NT16 Summary talk: Part 2

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ONERA
THE FRENCH AEROSPACE LAB

STATISTICS IN NT16

PLENARY PART

KEY NOTE LECTURE

INVITED TALK

CONTRIBUTED TALK

POSTER SESSION

Time	Sunday	Monday 8	Tuesday 9	Wednesday 10	Thursday 11	Friday 12	Sturday 13
08:45		Opening Remarks					
09:00		J.Kono	A. Hirsch	A.Goldoni	T. Heinz	C.Bichara	Satellite Symposia
09:15							
09:30				G. Argentero			
09:45		W. Li	R. Arenal	E. Gaufres	V L Nguyen	J. Bernholc	
10:00		Intro Posters	Intro Posters	R. Podila	Intro Posters	R. Saito	
10:15		E. Kauppinen	K.Kamarás		R. Saito	Y. Miyamoto	
10:30		Coffee Break /Posters A	Coffee Break /Posters D	A.Cherevan	Coffee Break /Posters G&H	T. Hertel	
10:45				Coffee Break			
11:00	REGISTRATION					Coffee Break	
11:15				L. Chang			
11:30						Y.Yaish	
11:45				L.Alvarez			
12:00		J.Zhang	L. Novotny	H. Kataura	Y. Ohno	S. Heeg	
12:15						D. Heller	
12:30	David Tomanek	T. Wagberg	D. Levshov	K.Kamarás	G.Fedorov		
12:45		H. Duong	A.Chuvilin		G.Borin-Barin	A. Bushmaker	
13:00	TUTORIAL Georg Kresse			Pack Lunch			
13:15		Lunch	Lunch		Lunch	Pack Lunch	
13:30						Surprise	
13:45				Conference Photo		Conference Summary and Poster Awards	
14:00							
14:15		J. Kong	H.Shinohara	Conference Tour	Y. Chen		
14:30						NT17 Announcement	
14:45	Coffee Break	H.Shiozawa			S. Satoro		
15:00	TUTORIAL Jörg Fink	G.Singer	U.J.Kim		K. Yanagi	Closing	
15:15		Y. Li	P. Rohringer		W.Wenseleers		
15:30		Intro Posters	Intro Posters		Intro Posters		
15:45		R.Krupke	A.Vijayaraghavan		M.Shaffer		
16:00		Coffee Break /Posters B&C	Coffee Break /Posters E&F		Coffee Break /Posters I&J		
16:15							
16:30	TUTORIAL Ferenc Simon						
16:45							
17:00							
17:15							
17:30		Walking Tour	Walking Tour		Walking Tour		
17:45							
18:00	Opening Ceremony			Banquet			
18:15							
18:30-.....							

Day	Topic	Poster Sessions
Monday 8th	Synthesis and Processing	A
	Sensors and devices	B
	Toxicology and Biomedical Applications	C
Tuesday 9th	Characterization and Processing	D
	Nanotube/Graphene Chemistry & Biology & Medicine	E
	Energy and environmental applications	F
Thursday 11th	Composites	G
	Theory and Simulation	H
	Graphene and van der Waals heterostructures	I
	Non-Carbon Materials	J

- 44 Oral presentations:
  - 5 Key notes
  - 12 Invited talks
  - 27 Contributed Talks
- 262 Poster presentations:
  - 53 'Synthesis and Processing'
  - 43 ' Sensor and Devices'
  - 24 'Toxico- and Biology'
  - 52 'Characterization and processing'
  - 16 'Composites'
  - 23 'Energy and environment appls'
  - 32 'Theory and simulations'
  - 27 'Graphene and VdW structures'
  - 05 'Non carbon materials'
- > 400 participants from 34 countries
- 133 students, 4 exhibitors

STATISTICS in NT16

PARALLEL SATELLITE SYMPOSIA

Time	CCTN16	CNBMT16	CNTFA16	GSS16	MSIN16	Time
09.00	OPENING	OPENING	I: Hata	OPENING	OPENING	09.00
09.05	K: Louie	K: Peng		K: Berger	I: Paio	09.05
09.30			I: Noda		I: Liu	09.30
09.45		I: von dem Bussche				09.45
09.50	I: Vets			I: Hofmann		09.50
09.55					C: Van Bezouv	09.55
10.00			C: Iseki			10.00
10.05					I: Pichler	10.05
10.10			C: Tanaka			10.10
10.15	COFFEE	COFFEE				10.15
10.20			C: Yasunishi	COFFEE		10.20
10.30			COFFEE		COFFEE	10.30
10.45				K: Lau		10.45
10.50		I: Heller	C: An			10.50
11.00	I: Wirtz		C: Laiho		I: Ming Cheng	11.00
11.10			C: Yamada			11.10
11.20		I: Liu	C: Mustonen			11.20
11.25	I: Koshino				C: Cakir	11.25
11.30			C: Hussain	I: Bandurin		11.30
11.35					C: Jorio	11.35
11.40			C: Otsuka			11.40
11.45					C: Svensson	11.45
11.50	C: Fuchs	C: Hirata	C: Yang			11.50
11.55					I: Wei	11.55
12.00			C: Hirotani	C: Gaufrès		12.00
12.10	C: Miyamoto	C: Ushiyama	C: Schießl			12.10
12.15				C: dos Santos		12.15
12.20			LUNCH		LUNCH	12.20
12.30	LUNCH	LUNCH		LUNCH		12.30
13.00	POSTER 1	POSTERS		POSTERS		13.00
13.30			C: Graf			13.30
13.45			I: Zaumseil		I: Loiseau	13.45
14.00	I: Blaha			I: Guy		14.00
14.10			C: Panes Ruiz		C: Chan-Park	14.10
14.20			C: Shi			14.20
14.25	I: Nakahishi					14.25
14.30		I: Marchesan	C: Forel	I: Matsuda		14.30
14.35					C: Hou	14.35
14.:40						14.:40
14.45					C: Zhu	14.45
14.50	C: Bondarev					14.50
14.55					C: Lefebvre	14.55
15.00		C: Alvarez	POSTERS & COFFE BREAK	C: Tabat		15.00
15.05					COFFEE	15.05
15.10						15.10
15.15	POSTERS & COFFE			COFFEE		15.15
15.00		COFFEE				15.00
15.35					I: Okazaki	15.35
15.45				I: Perebeinos		15.45
16.00	I: Sakurai	I: Wick	I: Sun		C: Cambré	16.00
16.10					I: Cronin	16.10
16.15				C: Schuler		16.15
16.25	I: Gillen					16.25
16.30		C: Lagier	I: Lefebvre	C: Takenobu		16.30
16.35					I: McSweeney	16.35
16.45				C: Okigawa		16.45
16.50	CLOSING	CLOSING				16.50
17.00			CLOSING	CLOSING	CLOSING	17.00

- CCTN16: Computational Challenges and Tools

  16 abstracts

- CNBMT16: Biology, Medicine and Toxicology

  25 abstracts

- GSS16: Graphene and 2D materials

  22 abstracts

- CCTNFA16: CNT thin films electronics and appls

  23 abstracts

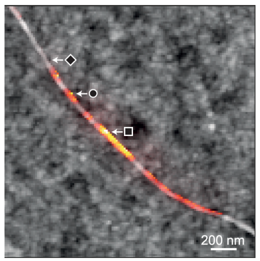
- MSIN16: Metrology, Standardization

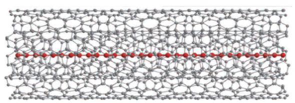
  25 abstracts

Statistics on Materials

NT conference: Nanotubes and Low –dimensional Materials

Materials	Posters	Talks	Satellite	Total	% NT16	% NT15
Nanotubes	200	24	55	279	69	62
Graphene	49	8	16	73	18	27
Other 2D	27	2	20	49	12	8
C chains	4		2	6	1.5	
Fullerenes	7	2	1	10	3.8	2
Other nano C, gels, fibers	19	10	6	35	8.7	7



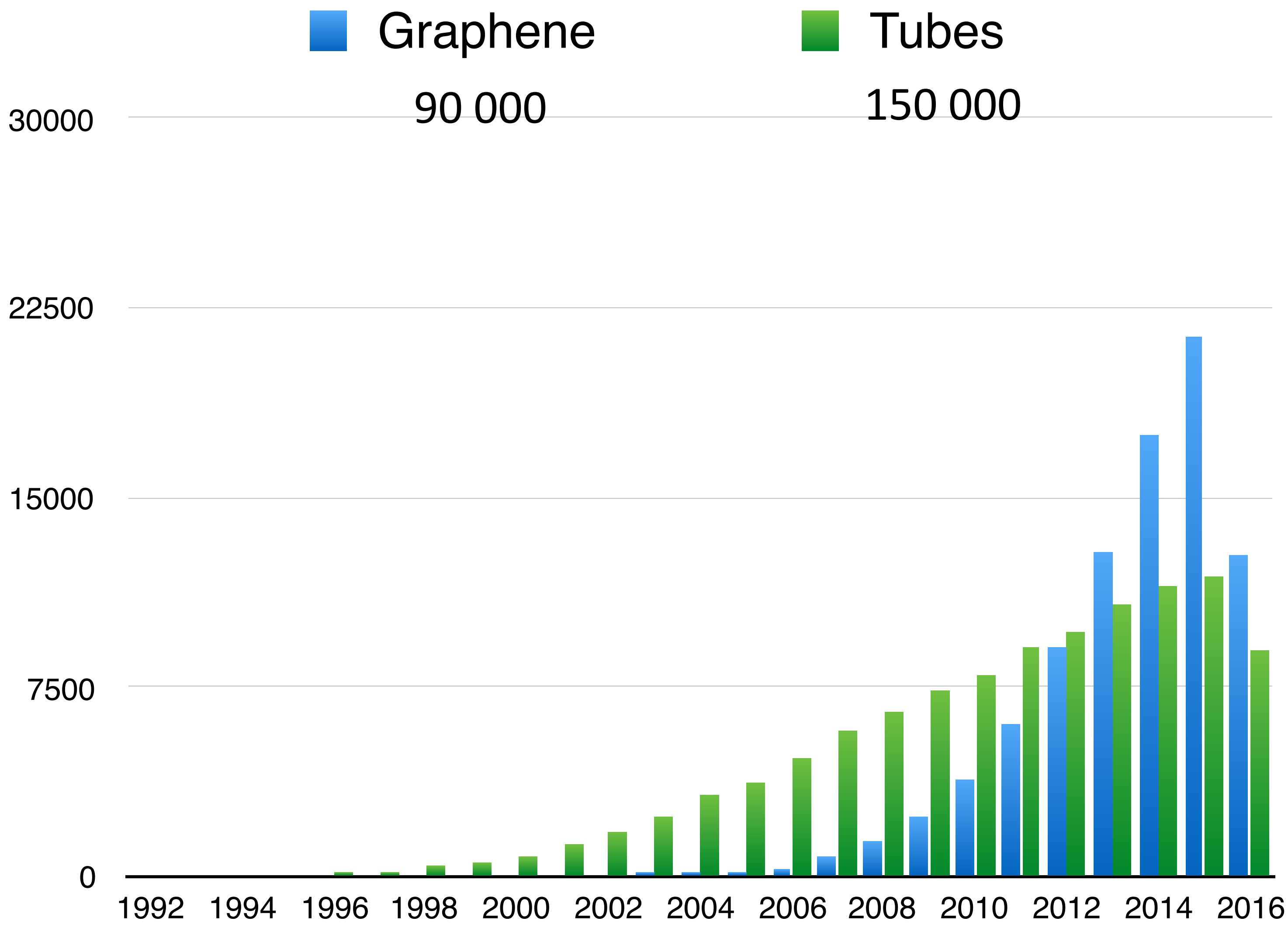


SWNT filled with carbyne chains done here at Vienna!

The Rise of Publications

Number of publications including ‘Nanotube’ and ‘graphene’ in title (Source web of Science)

08/2016



established by F. Ducastelle

Main topics we learned about

- Synthesis, Growth: 7

  KN5, IT1, IT6, CT2, CT6, CT17, CT19

- Material processing and manufacturing: 6

  KN1, IT2, IT9, CT3, CT4, CT5

- Chemistry, functionalization, sorting: 8

  KN2, KN3, IT7, CT5, CT7, CT11, CT13, CT14

- Spectroscopic properties and characterization: 8

  IT3, IT10, IT11, CT1, CT8, CT9, CT12, CT24

- Optical Properties: 8

  KN4, IT12, CT11, CT15, CT16, CT20, CT22, CT26

- Applications: 9

  IT4, IT5, IT8, IT9, CT18, CT21, CT23, CT25, CT27

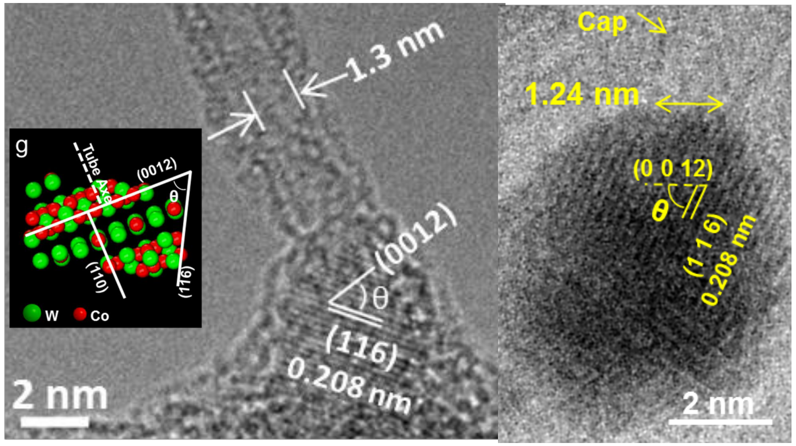
Summary on synthesis, growth, processing

- Growth of Single Wall Carbon Nanotubes:
  - Understanding and modeling the growth of SWNT (KN5)
  - Growth of SWNT with a control of the chirality (CT6)
  - Growth of SWNT with a control of the electrical type (IT6)
- Arrays of aligned SWNTs:
  - How to grow dense arrays of aligned and chiral selective SWNT (IT1)
  - Towards single crystals of SWNTs (KN1)
- 2D Materials:
  - Chemical route to the synthesis of nanoribbons (CT2)
  - bi-layer graphene at a wafer scale (CT17)
  - Nanoribbons: from synthesis to the device (CT19)
- 1D and 2D objects:
  - Aerogels (IT2, CT3)
  - Hierarchical assemblage of CNTs and graphene for energy storage (IT9)

A route to CVD grow SWNTs with specific chiralities

Y. Li - CT6

Approach is to design bimetallic catalyst used under optimized carbon feeding condition
Bimetallic system: the Co7W6 intermetallic compound chemically stable at 1100°C



SWNTs with given (n,m) such as (12,6) are observed to grow with specific orientations with respect to the crystal lattice of the catalyst

The crystal structure of the catalyst plays crucial role in growing SWNT with specific chirality.

Routes to grow SWNTs with specific structures

C. Liu- IT6

Different approaches for obtaining SWNT with uniform electrical (M or SC) type

- In situ etching by O_2 floating catalyst CVD route to selective growth of SC tubes
- Catalyst design of C partially coated Co NP to the growth of SC tubes with a yield > 95%

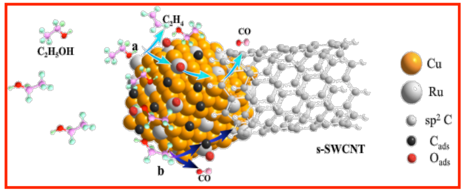
Controlled Growth of SWNTs Array on Surface

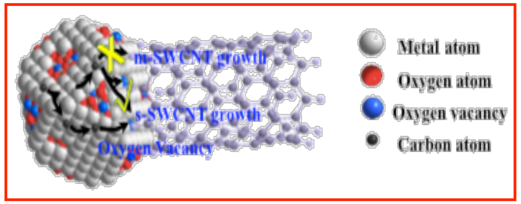
J. Zhang IT1

- How to Get Semiconducting SWNTs on substrates

Different approaches:

- separation m/s SWNT arrays by scotch tape
- growth of s SWNTs using bimetallic catalysts
- growth of s SWNTs using UV assistance
- growth of s SWNTs using $Ti0_{2-x}$ NP



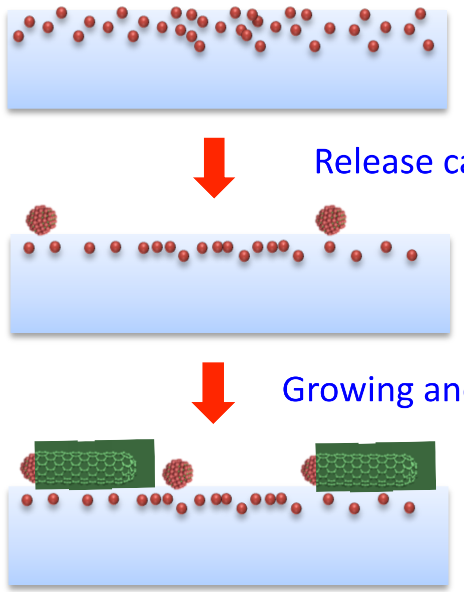


- How to get arrays with controlled chirality such as (2m, m) or (n, n-1)

Approach using refractory metal carbide catalysts as growth template

- How to Increase the Density of SWNTs on substrates

Approach using ‘Troy’ Catalysts



Release catalyst particles

Growing and Continue Releasing

Array density >130 tubes/um

Towards single crystals of SWNTs for optoelectronics

J. Kono – KN1

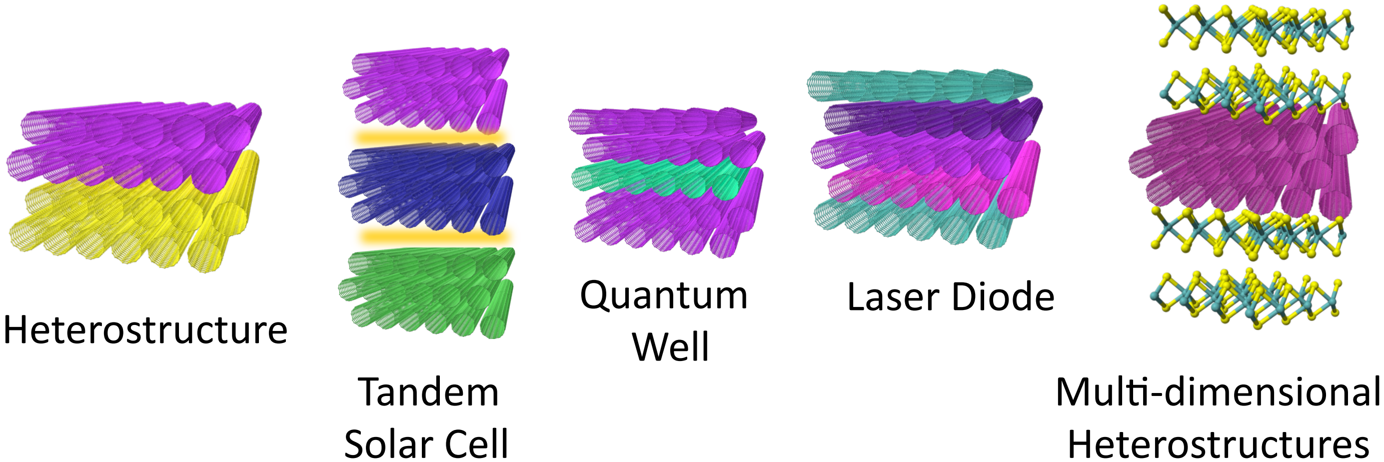
- act as THz and light polarizers
- display anisotropic electrical properties

- Novel method for fabricating films of aligned and sorted SWNTs

  chemical sorting and slow vacuum filtration of aqueous CNT suspensions

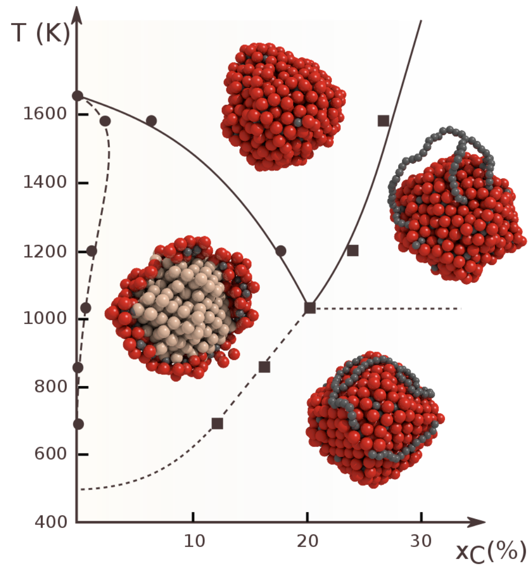
- Universal method which works at the wafer scale

- A lot to from this !!!



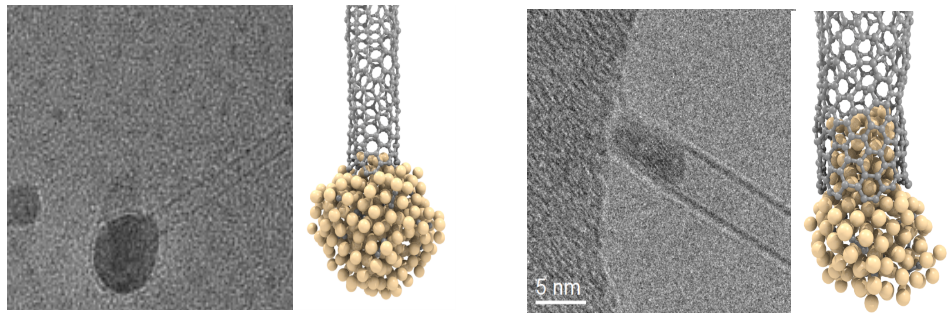
Understanding and modeling the growth of SWNT

C. Bichara, KN5



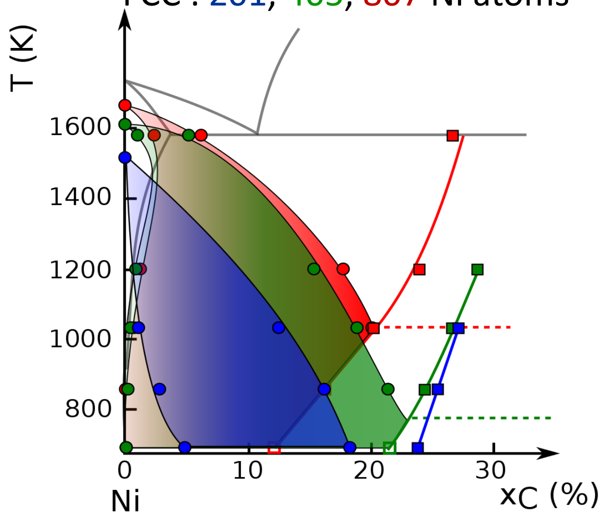
Phase diagram for Ni_{807} + C nanoparticle

- Calculation of Ni NP – C phase diagram
- Growth modes controlled by carbon fraction dissolved in catalyst



Large x_C : perpendicular   Small x_C : tangential

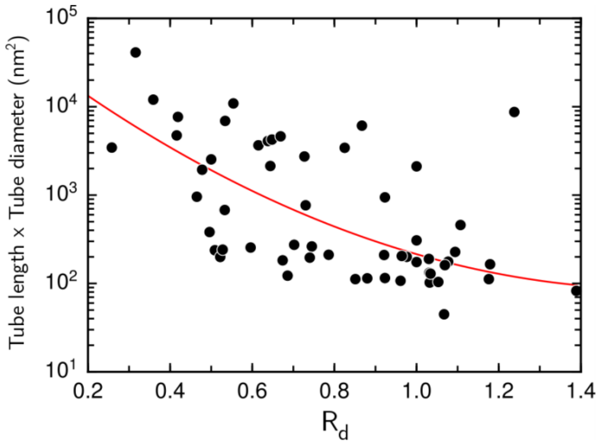
FCC : 201, 405, 807 Ni atoms



Size dependent phase diagram

- Tangential tubes are shorter

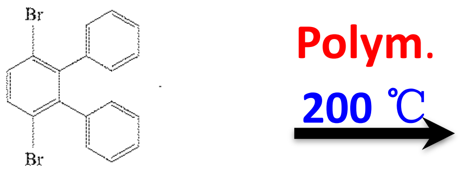
CVD synthesis using CH4 and Fe NP
TEM measurements of:
tube length, diameter, (n, m) NP diameter

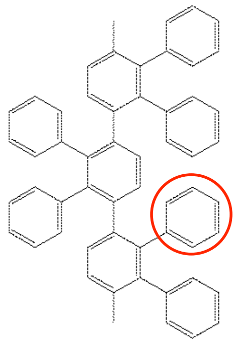


Bottom-up fabrication of nanoribbons:

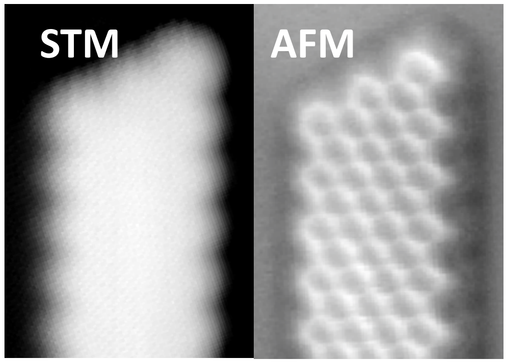
Graphene nanoribbons

G. Borin – Barin - CT19



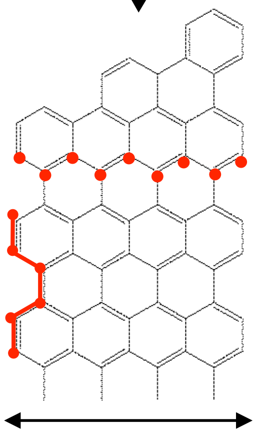


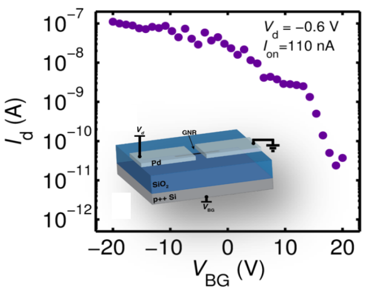
Fully automated synthesis process



9-armchair GNR (AGNR)

Cyclodehyd.
410 ℃





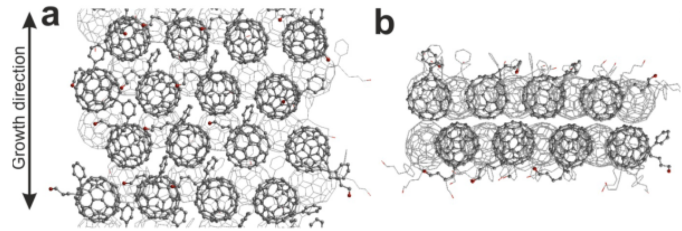
9-AGNR-FET devices

PCMB nanoribbons

Th. Wagberg – CT2

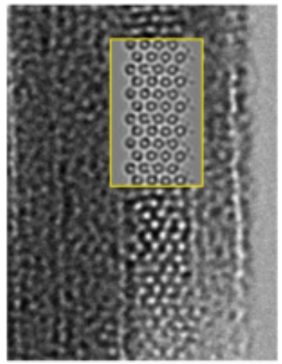
Motivation: fabricate C60 based wires with width < 10-15 nm for solar cells applications

Solution: PCMB nanoribbons



PCMB: C60 based molecule

[6,6]-Phenyl-C_{61}-butyric acid methyl ester

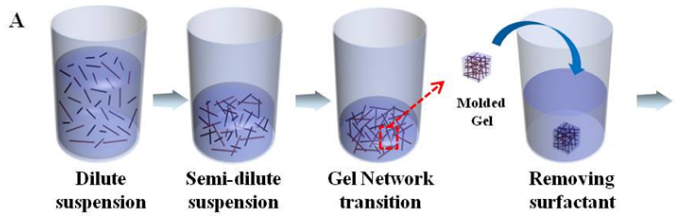


HRTEM image of a PCMB ribbon

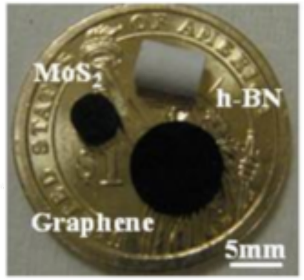
Aerogels from 1D and 2D structures

J. Kong – IT2

- Two fabrication methods for inorganic aerogels:
  - 1) first generation method from suspension
  - 2) generation method: hydrothermal synthesis



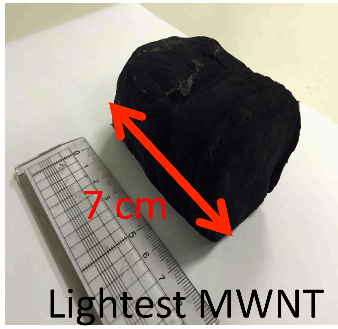
First generation method



Aerogel

- Continuous CNT aerogel from floating catalyst method

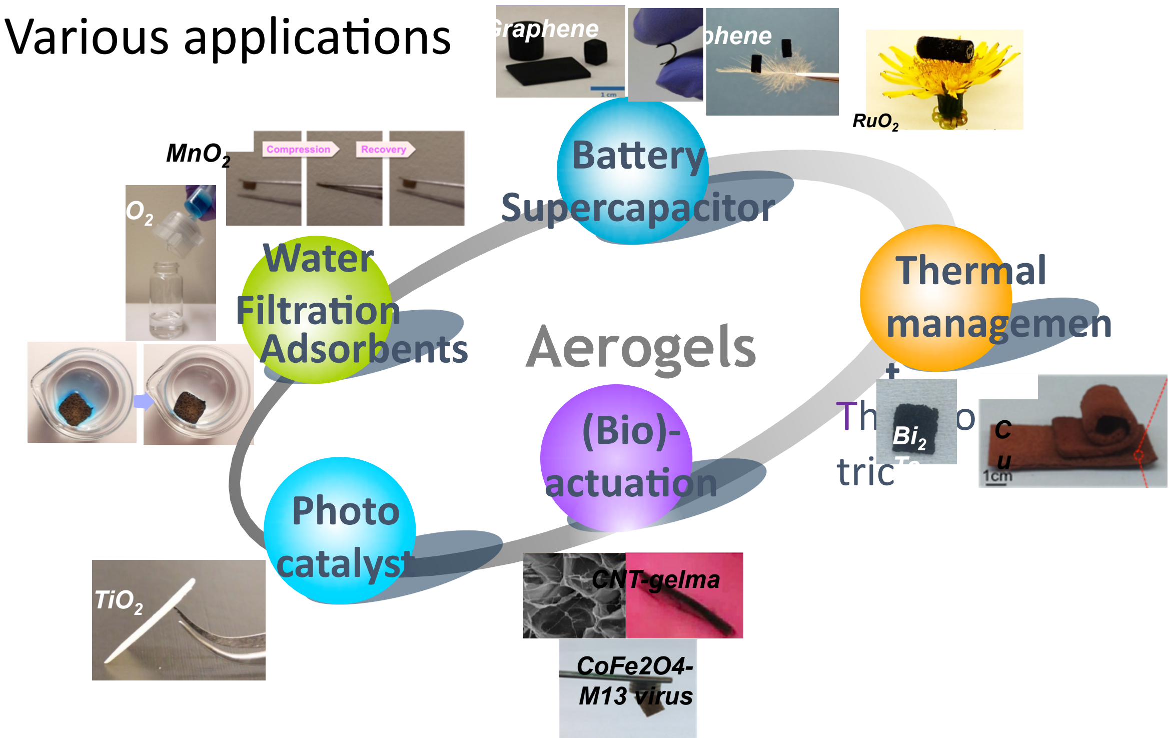
CT3 – Hua Dong



Lightest MWNT Aerogel

Manufacturing Pilot

- Various applications



Summary on Chemistry

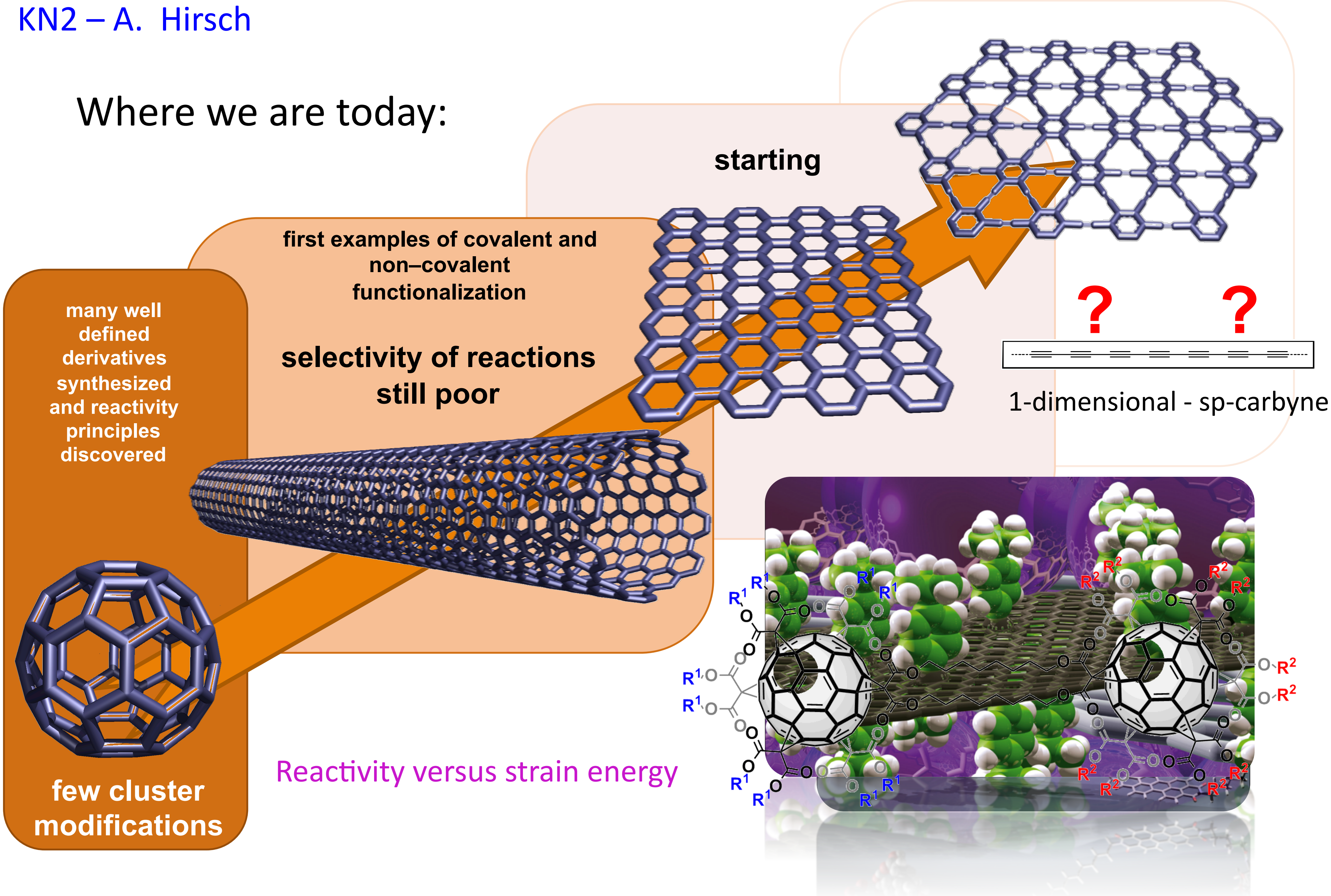
- Functionalization, doping and sorting :
  - A review on synthetic C allotropes: fullerenes, CNT, graphene (KN2)
  - CNT functionalization for composite materials (CT5)
  - Determine atomic configuration of heteroatomic and functionalized CNT (CT7)
  - Charge/ energy transfer in nanocarbon hybrids (CT14)
  - Large scale separation of SWNTs (IT7)

- Filling:
  - A review on using 1D and 2D space in C nanostructures (KN3)
  - Encapsulation process of a thiophene molecule in CSWNT (CT13)
  - Filling : a way to enhance luminescence of inner tube in DWNTs (CT11)
  - Properties of metal clusters encapsulated inside SWNTs (CT4)

Chemistry, functionalization of C allotropes

KN2 – A. Hirsch

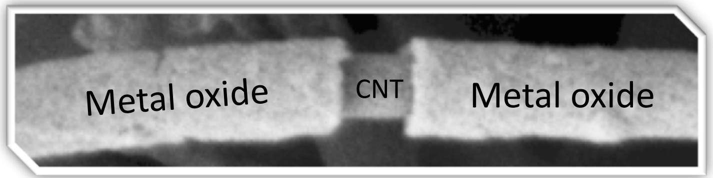
Where we are today:



Two different applications

• Charge/ energy transfer in inorganic – carbon hybrids

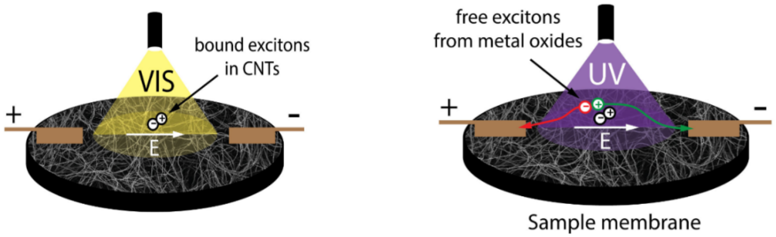
A. Cherevan CT14



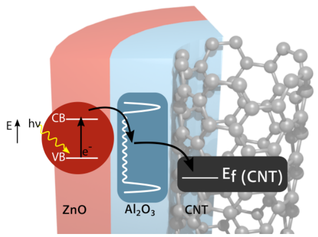
→ Hybrids designed for photocatalysis

→ Importance of the **interface** towards maximized performance

→ Evaluation of energy/charge transfer with DETPM



Dual Excitation Transient Photocurrent Measurement



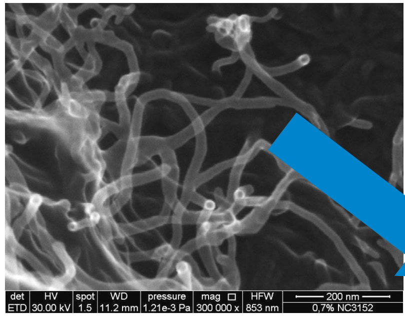
photoluminescence (PL)

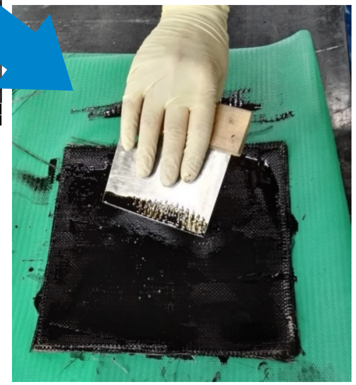
Distance dependent quenching effect: Charge vs Energy transfer

• Processing of nanofillers in epoxy for high performance composite materials

G. Singer - CT5

Functionalization of MWNT with NH_2





Lamination of a CRFP using nano-filled epoxy resin

Achievements:

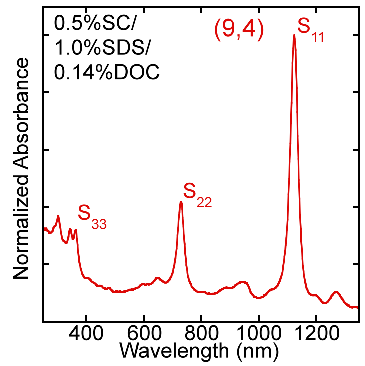
- good connection to the matrix
- dispersability
- roll-milling capability

From solubilization to chirality separation

H. Kataura– IT7

Multistep procedure using gel chromatography, elution order and combining different surfactants:

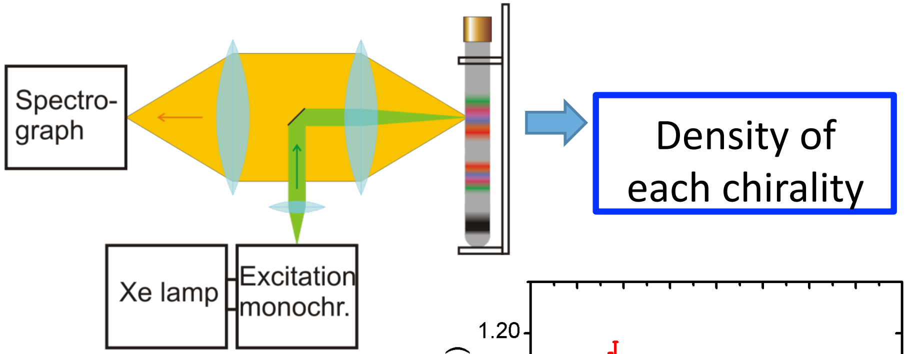
Obtention of high quality and high purity single chiralities samples
Obtention of 12 SWNT enantiomers

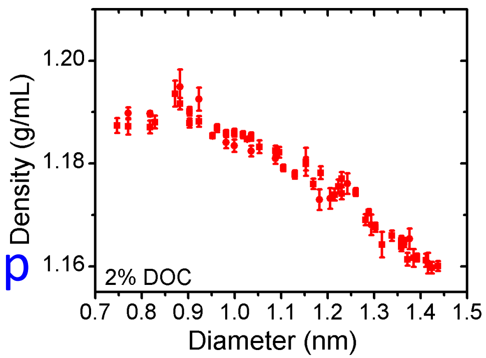


see more later

Comparison of different techniques

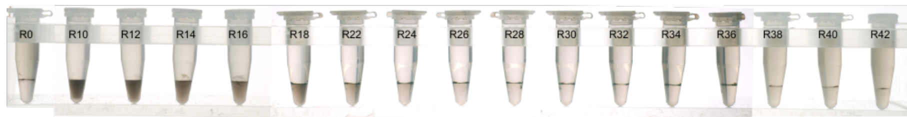
W. Wenseelers – CT22





1) *In situ* DGU characterization set up

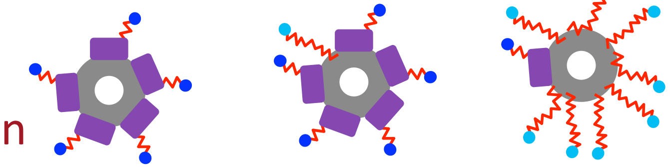
2) Systematic characterization of aqueous two-phase (hydrophilic/ hydrophobic) separations



Common picture:

Use a chiral selective surfactant (DOC) together with a non selective one (SDS)

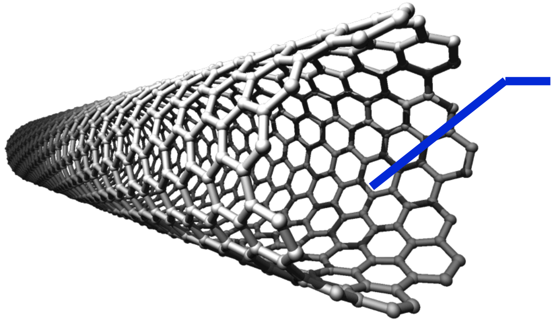
helpful competition



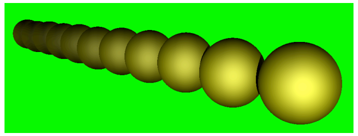
Using 1D and 2D space in C nanostructures

N. Shinohara - KN3

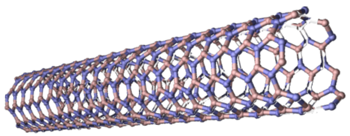
- CNTs: 1D nano-scale template for fabricating novel 1D materials



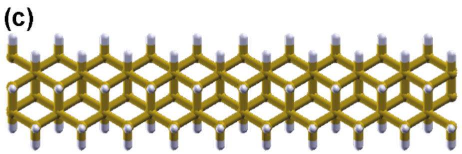
Metal-nanowire



BN-nanotube



Diamond-nanowire



We learned that:

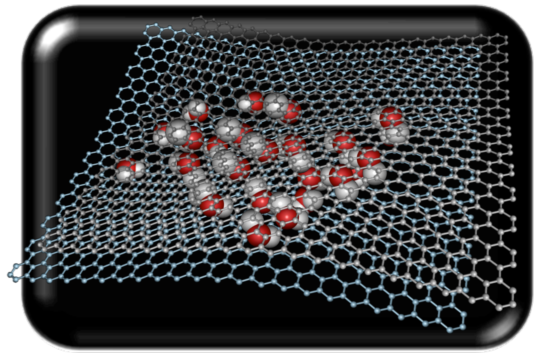
One may encapsulate

anything if size fits !

- Emphasis on BN SWNT@C-SWNT:

BN NT diameter varies : 0.4 – 0.8 nm with red shift of the band gap up to 0.33 eV for the smallest diameter as measured from low loss EELS

- Graphene: 2D nano-template

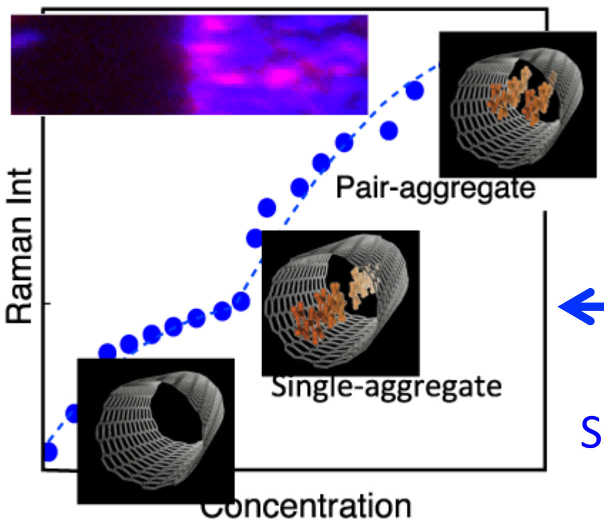


Room temperature ice structure sandwiched by two sheets of graphene

Encapsulation of dyes inside SWCNT

E. Gaufres - CT13

- Giant Raman scattering from Dyes molecules when encapsulated @SWNTs
- Effect used to evidence the mechanism of filling and the configuration of the molecules



Endothermic

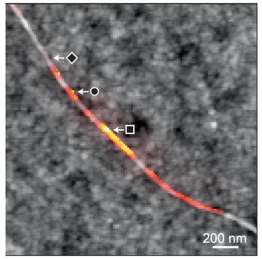
Spontaneous

Encapsulation only from the ends

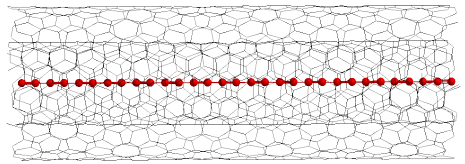
More on Raman enhancement in the talk by S. Heeg

Encapsulation of C chains inside DWCNT

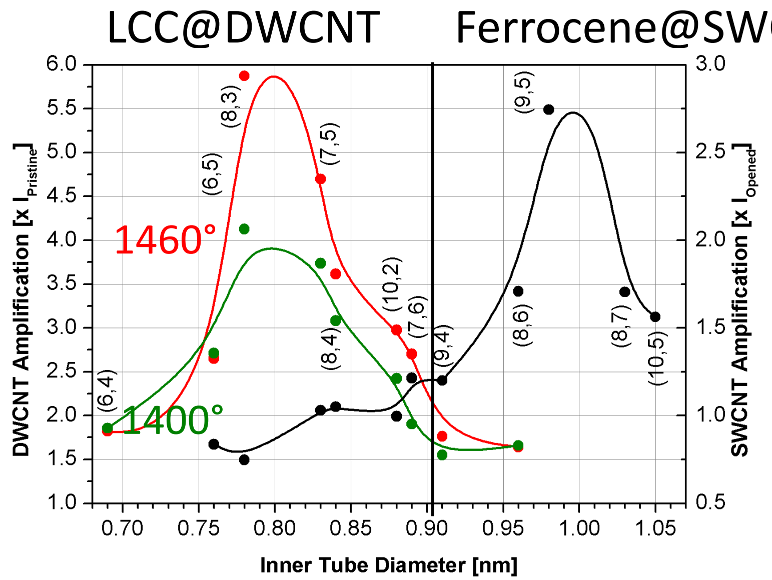
P. Rohringer – CT11



Raman map



Carbon chains grown at 2 T, 1400° and 1460°



Selective enhancement of inner tube photoluminescence, carbon chains counterbalance the outer‘s tube influence

Structure and spectroscopies

- Tools:

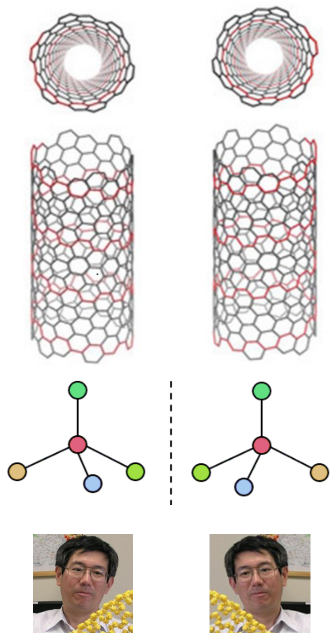
  - Optical absorption, photoluminescence, Time-resolved spectroscopy,
  - Raman and Rayleigh spectroscopies, THz spectroscopy,
  - Spatially resolved EELS, HRTEM, STEM-HAADF, circular dichroism

- Properties and problems investigated:

  - Determine chiral index dependant length of sorted fractions of SWNT (CT1)
  - Identify enantiomers in single chirality SWNTs (CT24)
  - Photophysics of chemically and doped SWNTs (IT10)
  - Impact of interlayer interaction on spectroscopic properties of DWNT (CT8)
  - Optical imaging of CNTs in a circuit (IT11)
  - Effects of defects on electronic and excitonic properties (IT3)
  - Defect mobility in graphene (CT9)
  - Stacking configurations of graphene-hBN heterostructures (CT12)

Separate and characterize SWNTs enantiomers

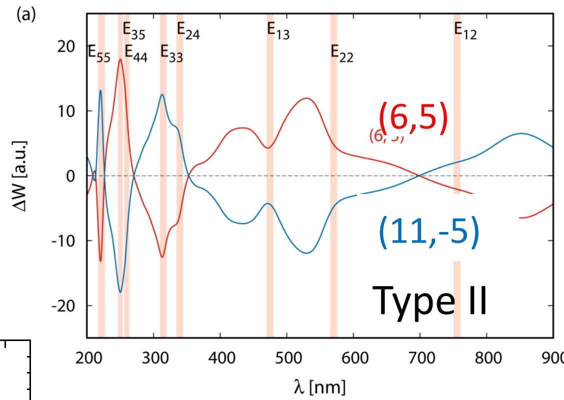
Mirror Image

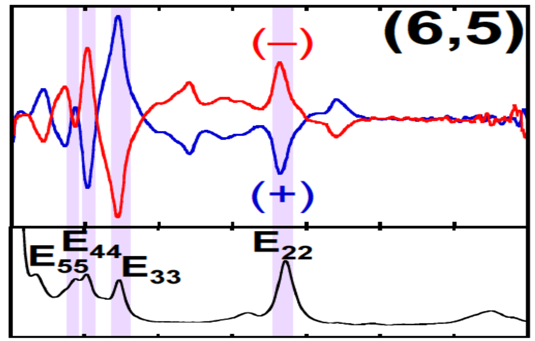


H. Kataura – IT7, R. Saito - CT24

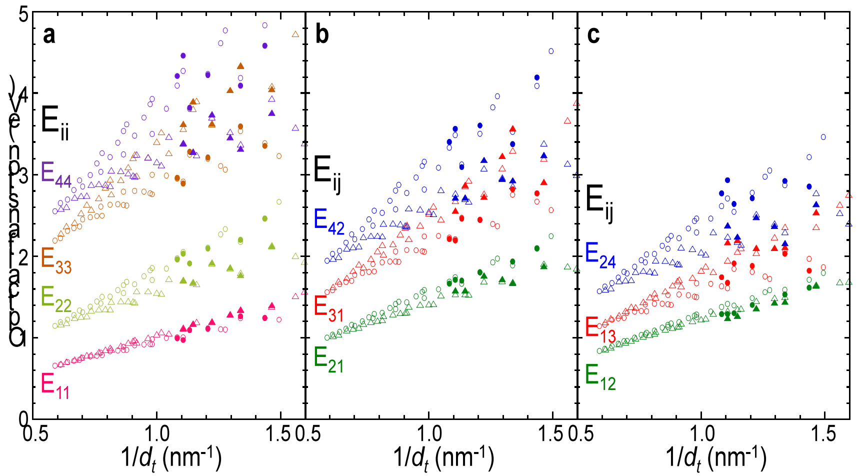
- 12 SWNTs enantiomers are separated experimentally using a two step chromatography procedure

- Characterization using Circular Dichroism





X. Wei, et al. Nat. Comm, in press (2016)



E_{ij} transitions

- We learned a new formalism able to calculate and reproduce experiments!

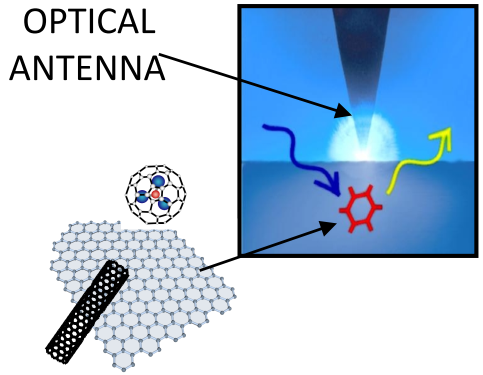
- New Kataura plot of the E_{ij} transitions energies!

Effects of defects on electronic and excitonic properties

L. Novotny-IT3

- The tool:

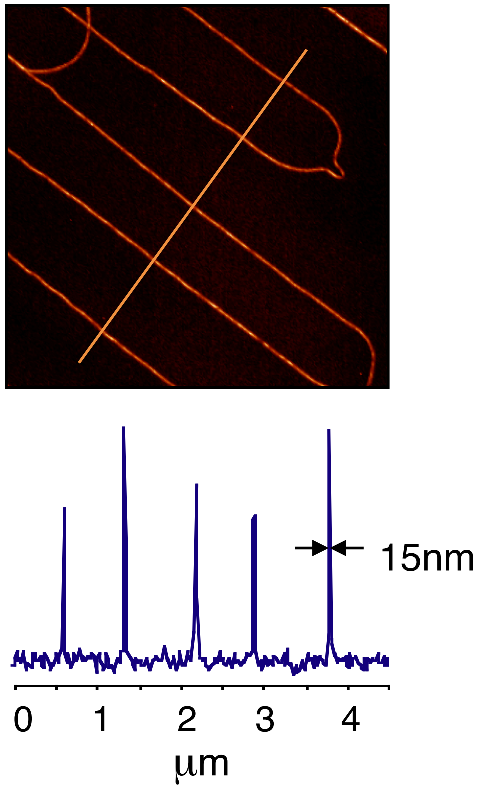
Near field Raman spectroscopy
using laser-irradiated optical antenna



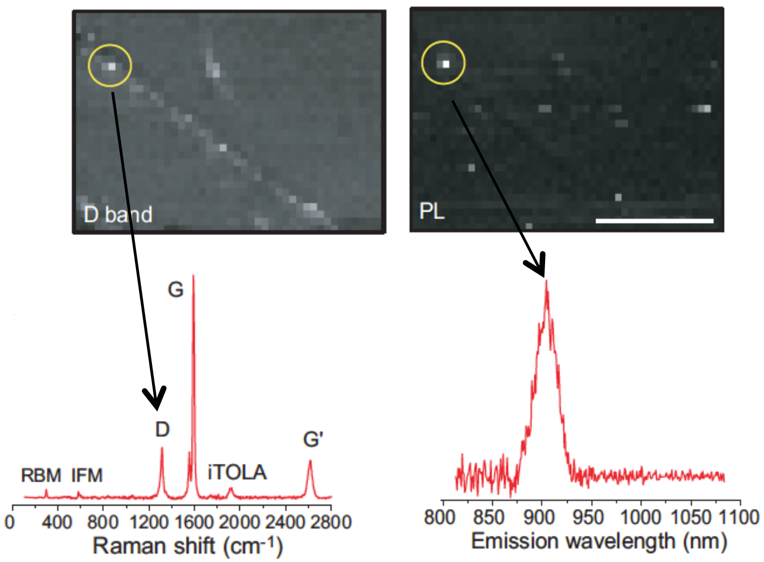
- Applications :

localization of defects, exciton trapping sites,
interaction with the environment

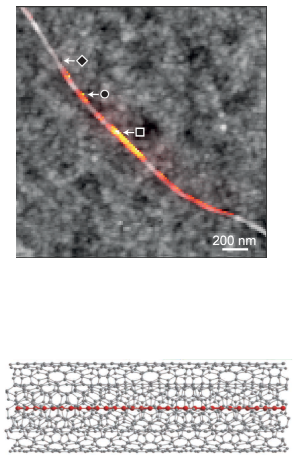
Near-field Raman:



Raman mapping of serpentine SWNT



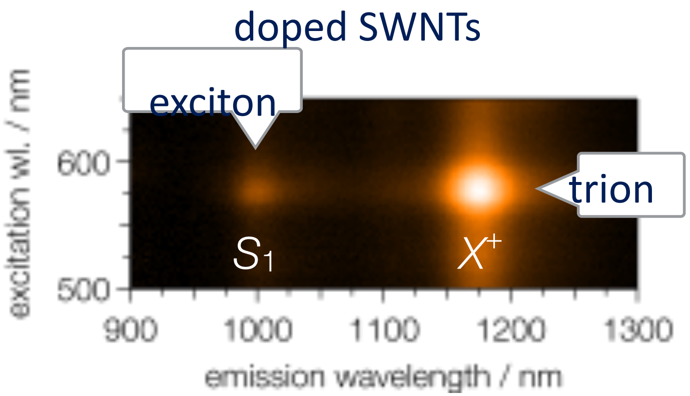
Phonon and exciton mapping of a SWNT



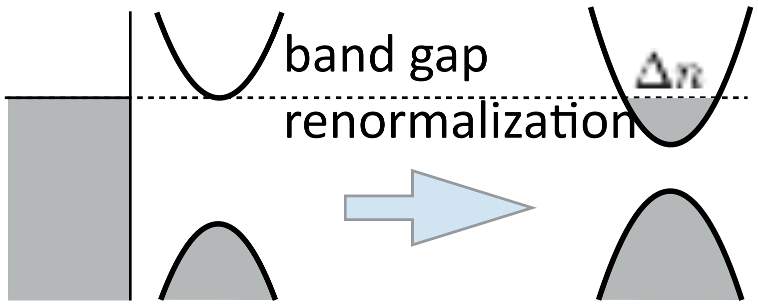
linear C. chain
inside a DWNT

Optical Spectroscopy of Doped SWNTs

T. Hertel - IT10

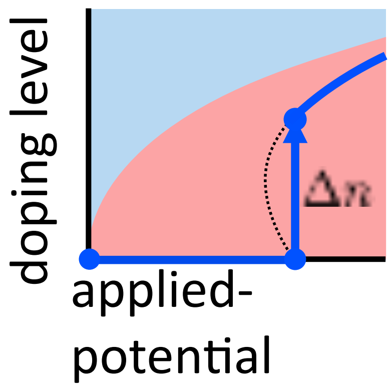


signature of electronic correlations



- how can we *p*- and *n*-dope SWNTs?
- how can we quantify doping spectroscopically?
- what is the effect of doping on electronic- and optical structure?

sudden increase of doping levels in 1D

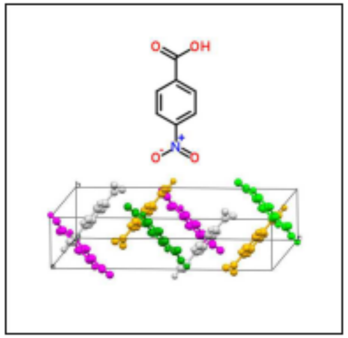


Optical Imaging of Carbon Nanotubes

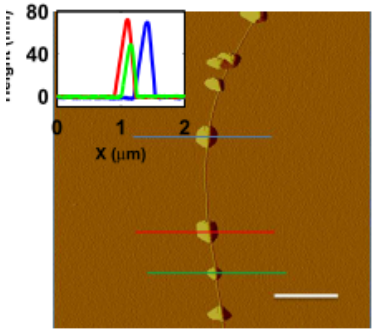
Yuval Yaish-IT11

Idea: Non Invasive Imaging

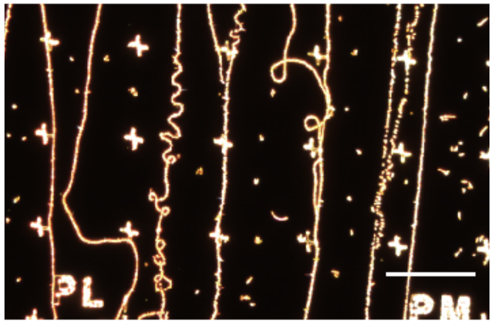
- The CNT scaffold serves as a seed for crystal growth
- Dark field imaging of the decorated CNTs with nano crystals
- Complete sublimation of the NCs without leaving any residue on the CNT sidewall



p-nitrobenzoic acid

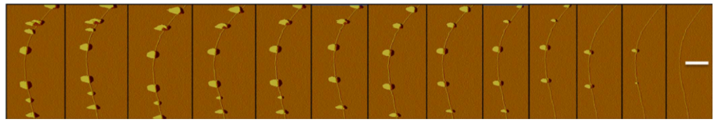


AFM

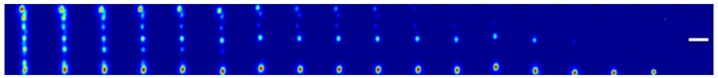


Dark Field

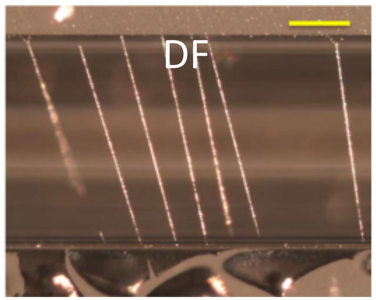
AFM 1 µm

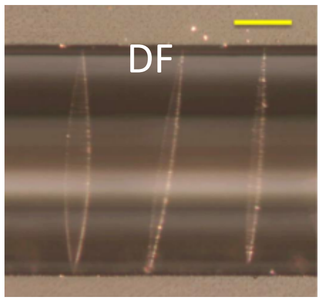


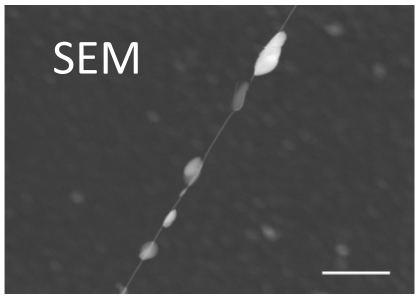
DF sublimation sequence 2 µm



Non invasive imaging







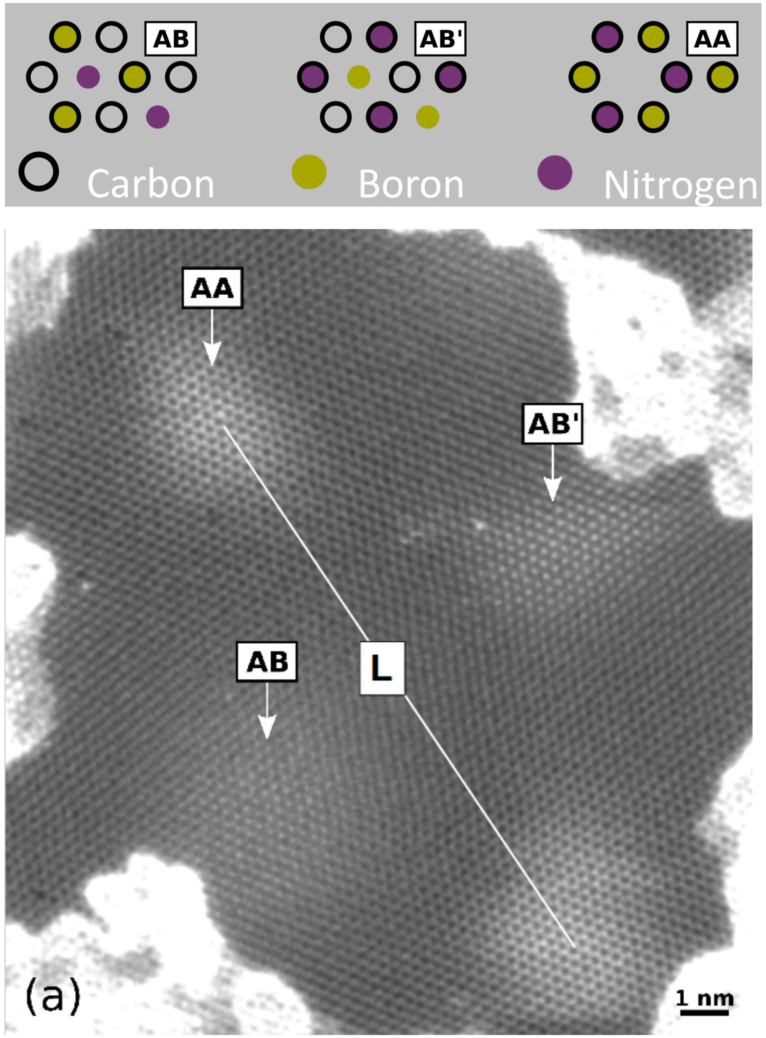
Applications:

- Imaging CNT after device fabrication for automatic circuit design
- Vibrational analysis of suspended CNTs

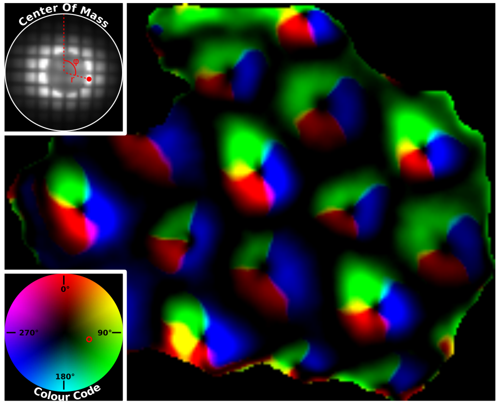
STEM study of graphene/hBN heterostructures

G. Argentero - CT12

• Problem: Nature of the stacking configurations



Atomically resolved stacking types

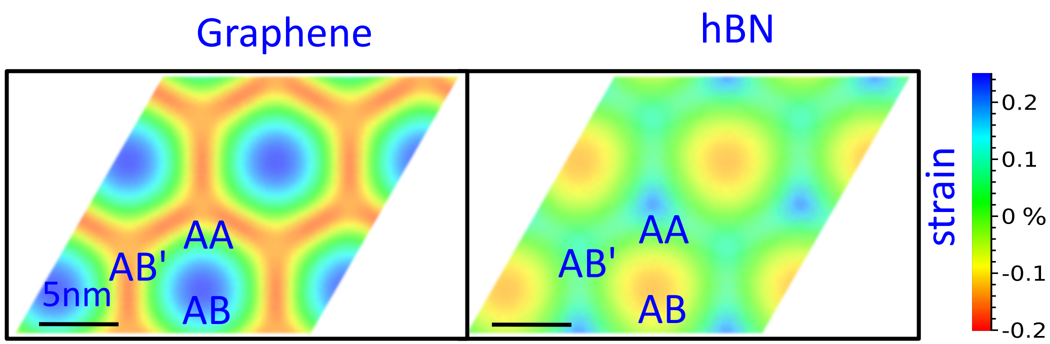


• Development of a new technique, the Direction-sensitive electron-scattering map:

AB zones larger than AA' and AB' zones

• Analysis with the support of DFT calculations

Graphene and hBN lattices tend to match at the energetically most favorable stacking type AB by differential strain:



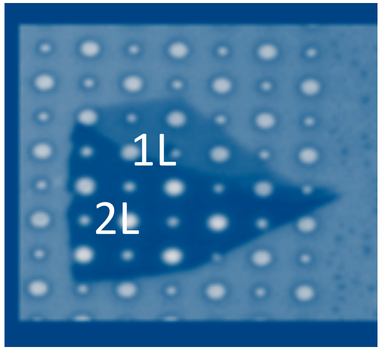
Summary on Optical properties

- C Nanotubes: filling and optical properties:
  - A way to modulate luminescence of SWNTs (CT15)
  - A way to enhance luminescence of inner tube of DWNTs (CT11)
  - Cloaking of encapsulated molecules in SWNTs (CT16)
  - Dye-filled CNTs for non linear optics (CT22) and for SERS (CT26)
- C Nanotubes luminescence for biomedicine (IT12, IT7)
- 2D Materials:
  - Optical properties of 2D semi-conductors (KN4)
  - THz spectroscopy of graphene based resonators (CT20)

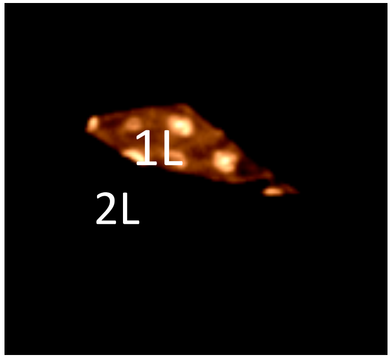
Probing electronic properties of 2D SC materials with light

T. Heinz - KN4

- At monolayer thickness properties of 2D SC materials change

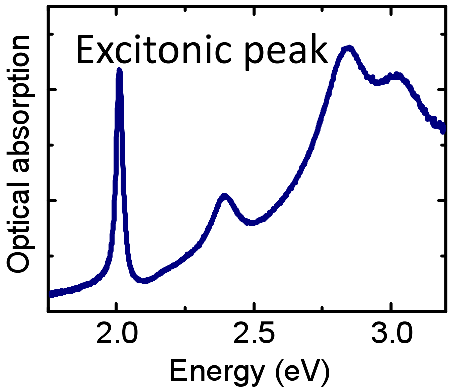


Optical contrast



Photoluminescence

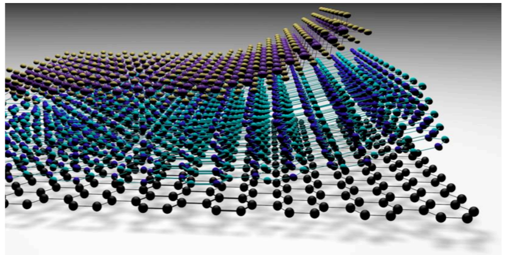
MoS_2 becomes a direct-gap SC



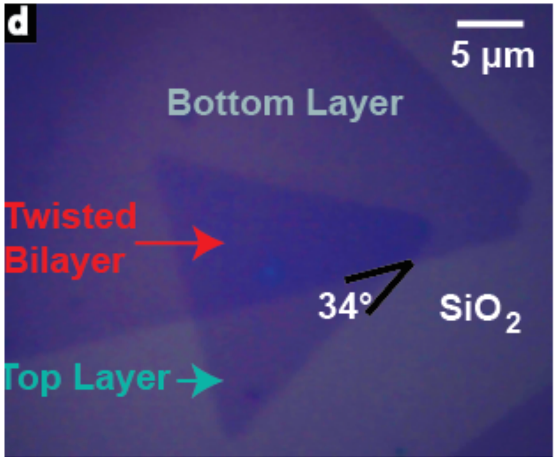
Optical absorption of WS_2

- Dominant excitonic response and higher many -body states
- Screening effects
- Tuning physics of the valleys

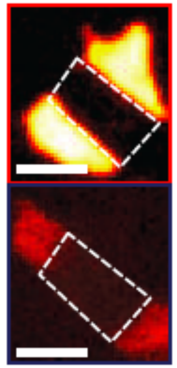
- Vertical heterostructures:
a huge research field just in its infancy



1) Twisted MoS_2 bilayers



2) MoS_2 /WSe_2



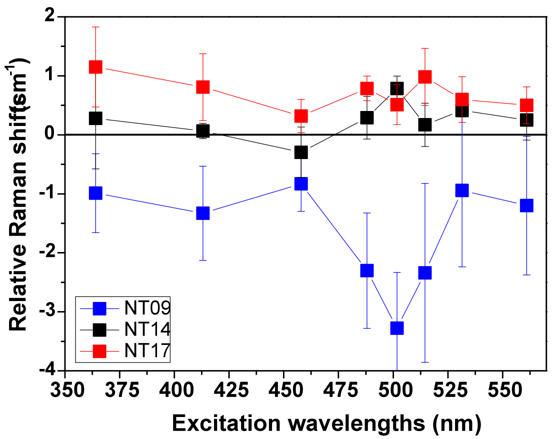
a good candidate for Bose-Einstein condensates

Filling: a way to modulate CNTs opto-electronic properties

Confinement of quaterthiophene into SWNT

L. Alvarez - CT15

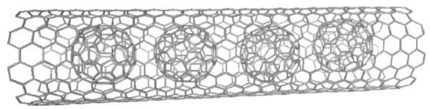
- Electron transfer from molecule to SWNT identified from Raman G band shifts
- No energy transfer from PL data
- Effects dependant on the tube diameter



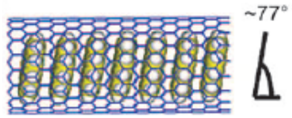
G-band shifts for different NT diameters

Cloaking of encapsulated molecules in SWNTs

K. Kamaras - CT16



C60@SWNT

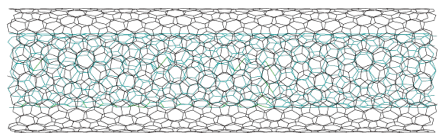


coronene@SWNT

Molecules get invisible in IR !

Phonon properties of DWNTs: effect of interlayer interaction

D. Levshov- CT8



Raman spectroscopy on individual index-identified DWNT using TEM

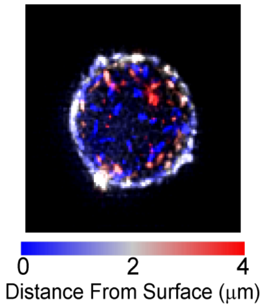
- Strong dependence of RLBM and G mode on the interlayer distance

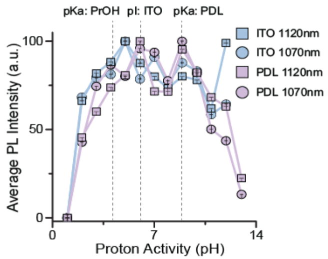
C-NTs Photoluminescence for Biomedicine

D. Heller - IT12

• A Job for Carbon Nanotubes:
Improve Quantification of Bioanalytes in live cells, animals and people…

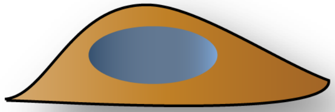
• The approach: CNTs optical measurements using a new IR hyperspectral imaging set up (col. R. Martel)

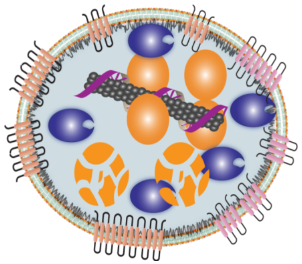




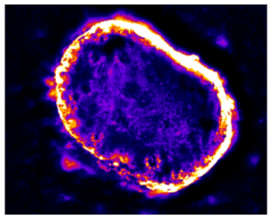
Cell surface charge

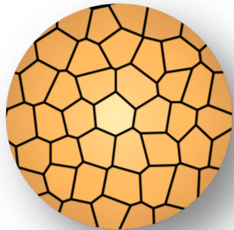
Roxbury, et. al., *ACS Nano* (2016)





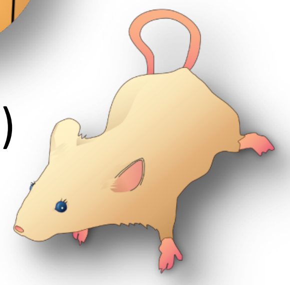
Intracellular metabolites

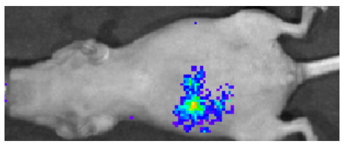




Tumor permeability

PV Jena, Y Shamay, et. al., *Carbon* (2016)



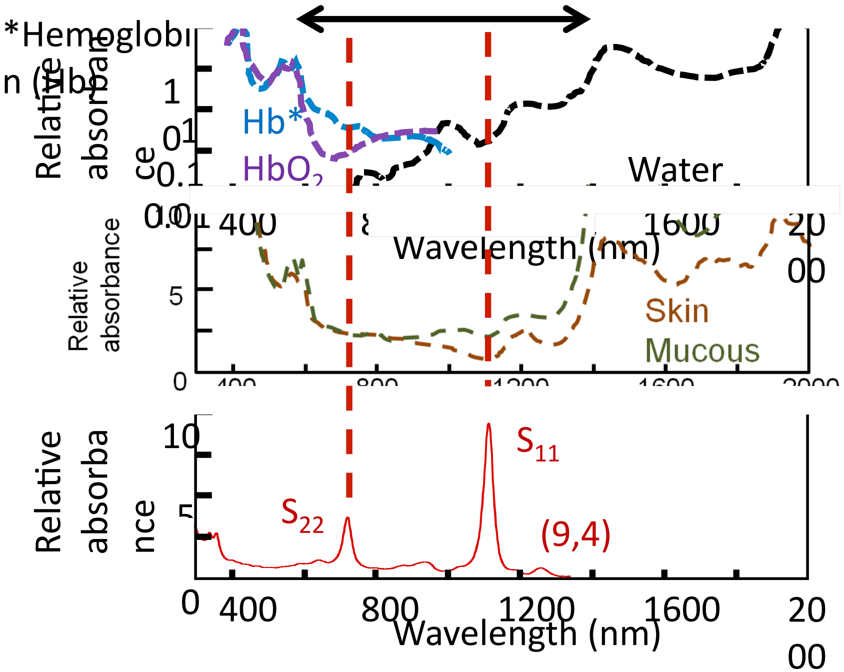


Cancer biomarkers

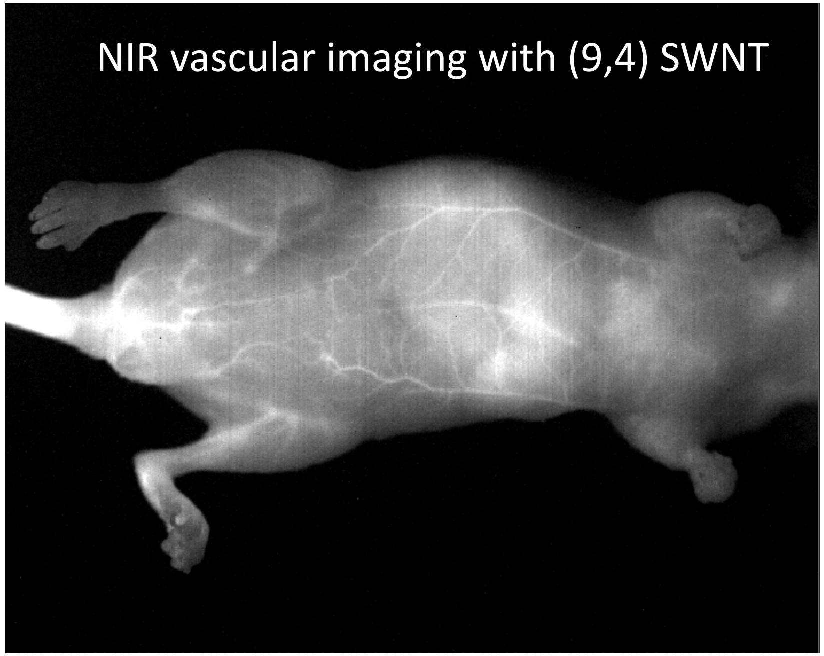
From SWNT sorting to NIR Vascular imaging

H. Kataura- IT7

- Idea: use (9,4) SWNT for biological imaging following previous work done by H. Dai's group



- Advantages:
  - better signal to noise and luminescence efficiency
  - dose lower by one order scale
  - high temporal resolution



(9,4)

- Multistep separation procedure using specific gel, SC/SDS/DOC
- Capability: 1mg/day allowing 5000 imaging

Y. Yomogida et al Nat Commun. 7 (2016)

From properties to applications

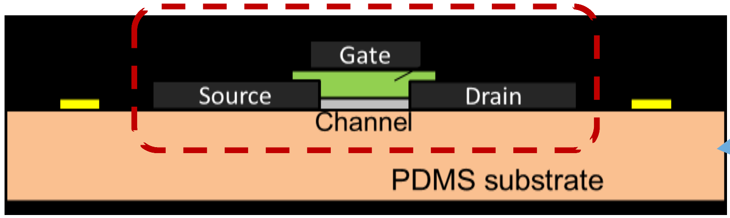
- Gas sensors:
  - Sensitive SnO2@CNT gas sensors(IT4)
  - Design of nanoscale sensors (CT23)
  - Sensing capability of a new single ion – SWNT heterostructure (CT27)
- Energy applications
  - potentialities of nanocarbons for Electrochemical energy storage (IT5)
  - Hierarchical assemblage of CNTs and graphene for energy storage (IT9)
  - thermoelectric properties of SWNTs (CT21)
  - producing hydrogen with graphitic materials (CT25)
- Electronics:
  - SWNT thin films for wearable electronics (IT8)
  - CNT for THz applications (CT18)

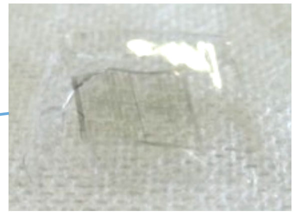
Wearable bio-electronics applications of CNTs thin films

Yutaka Ohno – IT8

- Fabrication of CSWNT thin films with flexibility, high mobility, transparency for wearable device applications
- Wafer scale characterization on 7000 devices!

  variation 5%, mobility = 10 – 20cm^2/Vs, ON/OFF = 10^5



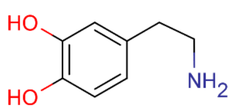


(contrast enhanced to see)

Extremely stretchable, invisible all-carbon TFTs & ICs

- Sensor application: Ultra-high sensitivity detection of dopamine

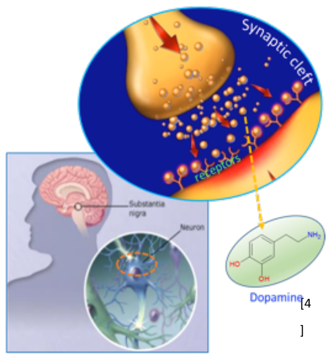
Dopamine (DA)

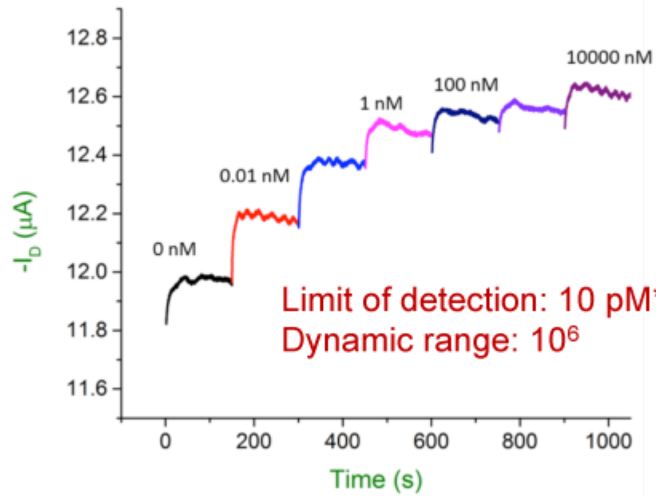


Neurotransmitter

Dysfunction of DA system
→ Parkinson's disease
schizophrenia

~10 nM in human brain



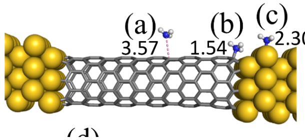


Computational Exploration and Design of Sensors

J. Bernholc - CT23

- Detection of NH_3 and NO_2 by NT sensors

  adsorption at metal-NT interface has the largest sensitivity

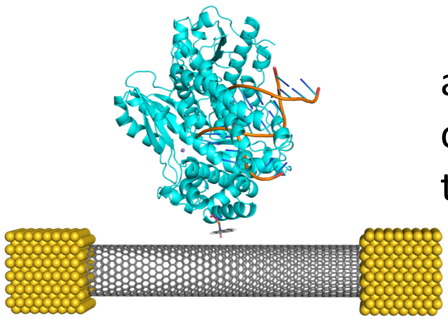


- Mechanisms of detection and sensitivity in functionalized NT sensors

  Covalent functionalization for ethylene detection

  Non-covalent functionalization for glucose detection

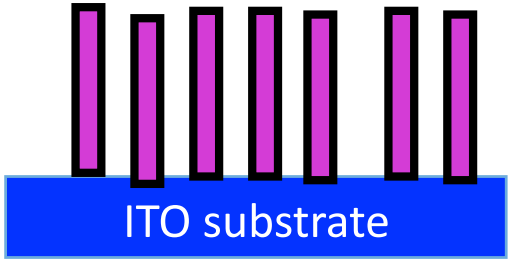
- Polymerase attached to CNTs for DNA sequencing



a different current is observed through CNT when the enzyme has just added a DNA base

SNO_2@CNT Gas sensors

A. Goldoni– IT4



- Growth of vertically aligned CNTs filled with Sn on ITO substrates
- Gas sensitivity tested for several gases:

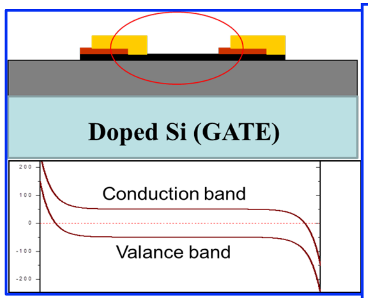
  H2, C2H4, NH3...

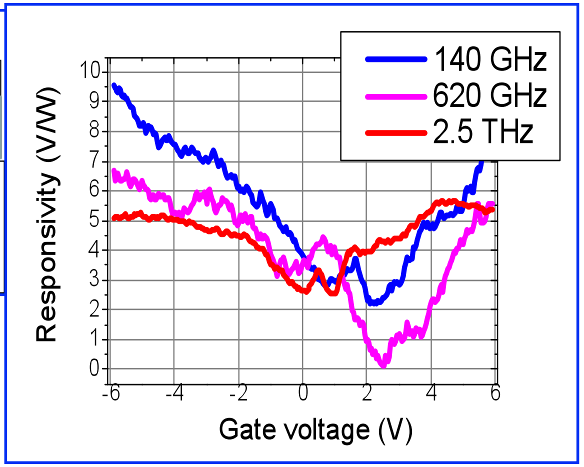
  and at variable temperatures up to 500K

- Very sensitive sensors with fast recovery:
  - ppm-ppb at room T
  - ppt at 500K
  - recovery time of 100 s in air at room T

CNT device for THz applications

G. Fedorov– CT18





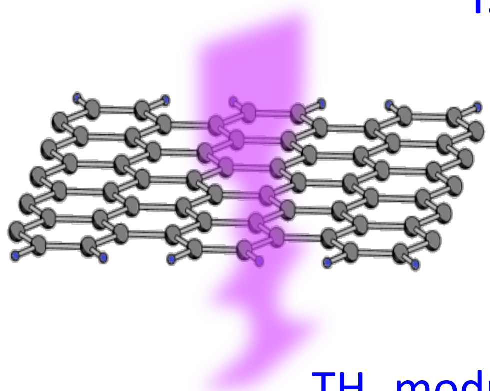
- Engineering CNT devices for THz detection

- Broadband (up to 2.5 THz) response of m-CNT based devices and high responsivity of s-CNT based devices up to 500GHz was demonstrated.

- Enhanced response of CNT arrays due to gate-tunable plasmon resonance was predicted

Theory UV to TH_Z light conversion by Gr nanoribbons

Y. Myamoto – CT25



TH_Z modulation of UV light

the proposition is that Graphene nanoribbon is the good material for doing that

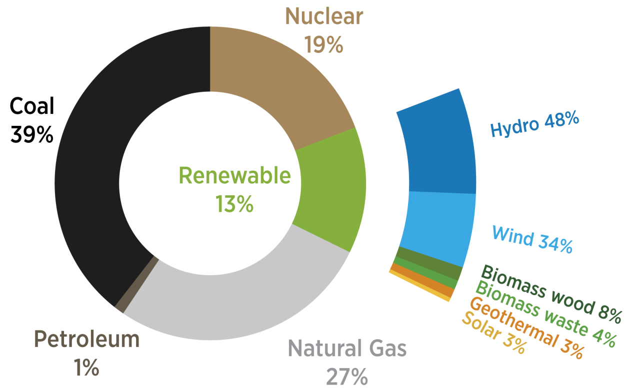
✓ Computation - TDDFT simulation
✓ Physics - interference among excited states of graphene nano-ribbon

✓ Application:
photocurrent modulation in antenna - TH_Z radiation device

Energy applications

Podila - IT5

Global energy situation in 2014



Need systems for storing renewable energy

Interest of carbon materials for electrochemical double-layer capacitors providing both high-power and high energy:

- Controllable structure, uniform pore size distribution
- Good chemical stability
- Flexible substrates – lower contact resistance

Development of different processes using graphene or NTS

Challenges

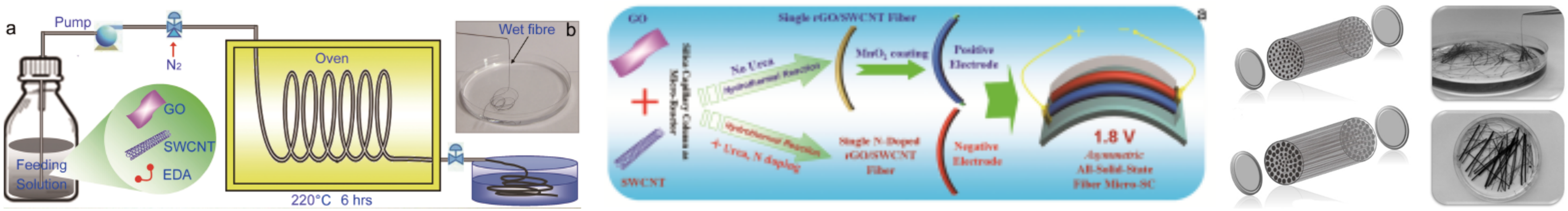
- Increasing the inherently low quantum capacitance of nanocarbons
- Improving the accessibility of inter-layer spaces in CNTs and few-layer graphene
- Scalable and cost-effective manufacturing of devices using roll-to-toll (R2R) methods

Are NTs and graphene competing or complementary?

Hierarchical assemblage of CNTs and graphene for energy and bio applications

Y. Chen, IT9

- Approach:
  - chemical process design and development of assemblies of C nanostructures
  - performance evaluation for designed applications
- Several steps:
  - S doped Co catalyst design for the synthesis of (9,8) SWNTs
  - architecture design of hybrid fibers using NT and GO for capacitive energy storage



- architecture design intercalating CNT into Gr sheets for stable membranes