Physics of atom

Lecture Four / Theoretical

Introduction of Nanomaterials

First stage

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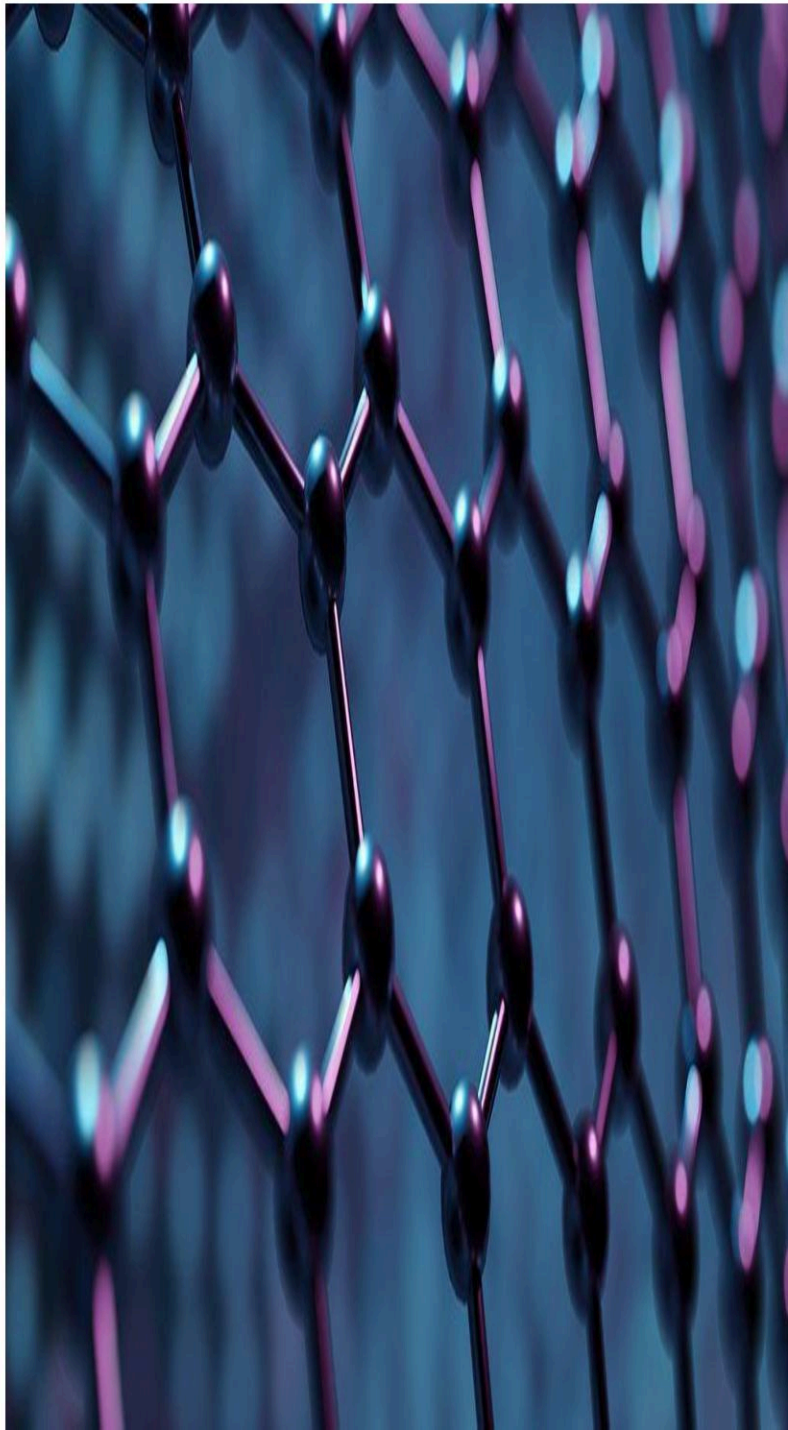
2025



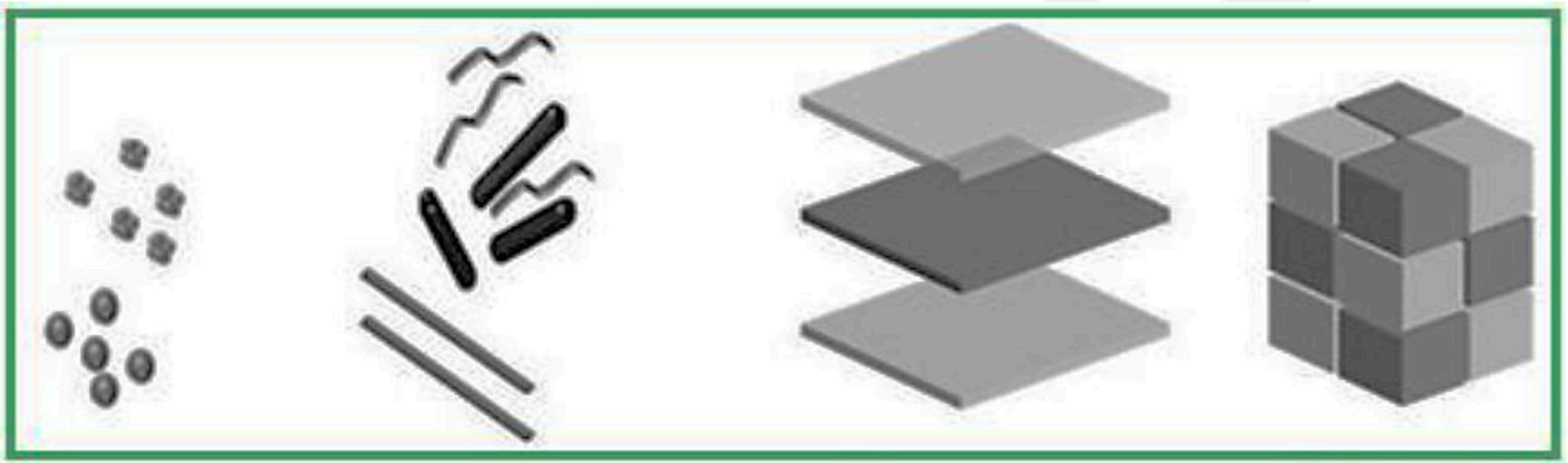
Introduction to Nanomaterials

Nanomaterials, defined as materials with at least one dimension (x, y, z) in the nanoscale range (1–100 nm), One nanometer is one billionth (10^{-9}nm) of a metre.

Nanomaterials are categorized based on their dimensions:

1. **Zero-dimensional (0D):** Here, all dimensions (x, y, z) are at nanoscale, i.e., no dimensions are greater than 100 nm. It includes nanospheres and nanoclusters.
2. **One-dimensional (1D):** Here, two dimensions (x, y) are at nanoscale and the other is outside the nanoscale. It includes nanofibres, nanotubes, nanorods, and nanowires.
3. **Two-dimensional (2D):** Here, one dimension (x) is at nanoscale and the other two are outside the nanoscale. The 2D nanomaterials exhibit platelike shapes. It includes nanofilms, nanolayers and nanocoatings with nanometre thickness.

4. **Three-dimensional (3D):** Bulk nanostructured materials, such as nanoporous solids or nanocomposites.

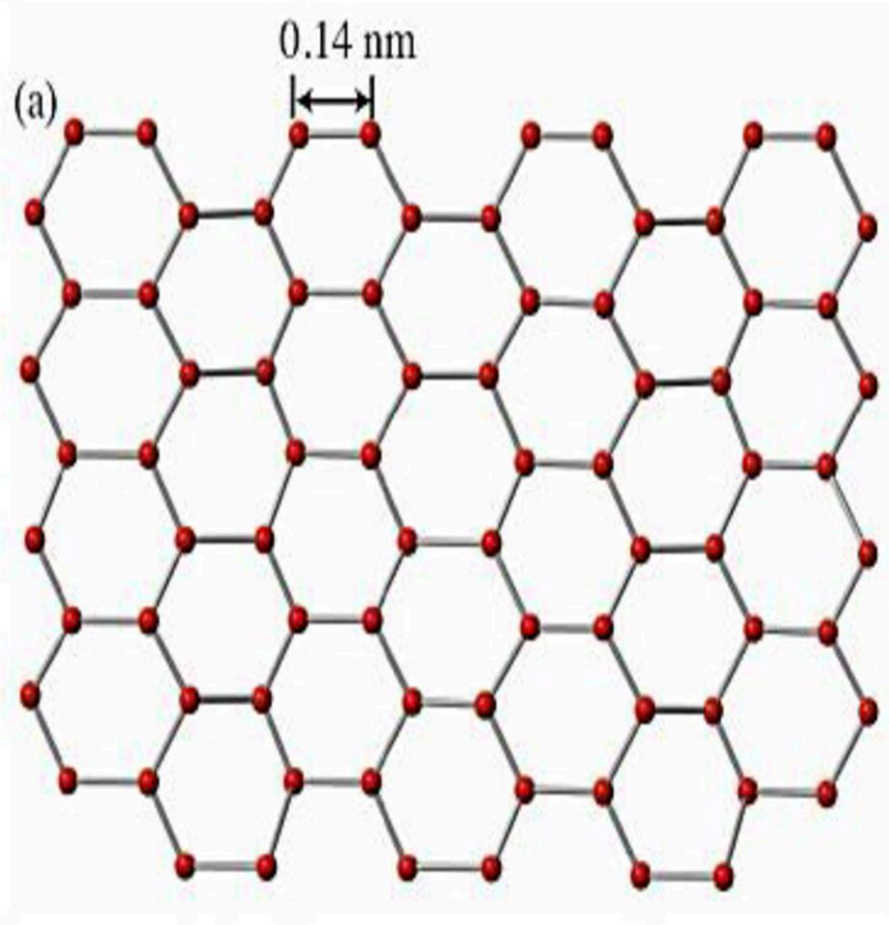


Synthesis and Characterization

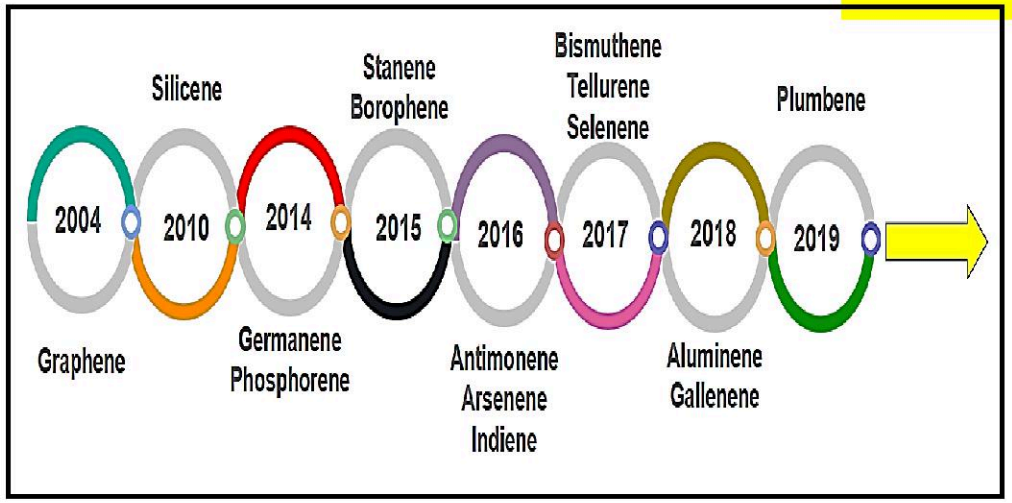
1. **Top-down approaches :** (e.g., ball milling)
2. **Bottom-up approaches :** (e.g., chemical vapor deposition (CVD)).

Graphene (GR)

Fifteen years after the Nobel Prize in Physics was awarded and twenty-one years after the first report on Graphene, global interest in this "wonder material" is still growing. It is a **two-dimensional (2D) allotropic form of carbon with a hexagonal lattice (honeycomb pattern) structure formed by a single layer of bound carbon atoms with a one-atom thickness of 0.35 nm** and distinct chemical, mechanical, electrical, and thermal properties. These properties make it a versatile platform for innovative medical applications, ranging from diagnostics to therapeutics.



Abundance



atomic # → 29 0.01% ← Percentage of Abundance in Earth's crust
atomic symbol → Cr*** ← *-Ionic, **-Covalent, ***-Metallic hydride
Element Name → Chromium
11 ← Price (AUD$/kg)

Abundance (%): 0.00% None | 0.01% Low | 1.00% Medium | 50.00% High

Draft

	3 III B	4 IV B	5 V B	6 VI B	7 VII B	8 VIII B	9 VIII B	10 VIII B	11 I B	12 II B	13 III A	14 IV A	15 V A	16 VI A	17 VII A	2 0.00% He Heer
2p											5 0.09% B** Boron 3	6 0.18% C** Carbon	7 0.20% N** Nitrogen 3	8 45.68% O** Oxygen	9 0.05% F** Fluorine	10 0.00% Ne Neon
3p											13 8.14% Al** Aluminium 2	14 [illegible] Si** Silicon 4	15 0.10% P** Phosphorus 0.17	16 0.04% S** Sulfur 11	17 0.02% Cl** Chlorine	18 0.01% Ar Argon
4p						26 6.26% Fe Iron 0.40	27 0.30% Co Cobalt 22	28 0.89% Ni Nickel 23	29 0.68% Cu Copper 8	30 0.78% Zn Zinc 3	31 0.19% Ga** Gallium	32 0.01% Ge** Germanium 2,356	33 0.02% As** Arsenic	34 0.00% Se** Selenium	35 0.03% Br** Bromine	36 0.00% Kr Krypton
5p						44 9.93E-08% Ru Ruthenium 6,817	45 6.95E-08% Rh Rhodium 101,000	46 6.26E-07% Pd*** Palladium 20,000	47 7.94E-06% Ag Silver 708	48 1.49E-05% Cd Cadmium 5	49 0.00% In Indium 550	50 0.02% Sn** Tin 21	51 0.00% Sb** Antimony	52 0.00% Te** Tellurium	53 0.00% I** Iodine	54 0.00% Xe Xenon
6p						76 1.79E-07% Os osmium	77 3.97E-08% Ir iridium 23,000	78 3.67E-06% Pt platinum 51,000	79 3.08E-07% Au gold 42,000	80 6.65E-06% Hg mercury	81 0.01% Tl thallium	82 0.10% Pb** Lead	83 0.00% Bi** bismuth 22	84 0.00% Po** polonium	85 0.00% At** astatine	86 0.00% Rn radon

Graphene

Table 1	Mechanical properties comparison			
Material	Modulus (Gpa)	T.S. (GPa)	Density (g/cm^3)	Diameter
SWCNT/MWCNT	~ 1,000	~ 100-200	~0.7-1.7	~1/20 nm
Carbon nanofibers	~ 500	3-7	1.8-2.1	20-200 nm
Graphene	~ 1,000	~ 100-400	~1.8-2.2	Platelet
Glass Fiber	22	3.4	2.6	5-10
High Tensile Steel	210	1.3	7.8	--
Carbon Fiber	230	3.5	1.75	5-10
Aramid Fiber	60	3.6	1.44	5-10

Charge carrier mobility of metals (Al-Cu-Ag) = 10-50 cm^2/ V. sec

Thermal conductivity of Cu and diamond = 400 and 2000 W / m.K

Table 2	Mechanical properties comparison			
Material	Modulus (Gpa)	T.S. (GPa)	Density (g/cm^3)	Diameter
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Table 3	Physical properties
Charge carrier mobility	~200,000 cm^2/ V. sec
Thermal conductivity	~ 5000 W / m.K
Transparency	~ 97.4 %
Specific surface area	~ 2630 m^2 / g