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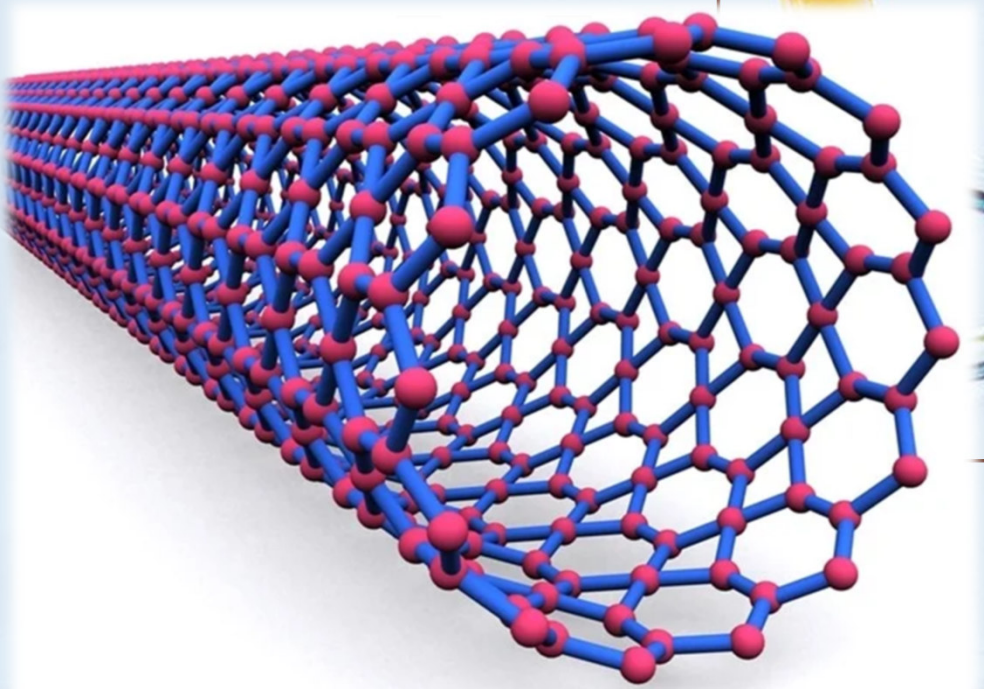

CARBON NANOTUBES

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JURUSAN KIMIA, FMIPA UNIVERSITAS NEGERI MEDAN

CAPAIAN PEMBELAJARAN LULUSAN (CPL)

CPL1 (S2) Memiliki moral, etika, dan kepribadian yang baik di dalam menyelesaikan tugasnya

CPL2 (P2) Menguasai prinsip dan metode keteknik kimia, prinsip ekonomi, dan proses ekologi untuk dapat berperan sebagai tenaga ahli (sub professional) yang menangani masalah rekayasa Kimia

CAPAIAN PEMBELAJARAN MATA KULIAH (CPMK)

Mampu memahami ilmu nanoteknologi untuk menyelesaikan masalah berdasarkan prinsip rekayasa Kimia yang saling terkait dengan aspek material, energi, dan lingkungan (CPL4).

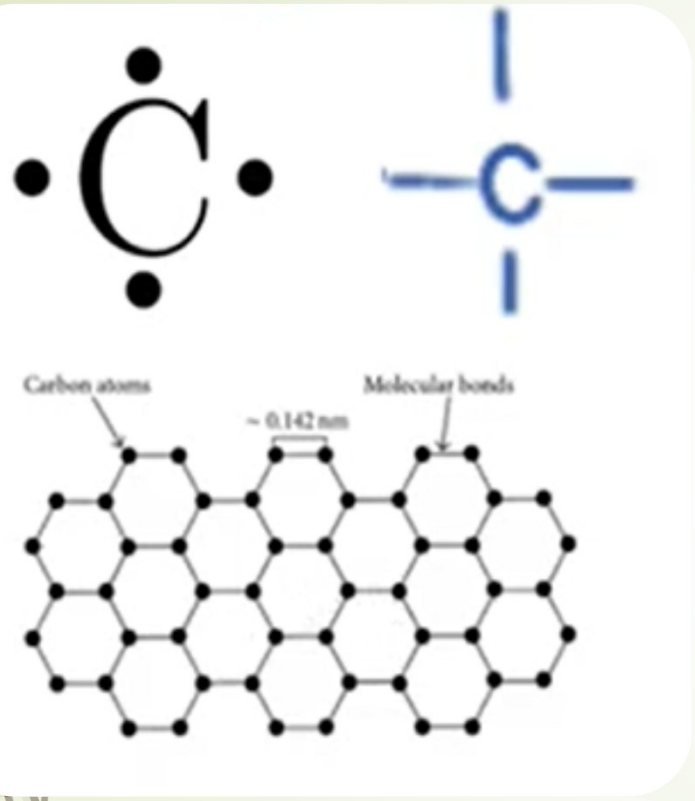
OUTLINE MATERI PEMBELAJARAN

1. Material Karbon
2. Alotropi Karbon
3. Carbon Nanotubes

CARBON NANOTUBES

1. Material Nano Karbon
2. Alotropi Material Karbon
3. Carbon Nanutube

Material Carbon

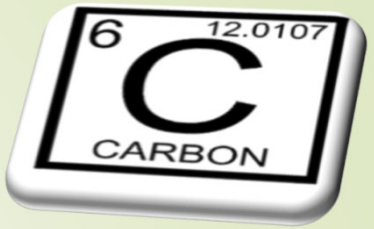


- Empat elektron valensi pada karbon memebuatnya menjadi material istimewa, karena dengan mudah bisa membentuk ikatan kovalen tunggal, rangkap dua dan rangkap tiga dengan unsur lain maupun sesame unsur karbon
- Bisa berpolimerisasi membentuk rantai karbon Panjang
- Dapat berada dalam berbagai bentuk molekul yang berbeda, disusun oleh jenis atom yang sama tetapi strukturnya berbeda dan sifat pemrosesannya berbeda.

→ Alotropi

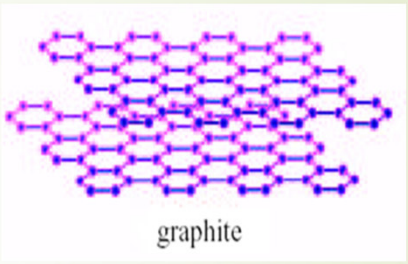
Alotropi Carbon :

Carbon Nanotubes (CNTs)



Carbon → Graphite (Ambient conditions)

sp^2 hybridization: planar


graphite

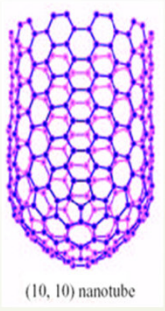
Diamond (High temperature and pressure)

sp^3 hybridization: cubic


diamond

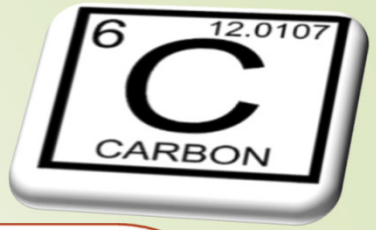
Nanotube/Fullerene (certain growth conditions)

sp^2 + sp^3 character: cylindrical

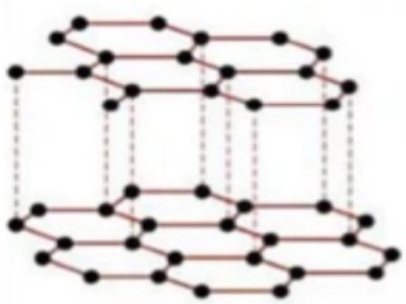

(10, 10) nanotube


C_{60} fullerene

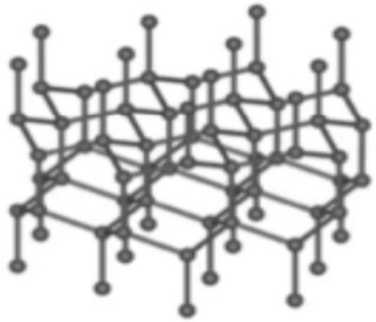
Alotropi Carbon



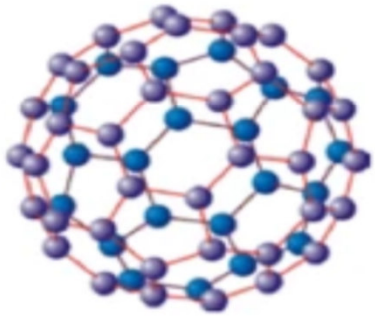
Diamond



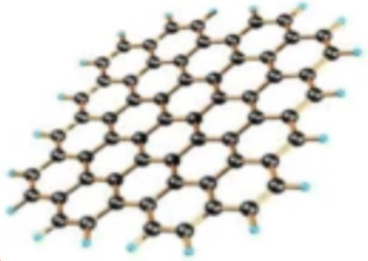
Graphite



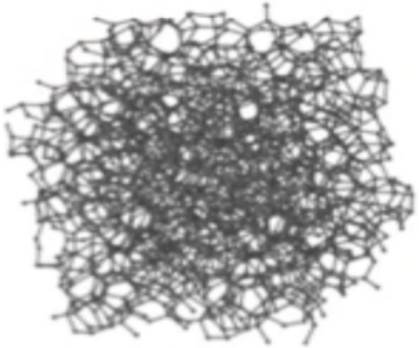
Londsdaleite



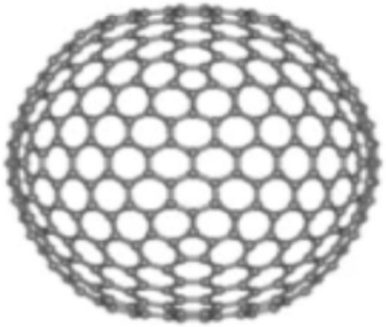
C60-fullerene



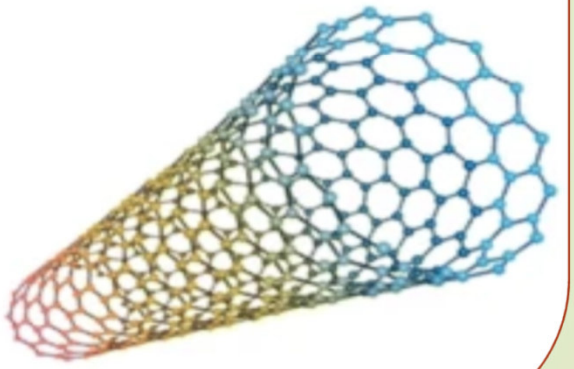
Graphene



Amorphous carbon

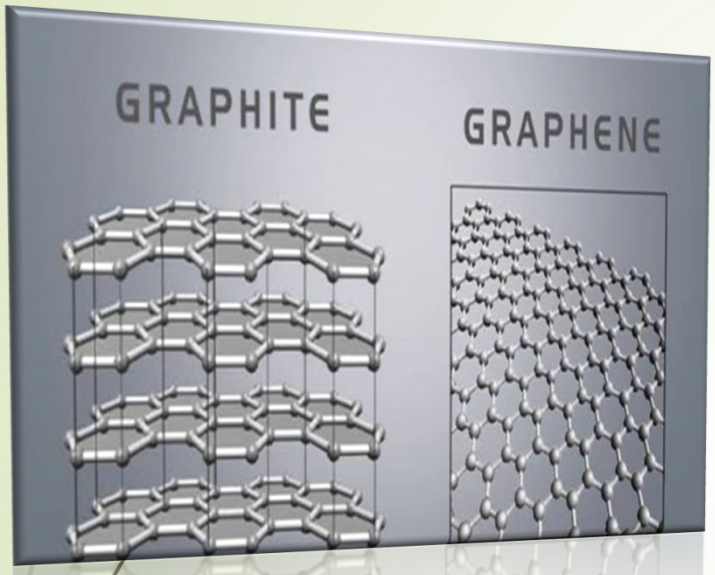


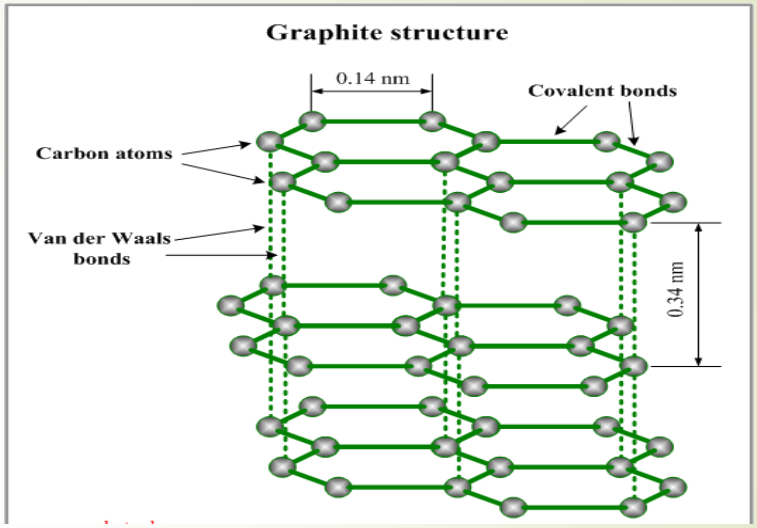
C540-fullerite



Carbon nanotube

- CNT adalah silinder karbon yang panjang dan tipis yang merupakan lembaran grafit (kisi karbon heksagonal) yang digulung menjadi sebuah silinder

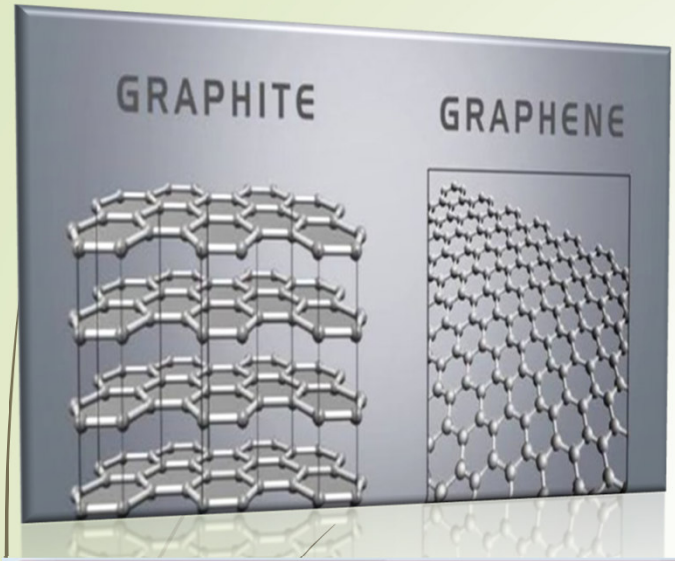




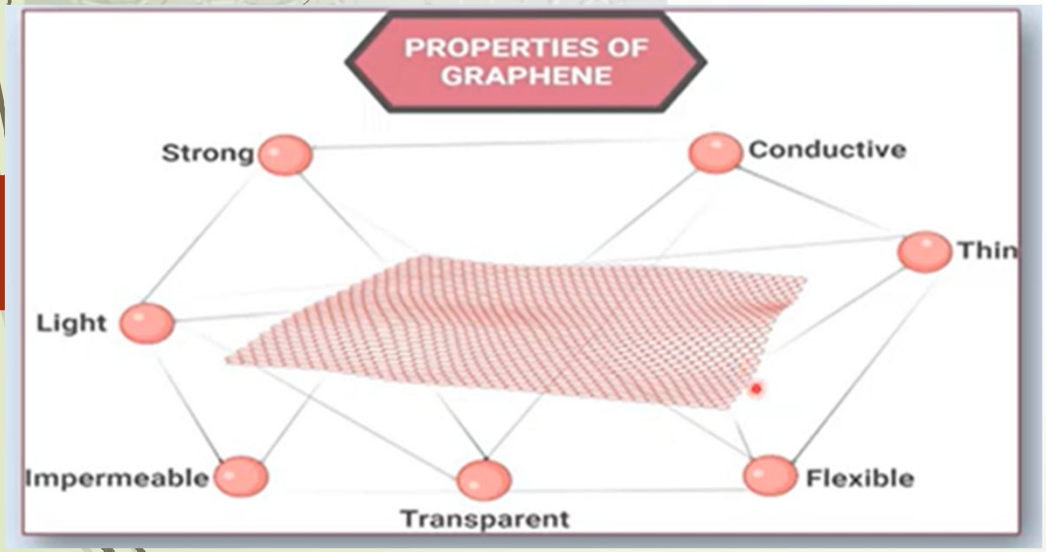
- **Grafit :** Alotropi karbon kristal 3 dimensi
- Lapisan Karbon Heksagonal yang terikat lemah satu dengan lain
- Memiliki daya hantar listrik yang baik karena keberadaan electron bebas diantaran lapisannya

Pensil

Pelumas



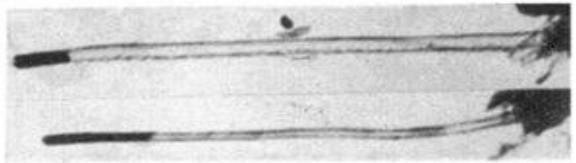
- **Graphene :** lapisan tunggal grafit yang dibuat dengan beberapa teknik
- Merupakan lapisan tunggal 2 dimensi dengan luas permukaan yang besar dan struktur menyerupai sarang madu



Material 2 dimensi dengan sifat listrik, panas dan mekanik yang luar biasa.

- Lebih kuat dari diamond, tapi ;
  - ✓ Lebih elastis dari karet
  - ✓ Lebih keras dari baja
  - ✓ Lebih ringan dri aluminium

Discoveries of Carbon Nanotube



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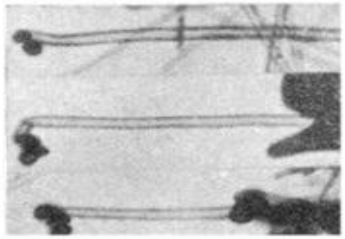


Radushkevich and Lukyanovich observe 50 nm diameter MWCNTs via TEM.

1952

Bacon observes microscale carbon whiskers that, "…consist of cylindrical or prismatic layers of graphite extending over large distances along the axes…"

1956

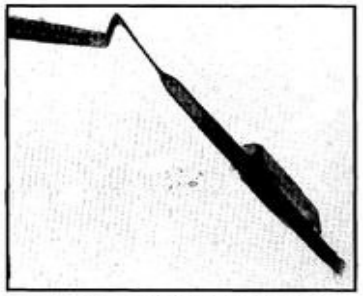


Fig. 8. Hollow tube collapsed into a ribbon. (6500X.)

1955

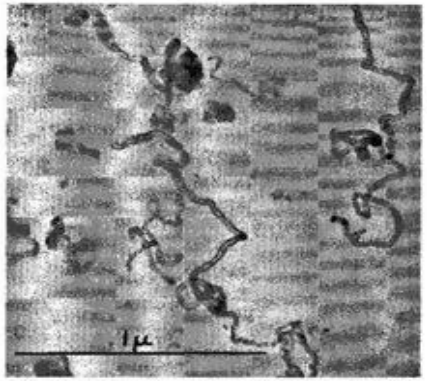


Fig. 3.—Carbon deposited on nickel [from Ni(OH)$_2$]; sample 215. Note well developed bifilamentary or tubular structure.

Hofer et. al. observe nanoscale cylindrical carbon.

1976

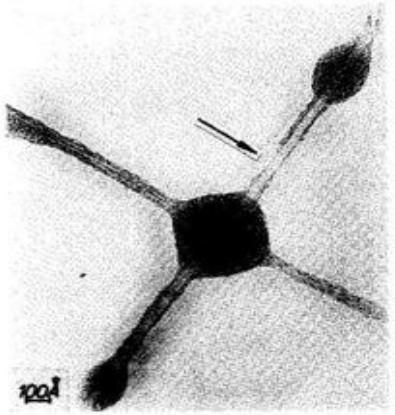
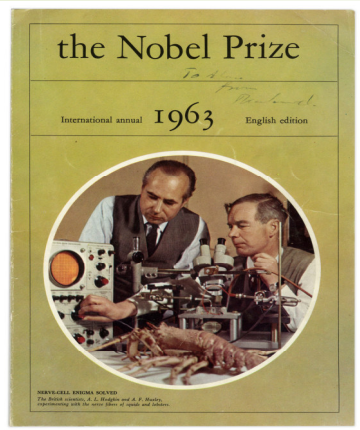


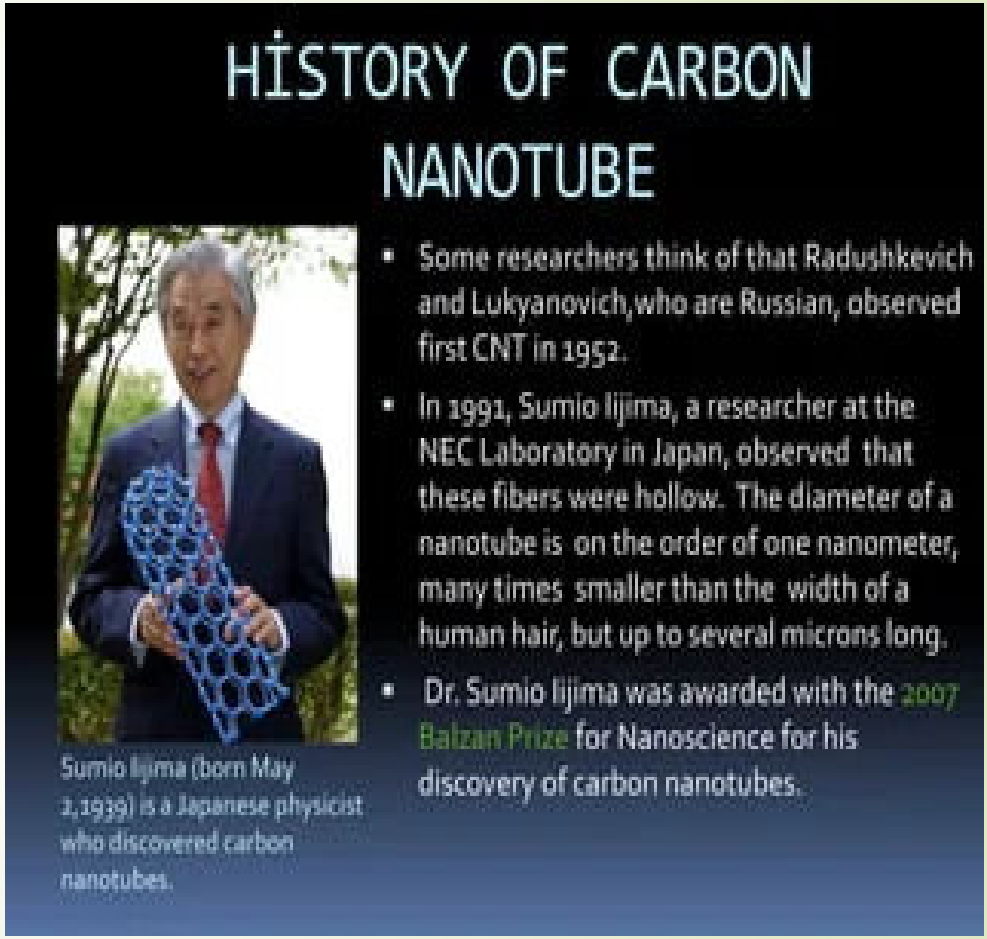
Fig. 11. Bright-field image of branched inhomogeneous fibres.

Endo reports nanoscale CVD growth of hollow carbon tubes.

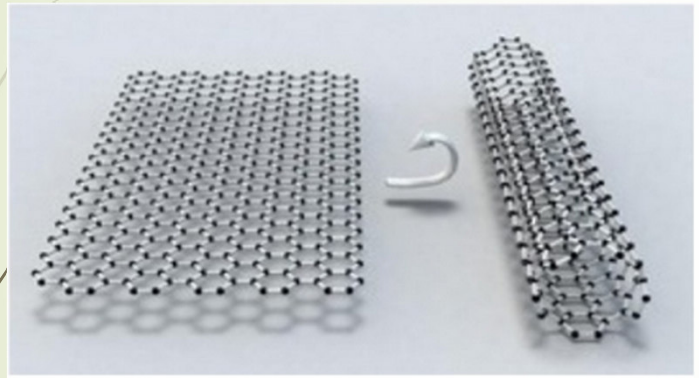
Discoveries of Carbon Nanotube



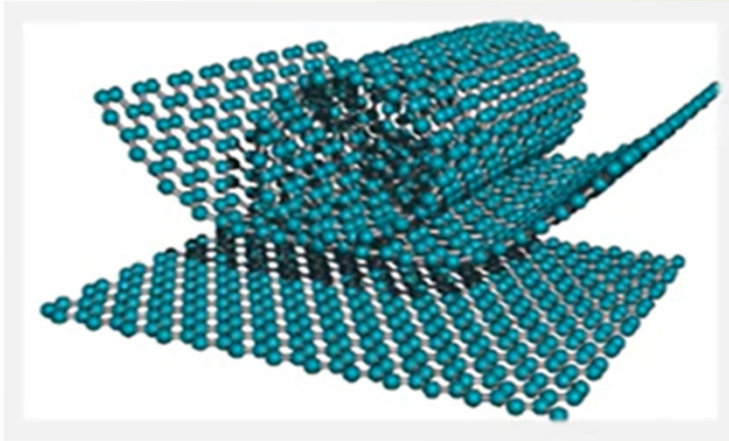
1952 ; Radushkevich and Lukyanovich : Mempublikasikan artikel di Soviet Journal of Physical Chemistry tentang Karbon Grafit berongga yang berdiameter 50 nm



- Lapisan karbon setebal satu atom dari Graphene, dan dibungkus dalam bentuk silinder dan diikat menjadi satu untuk membentuk tabung nano karbon (**Carbon Nanotubes**).
  - Nanotubes ada 2 jenis :
  - ✓ Single-walled carbon nanotube (SWCNT)
  - ✓ Multi-walled carbon nanotube (MWCNT)



CNTs were discovered in 1991 by Sumio Iijima

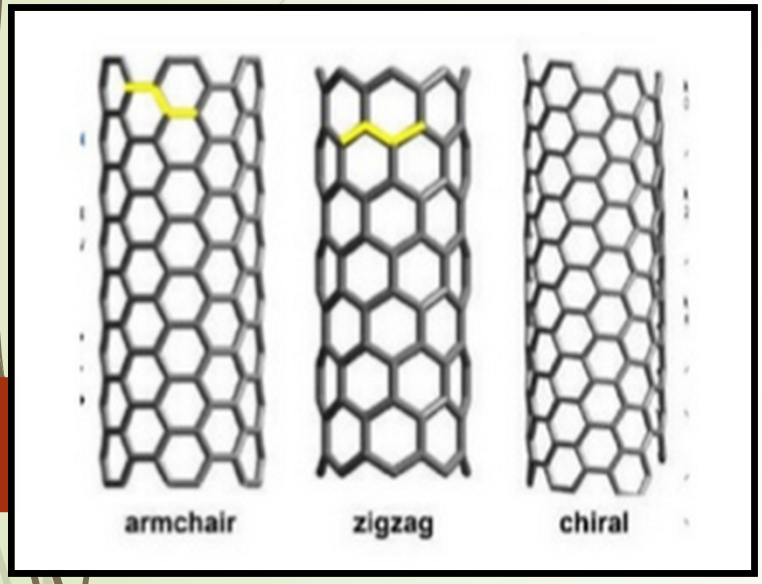


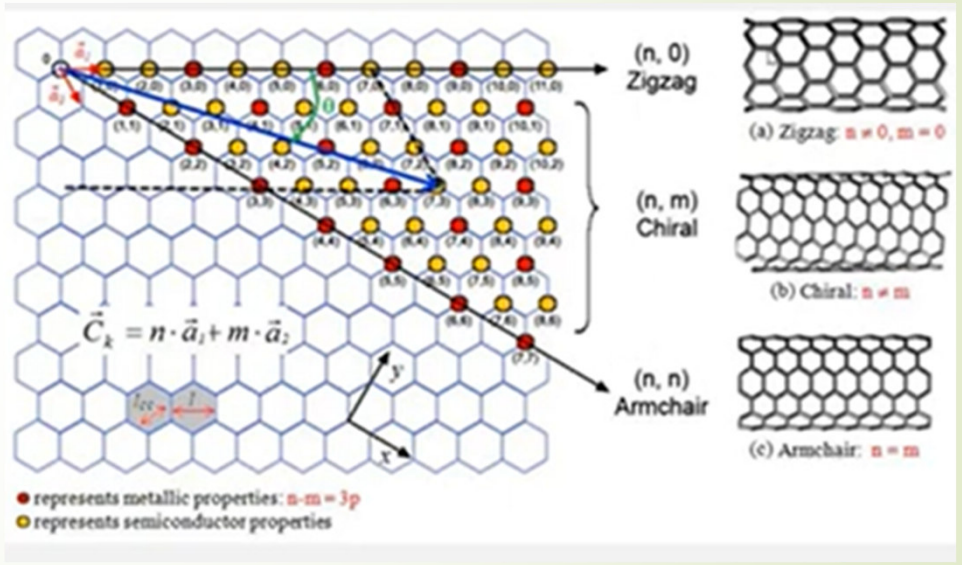
3 Metode Umum Pembuatan CNTs :

- Arc Discharge
- Laser Ablation
- Chemical Vapour Deposition (CVD)

Single-walled carbon nanotubes (SWCNT)

Single-walled carbon nanotubes dapat dibentuk dalam tiga desain berbeda yang bergantung pada bagaimana graphene dibungkus ke dalam silinder.



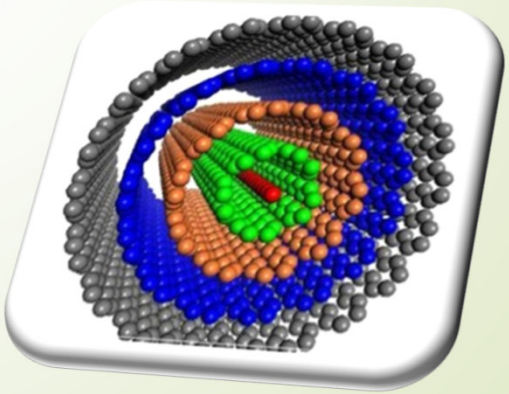


Multi-walled carbon nanotubes (MWCNT)

Jenis MWCNT :

Parchment Model

Russian Doll Model



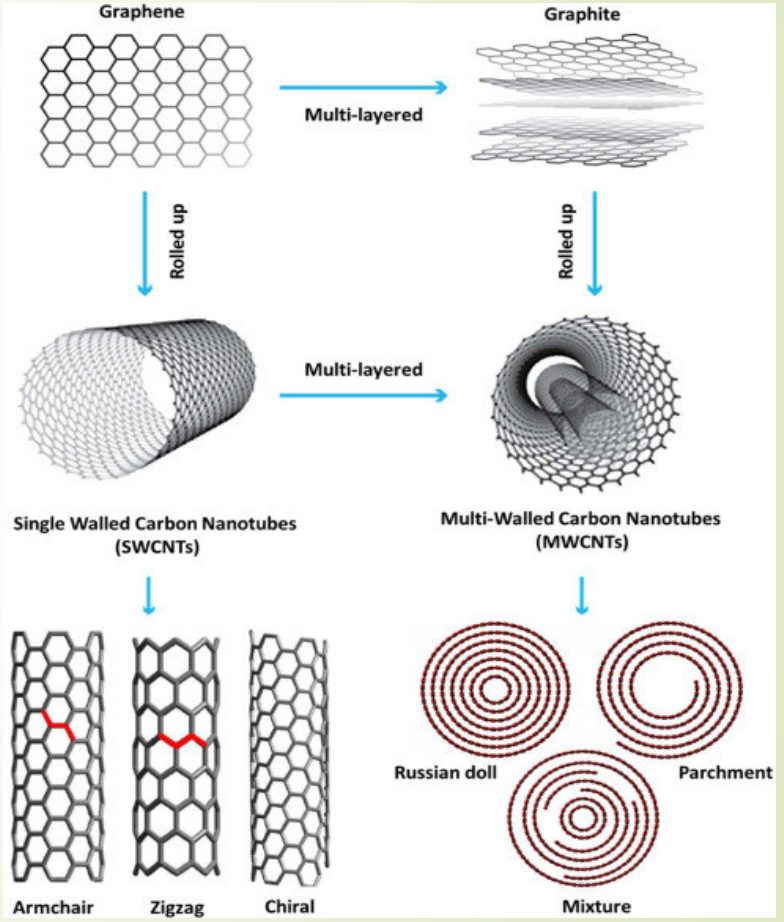
Mechanical Properties of Engineering Fibers

Fiber material	Specific Density	Young's modulus(Tpa)	Strength (Gpa)	Strain at break(%)
Carbon Nanotube	1.3 – 2	1	10 – 60	10
HS Steel	7.8	0.2	4.1	<10
Carbon fiber-PAN	1.7 – 2	0.2 – 0.6	1.7 – 5	0.3 – 2.4
Carbon fiber-Pitch	2 – 2.2	0.4 – 0.96	2.2 – 3.3	0.27 – 0.6
E/s-Glass	2.5	0.07 – 0.08	2.4 – 4.5	4.8
Kevlar-49	1.4	0.13	3.6 – 4.1	2.8

Properties of Conductive Materials

Material	Thermal conductivity	Electrical conductivity
Carbon Nanotube	> 3000	10^6 – 10^7
Copper	400	6 x 10^7
Carbon fiber-Pitch	1000	2 - 8.5 x 10^6
Carbon fiber-PAN	8 - 105	6.5 - 14 x 10^6

SUMMARY


Graphene
Graphite
Multi-layered
Rolled up
Rolled up
Multi-layered
Single Walled Carbon Nanotubes (SWCNTs)
Multi-Walled Carbon Nanotubes (MWCNTs)
Armchair
Zigzag
Chiral
Russian doll
Parchment
Mixture


спасибо
谢谢
GRACIAS
THANK YOU
ありがとうございました
MERCI
DANKE
धन्यवाद
شُكراً
OBRIGADO

Carbon Nanotube Application