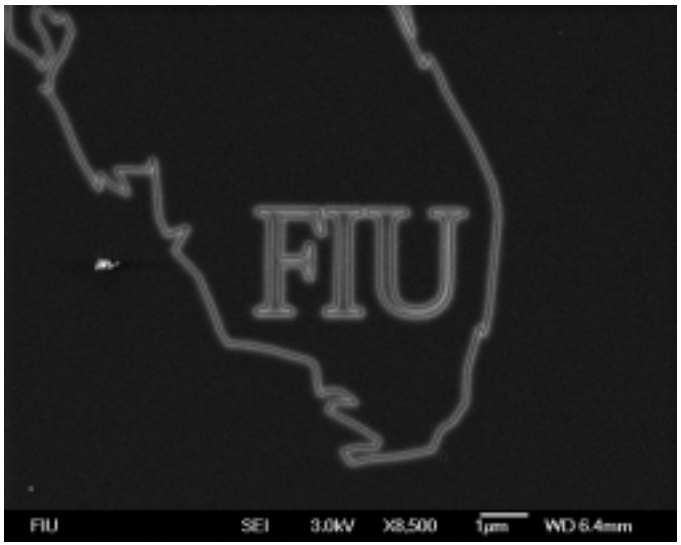
Nano Fabrication Research at FIU



FIU logo with 25nm line width by e-beam lithography

- **Fastest growing University in the US- Ranked in top 25 largest Universities (34,000 students)**
- **Research I status- highest ranking in shortest time**
- **Minority Institution- designated a Hispanic Serving Institution (HIS) - only one of two with Research I status**
- **External research in excess 0f $60MM, with 20% growth every year for the past 6 years**
- **College of Engineering (COE) offers Ph.D. in ME, EE, CE and MS in MSE, BioMed, Environ. Eng., IE, Eng. Management. Ph.D. in Materials Science in process**

Nanotechnology processing Facilities in FIU (AMRIE)

Professor W. Choi's Nano Materials and Devices Lab

Field Emission System

CNT growth CVD System

Photo Lithography Room (100 class)

Nano Processing Clean Room (10,000 class)

Focused Ion Beam system

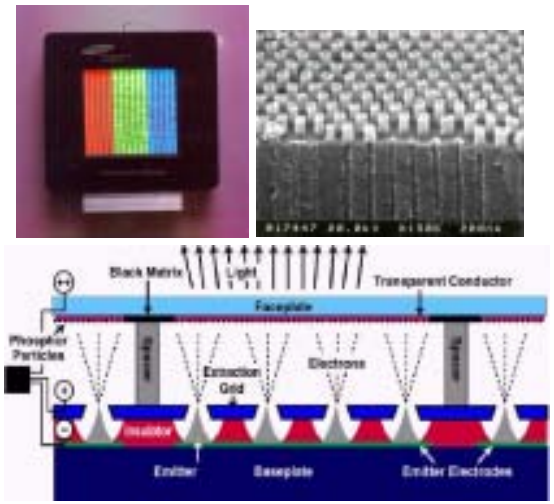
- Characterization and Processing Laboratories; thermal processing, thermal characterization, mechanical characterization and processing
- Analytical Instrumentation Laboratory; SPM, SEM, TEM

Nano E-beam Source

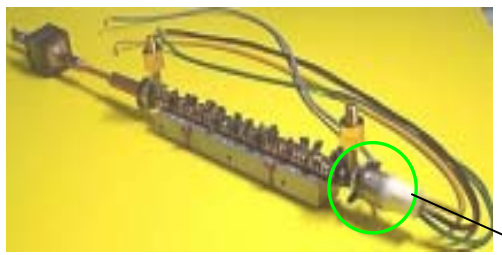
- **Goal**
  - Develop nano scale electron beam source
  - High current density generator, High power generator, and field emission display(compact size & flat panel)

- **Advantages**
  - -. High aspect ratio
  - -. High electrical conductivity
  - -. High thermal conductivity
  - -. Rigidity

Field emission display

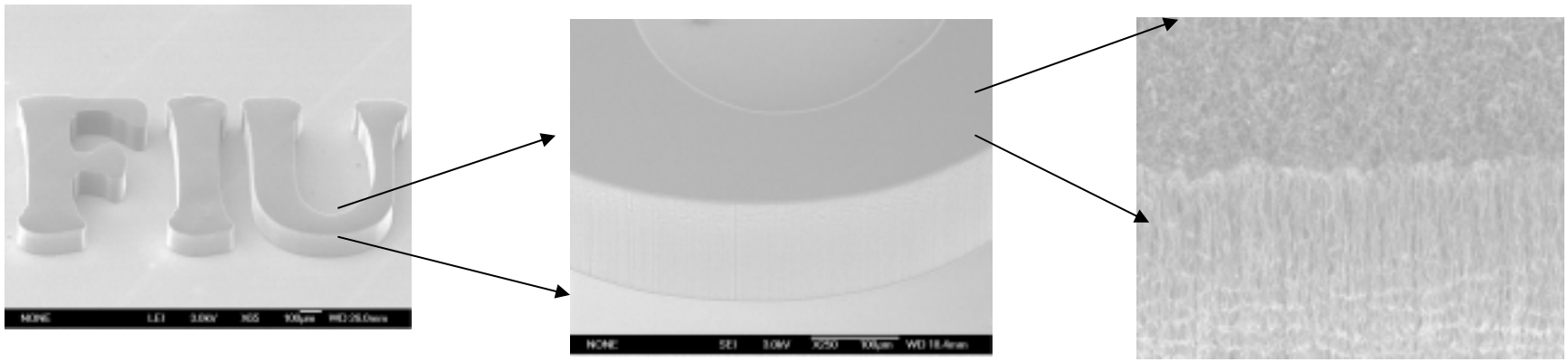


W.B. Choi et al., Appl. Phys. Lett. 75 3129 Nov. (1999)
W. Choi et al., Adv. Fun. Mat. 80 13 Jan. (2003)

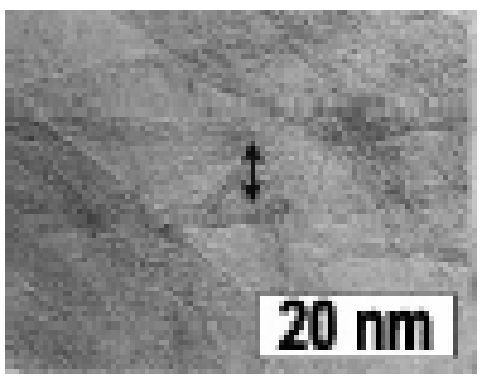


Microwave Device
(Pierce-type gun)

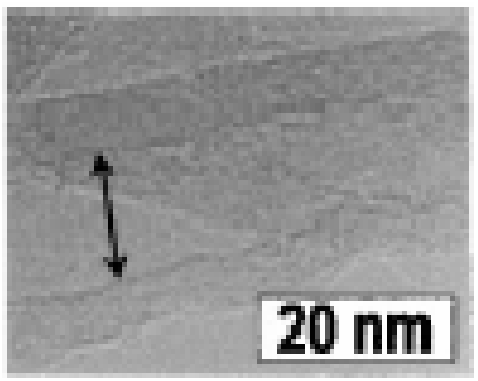
Selective Growth and Vertically aligned Carbon nanotubes



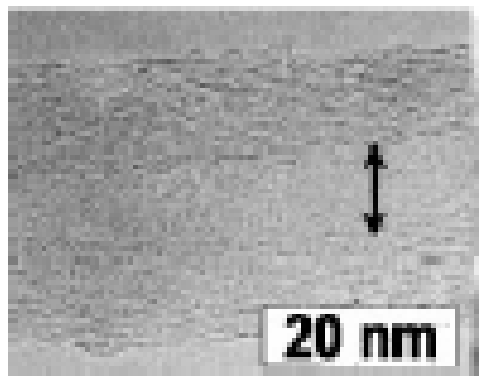
- *Number of graphitic wall is controlled by size of catalyst particle.*
- *Field emission properties is being investigated with structural change.*



4 walls



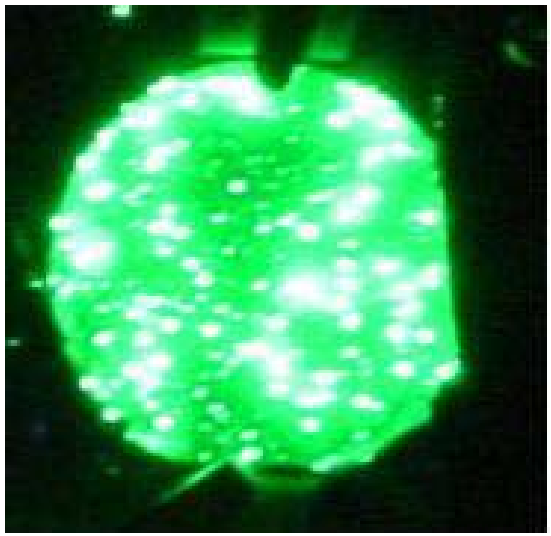
10 walls



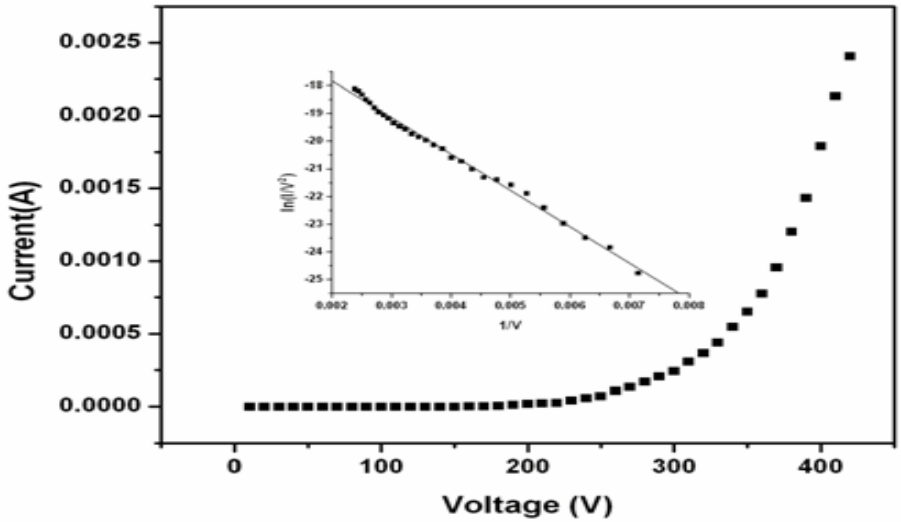
25 walls

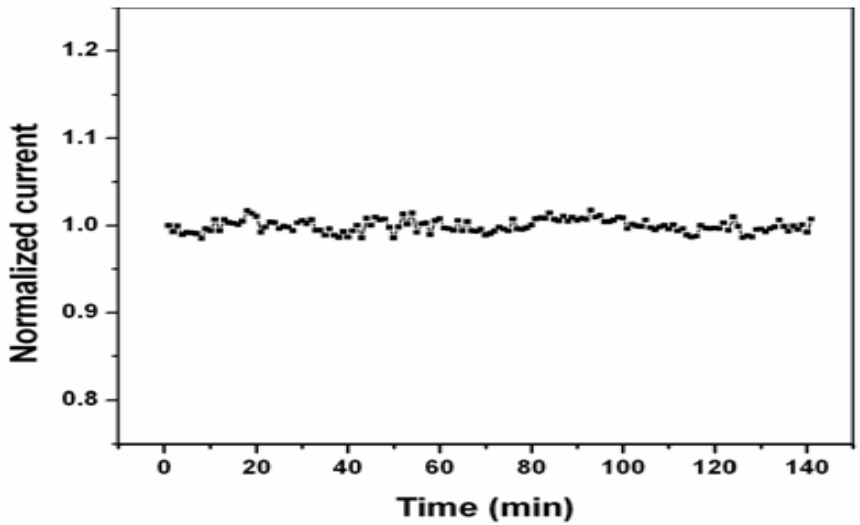
(Y. Choi et al. Appl. Phys. Lett.)

Field Emission Characterization from Multiwall Carbon nanotube



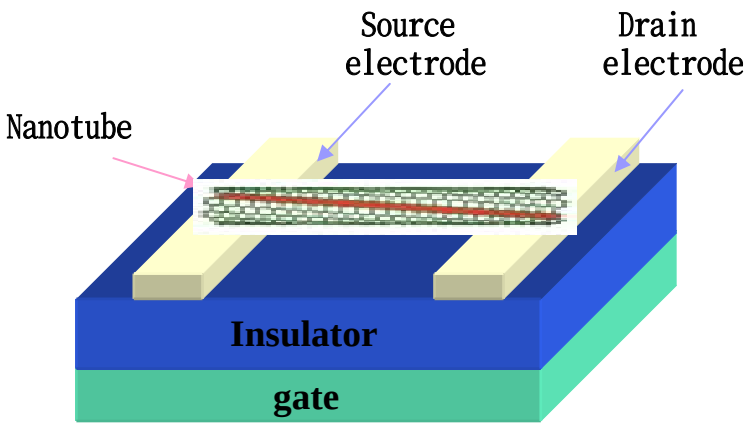
Emission pattern of thin MWCNT grown by CVD



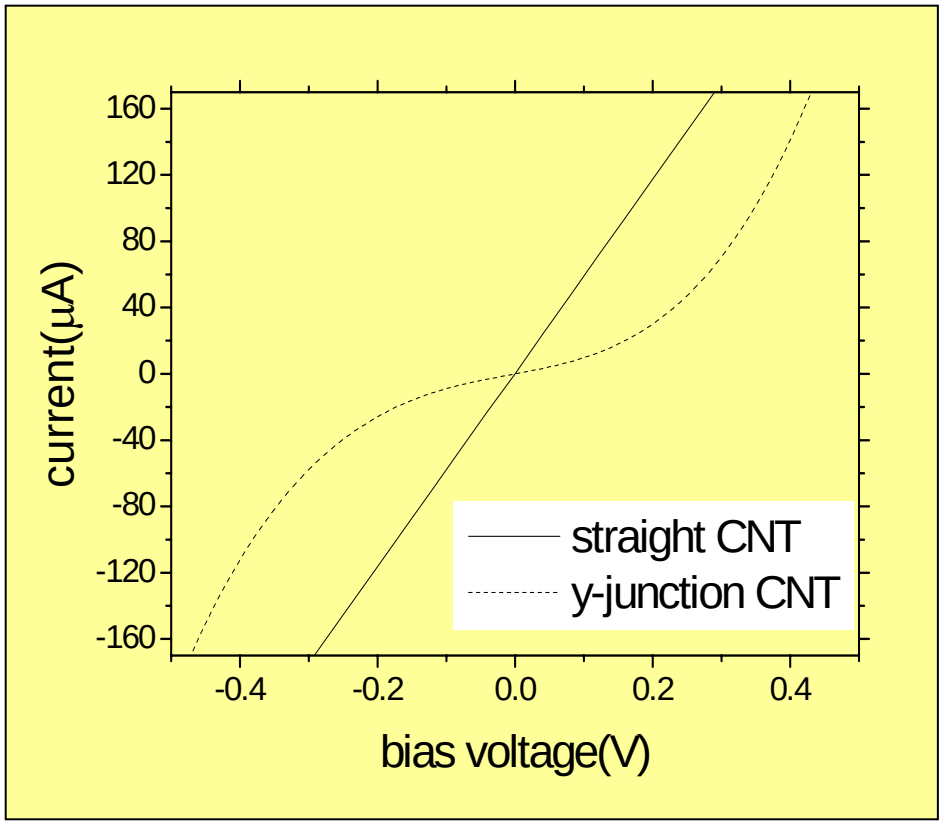


CNT for Electronics

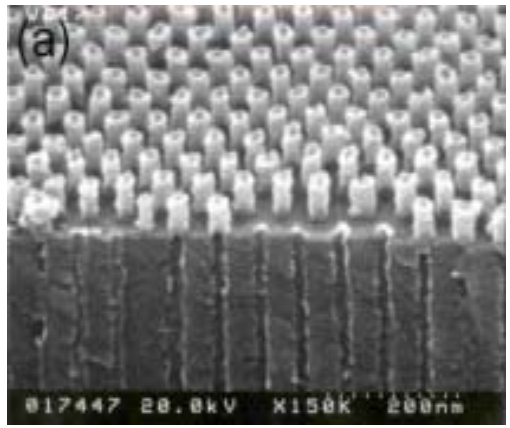
- Low dimension --> Tera-level high density device
- Low power consumption
- High current carrying capacity (1 X 10^{10} A/cm^2)
- Heat dissipation (6000 W/m.K)
- High mobility (Quasi Ballistic) for charge transport



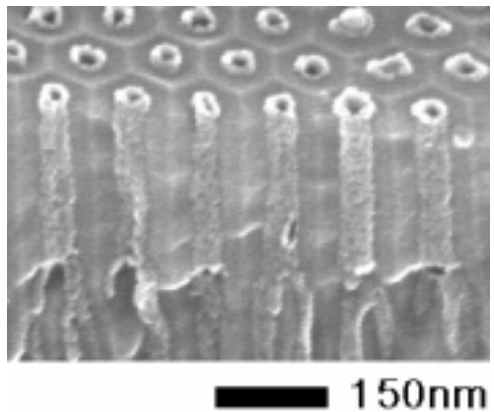
Y-shape CNT arrays



I-V data of straight- & Y-shape CNT



SEM image of straight CNT

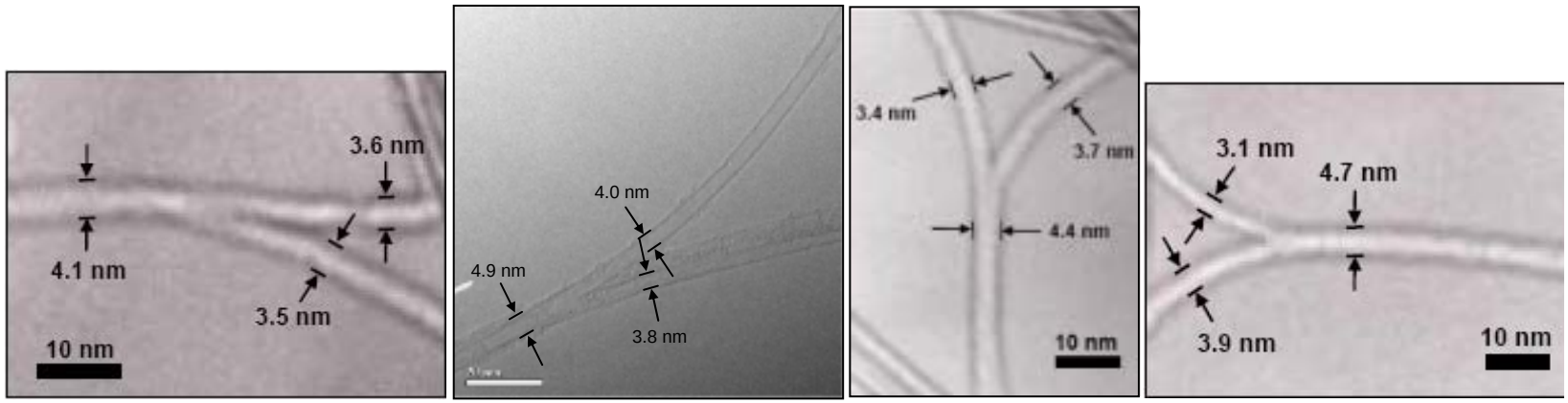


SEM image of Y-shape CNT

W. Choi et al, Nanotechnology 2004

TEM images of Y-junction SWNTs

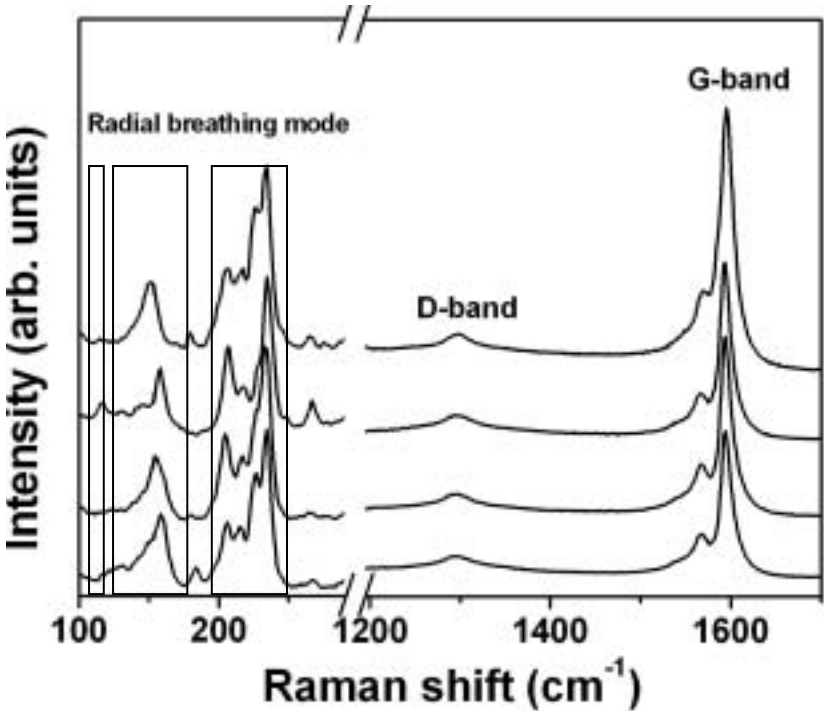
<< This is the first report on the TEM images of Y-junction SWNTs >>

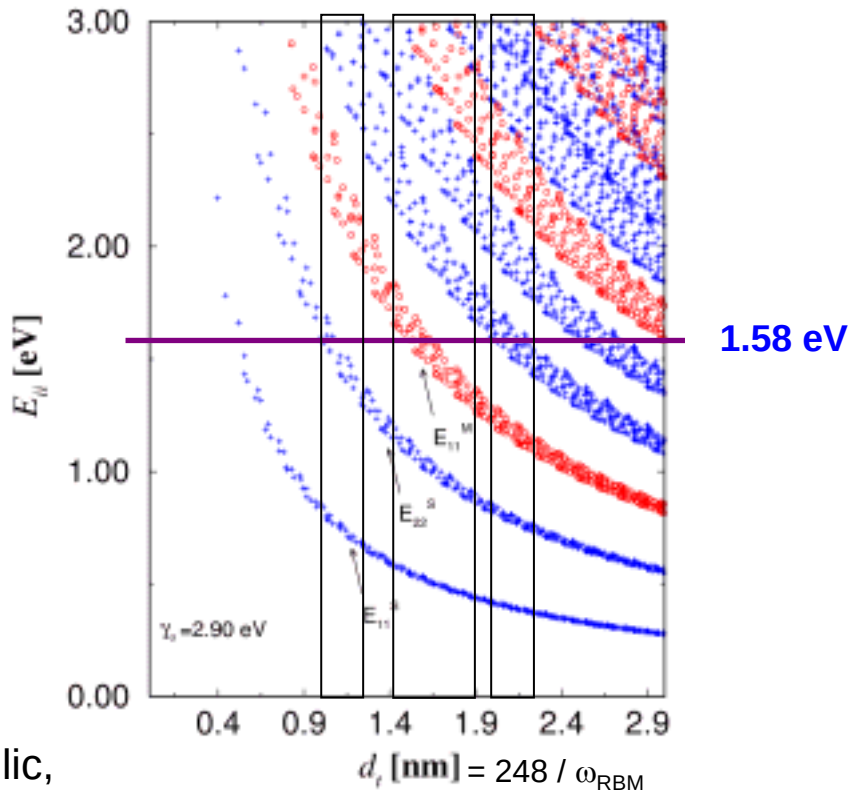


- Branch SWNTs seem to be nucleated and grown from the wall of stem SWNTs.
- Three individual SWNTs with different diameters.
- Diameters of stems (4 – 5 nm) is larger than those of branches (3 – 4 nm).
- Interestingly, the diameter of stem decreases after branching occurs.

Raman spectra of Y-junction SWNTs

(Grown at 900 °C, 785 nm-laser)

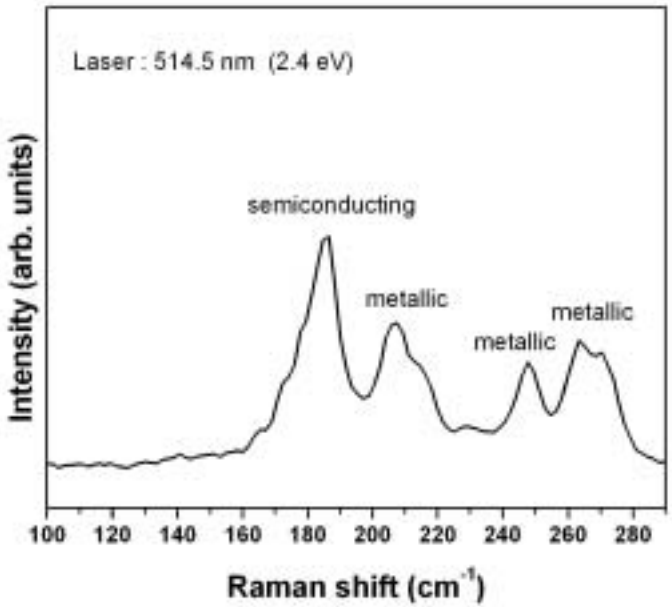


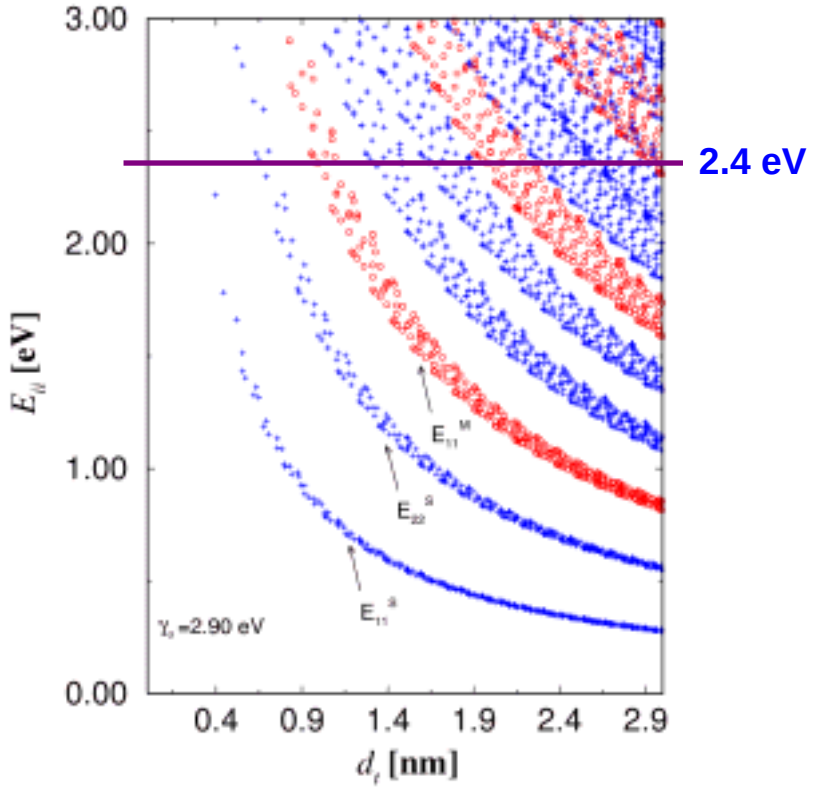


- ▭ ▭ semiconducting, ▭ metallic,
  - ⇨ indicating possible formation of Y-SWNTs with different electrical properties
- Dia. : 1 – 2.25 nm, larger diameters could not be detected due to measuring limitation.
- two components of G-band and RBM peaks reveal SWNTs.
- very weak D-band : proof of exclusive existence of SWNTs.

Raman spectra of Y-junction SWNTs

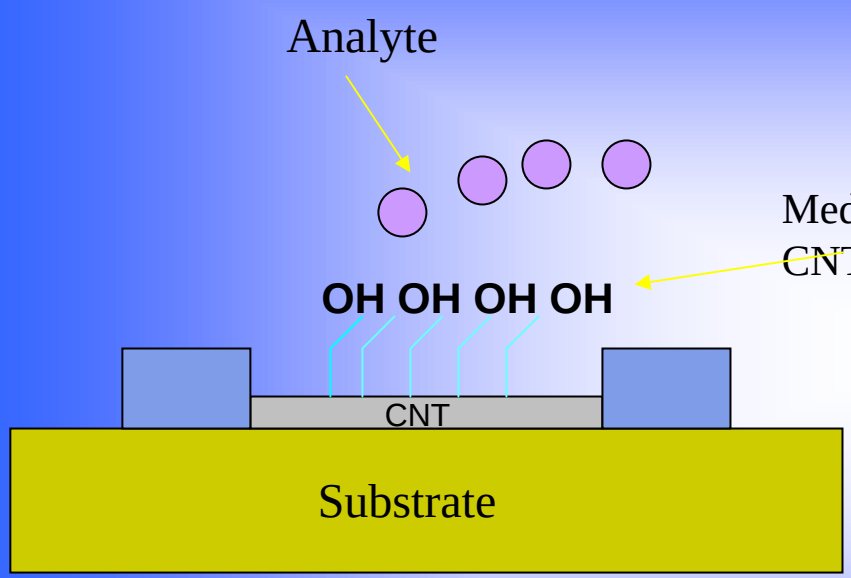
(Grown at 900 °C, 514.5 nm-laser)

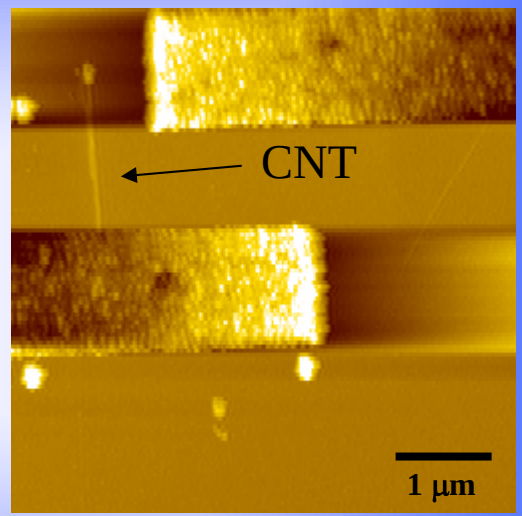




- This also show the existence of both metallic and semiconducting SWNTs.

CNTs for Sensor

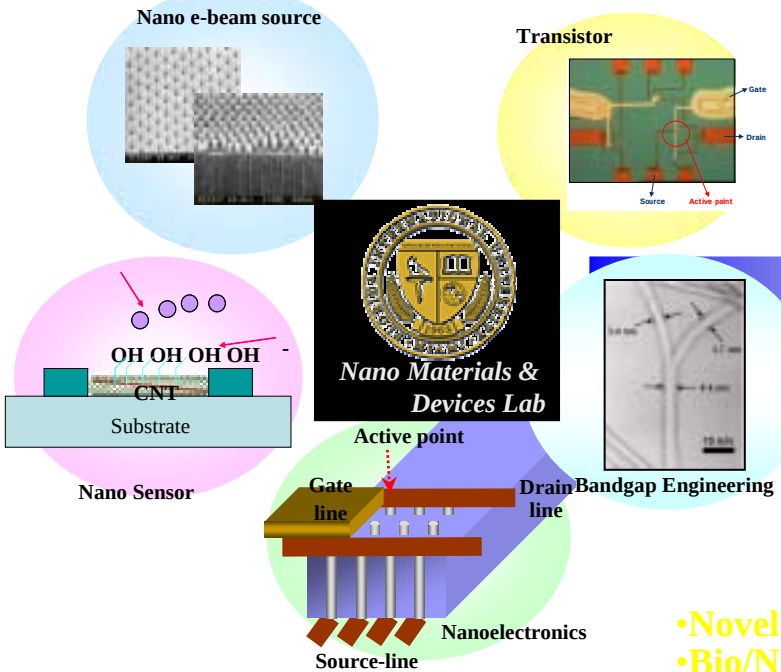




Atomic Force Microscope of CNT-Sensor

WB Choi et al. , Appl. Phys. Lett. Nov. 19 79 (2001)

- Raman analysis revealed that the majority of the nanotubes in the Y-junction SWNT are semiconducting as compared to SWNT which are both metallic and semiconducting.
- Upon functionalisation with PVOH, nanotubes show a drastic decrease in the contact angles which signifies the increase in the wettability and increase in hydrophillic nature.
- Impedance measurements showed that functionalised Y-SWNT have high sensitivity for relative humidity changes.



Outcomes

- Innovative Nano & Bio Devices
- IPs/ Publications
- Education and Human Resource
- Expansion of Biotech Industry
- Fostering Nano Electronics Industry

- Novel nano materials
- Bio/Nano processes
- Nano characterization techniques
- Nano-bio sensors
- Ultra high density Information Storage
- Future logic/memory device

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