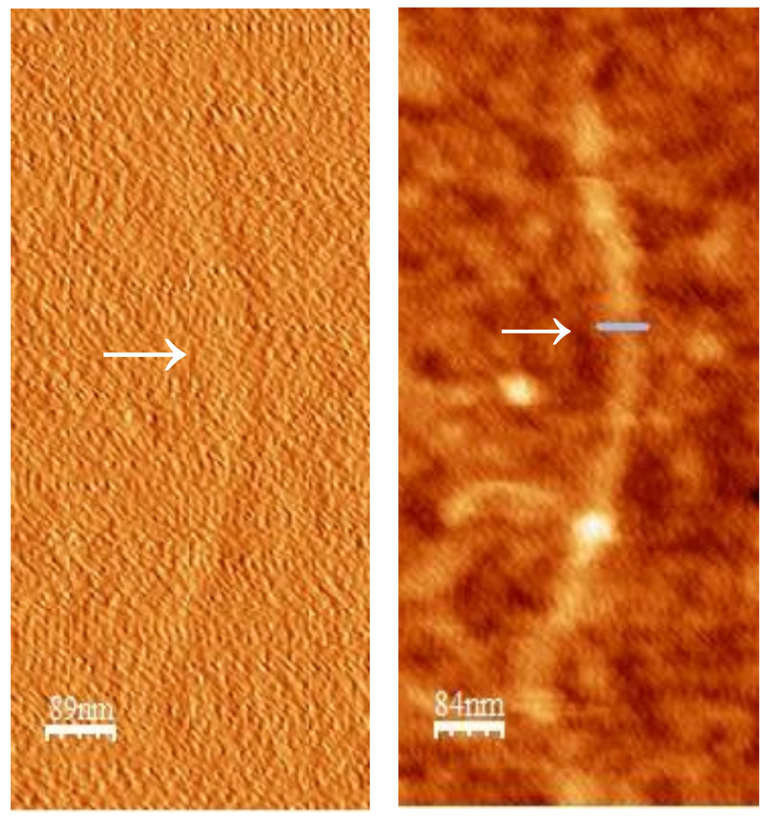
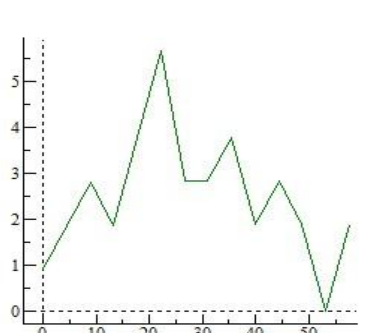


Image 3: Individual nanotube



Height profile for Image 3:



✓ About 1 nanotube per μm: Nanotubes are correctly individualized.

Sample Analysis: SWCNTs?

	Image 1 A	B	C	D	Image 2	Image 3
Height	~8 Å	~1.4 nm	~4 Å	~1.2 nm	~7 Å	~8 Å
Length	1.6 μm	600 nm	500 nm	300 nm	120 nm	700 nm
Diameter	16 Å	2.8 nm	8 Å	2.4 nm	14 Å	16 Å
SWCNT?	Yes	Yes	Yes	Yes	Yes	Yes

Sample Preparation: PMMA Layer

- 2 drops of PMMA deposited on sample in spin-coating machine.
- Spinning: 5 seconds at 500 rpm, 45 seconds at 5000 rpm.
- Treatment yields a flat surface with controlled, homogeneous thickness.
- Baking: Hot plate for ~2 days at 150° C.
  - Removes PMMA impurities by desorption, and allows PMMA to polymerize.

A possible explanation for expected signal increase:

- A lot of mechanisms enhance blinking; what they have in common is that they come from adsorbed chemical species. PMMA is protecting the SWCNTs from them.

Conclusions and Future Work

- The preparation yielded a sample that was well-distributed with individual SWCNTs at approximately 1 nanotube/ μm.
- A micro-PL analysis was started on the sample to observe the photoluminescence.
- Future Work involves the study of the SWCNTs under an electric field.

References

† Ai, N., *et al*. "Suppression of Blinking and Enhanced Exciton Emission for Individual Carbon Nanotubes." **ACS Nano**. 5, 2664-2670. (2011)

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