Today's program

Concepts

- Crystal structures

- Lattice + Basics
- Primitive translation vectors

- Unit cells
- Conventional cells
- Wigner-Seitz cells

- Packing factor
- Nearest neighbours

Examples

2-dimensions (Square & hexagonal)

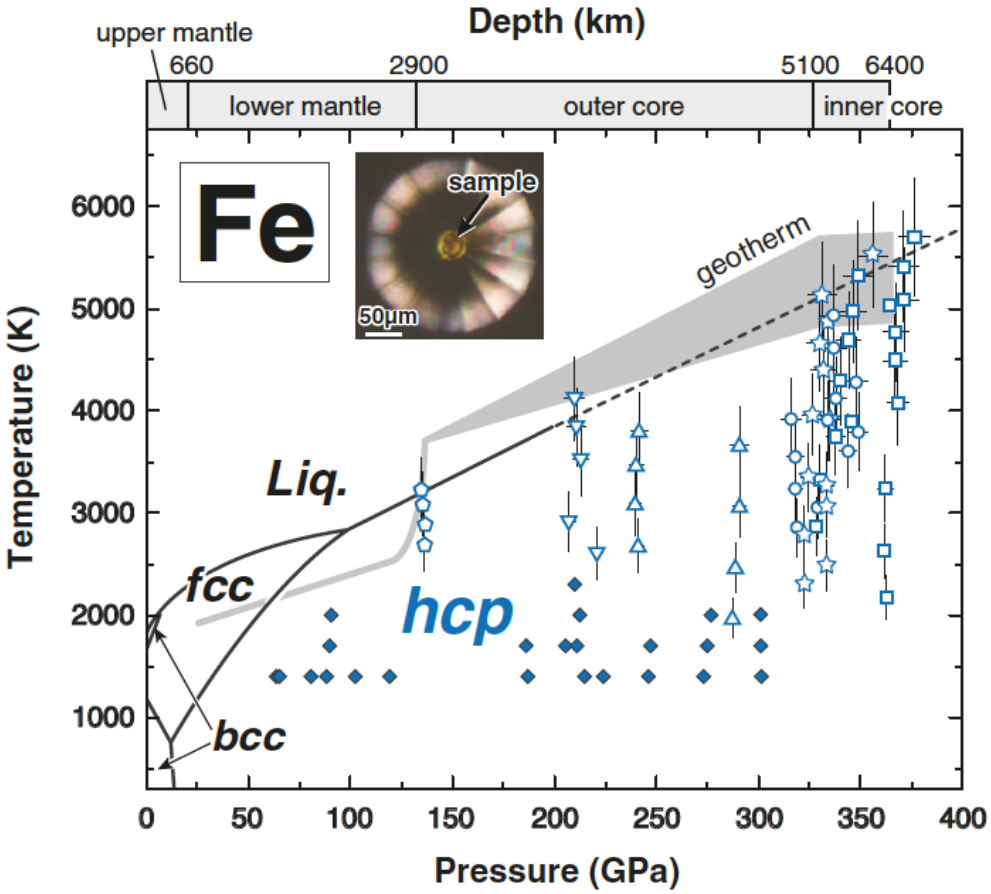
- Concept / vocabulary
- Graphene (Nobel prize 2010)

3-dimensions structures

- Cubic crystal strcutures
- Quiz
- Discuss diamond & table salt

Tasks for next week:

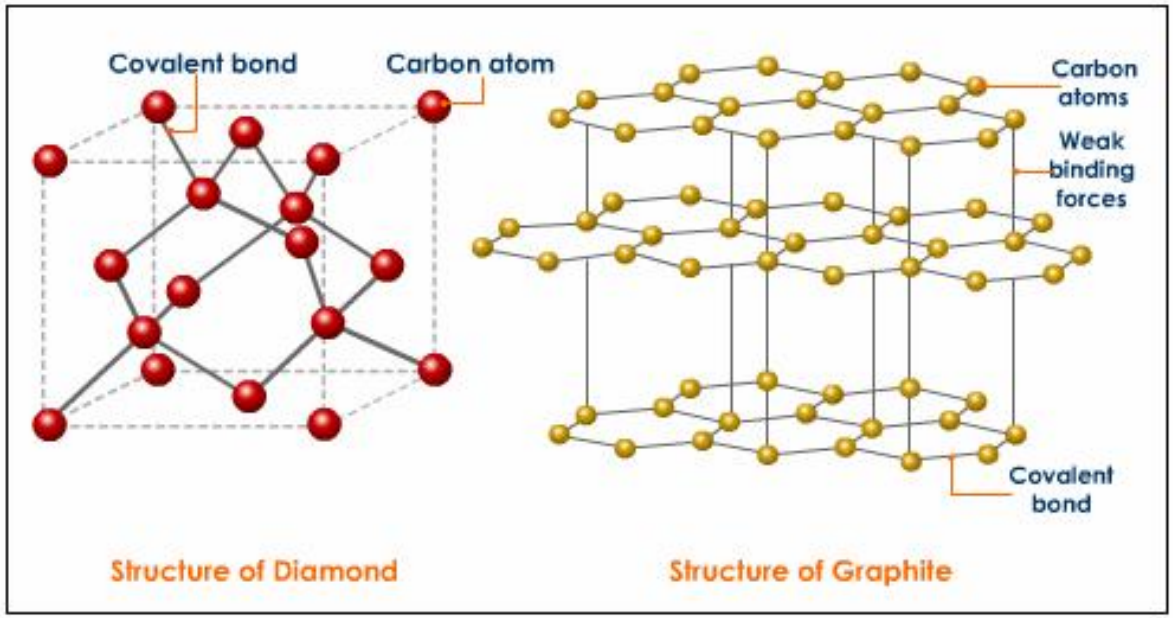
Structure of Iron in the Earth's Inner Core



Temperature-Pressure: Phase diagram

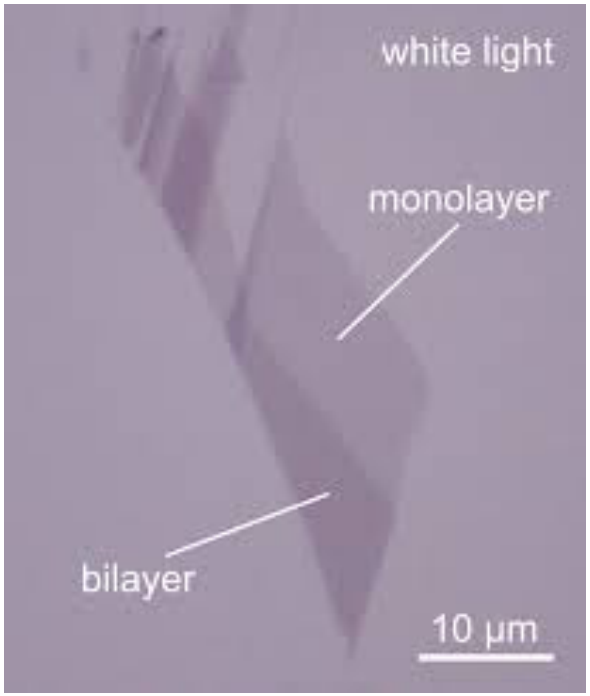
Science **330**, 359 (2010)

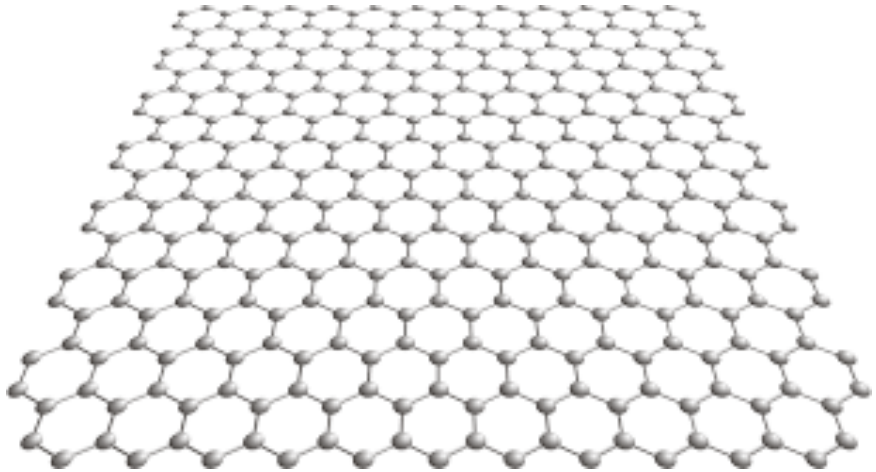
Same Material – Different crystal structures



https://ceasarjames.wordpress.com/2010/12/27/the-social-lattice/

Graphene – monolayer of graphite





Nobel Prize 2010

Andre Geim & Konstantin Novoselov

Red - thread

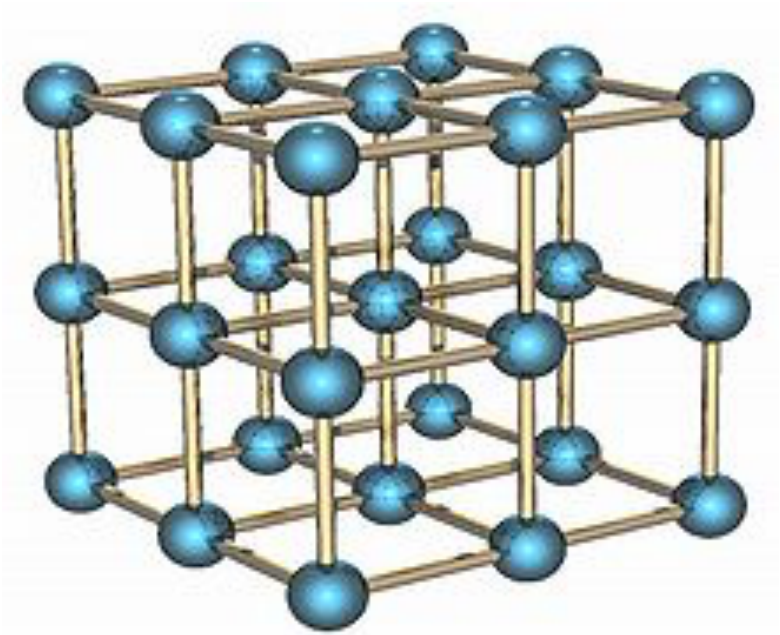
(1) Description of crystal structures (Today)

Concepts & Vocabulary
Examples
Quizzes

(2) How to measure crystal structure (next Wednesdays)

Deriving the crystal structure of new superconductor
Reciprocal space
Scattering theory

Polonium: Rare example of elementary simple cubic structure.

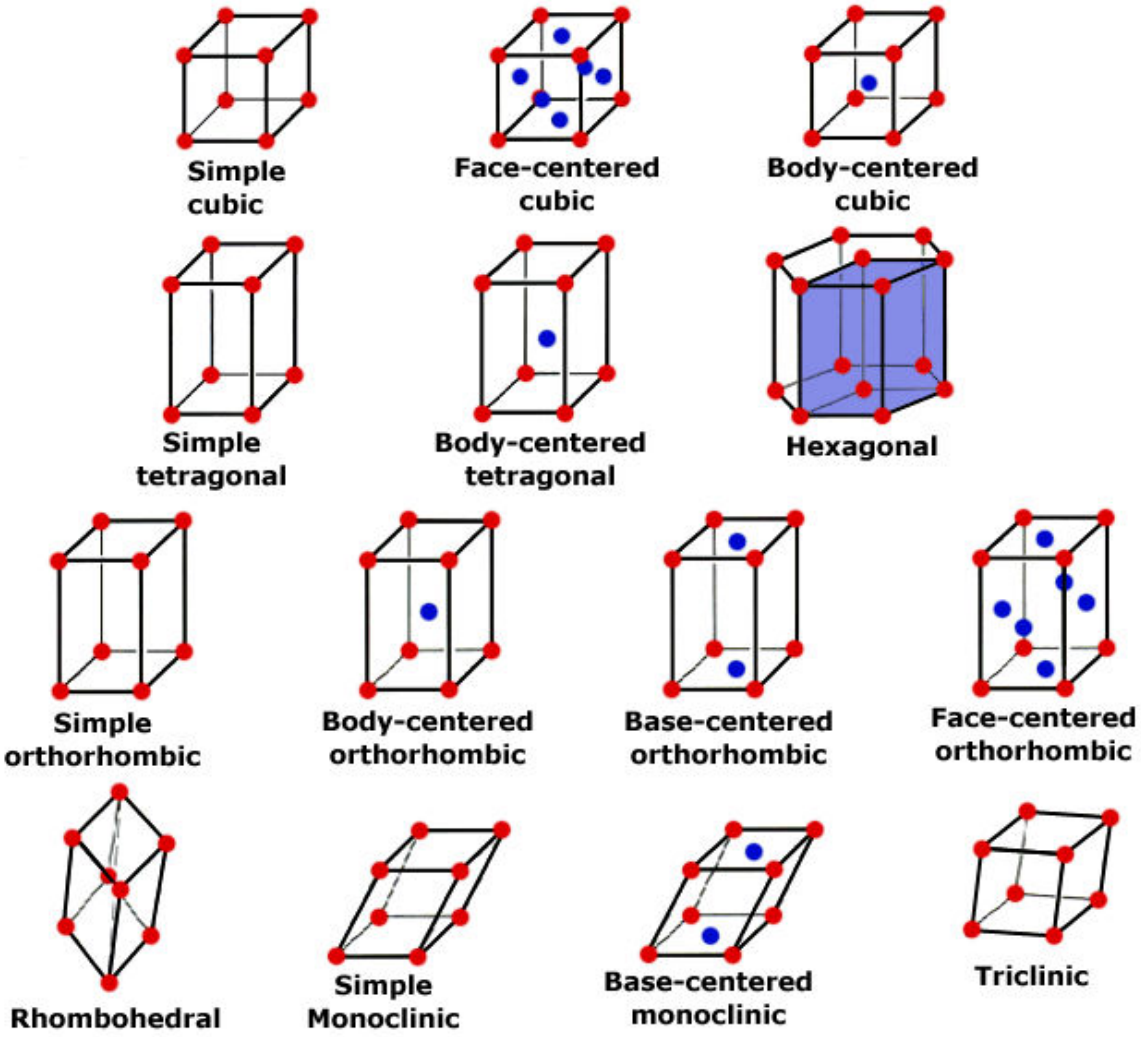


The alpha form of solid polonium.

Alexander Litvinenko

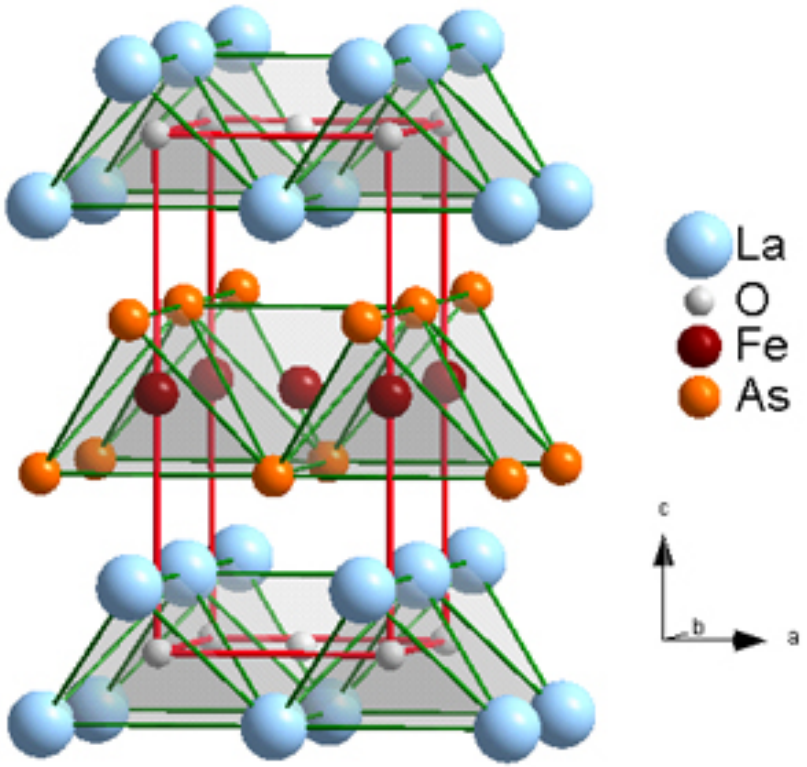
first confirmed victim of lethal polonium-210-induced acute radiation syndrome

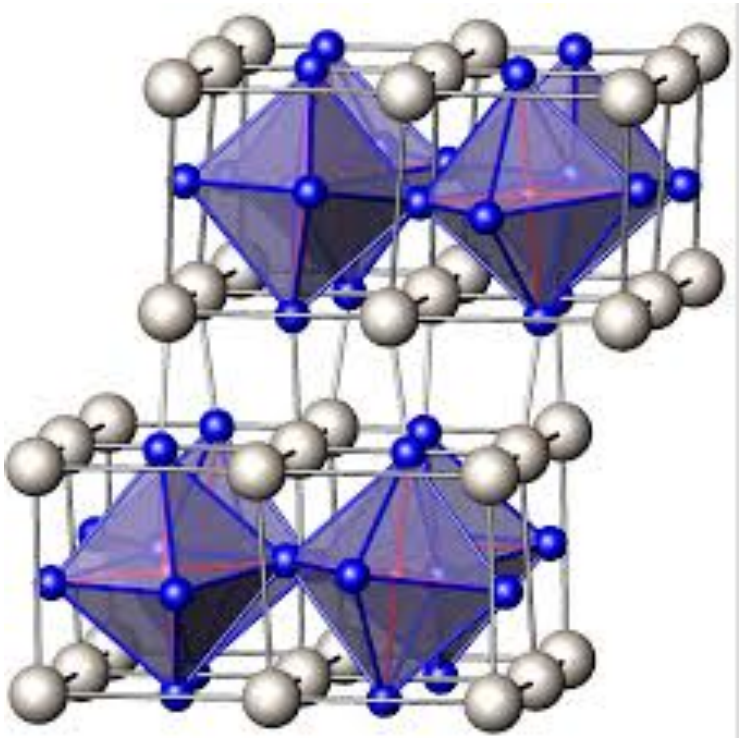
3D Lattices



http://www.jayfisher.com/Heat_Treating_Cryogenic_Processing_of_Knife_Blade_Steels.htm

Complicated Crystal Structures

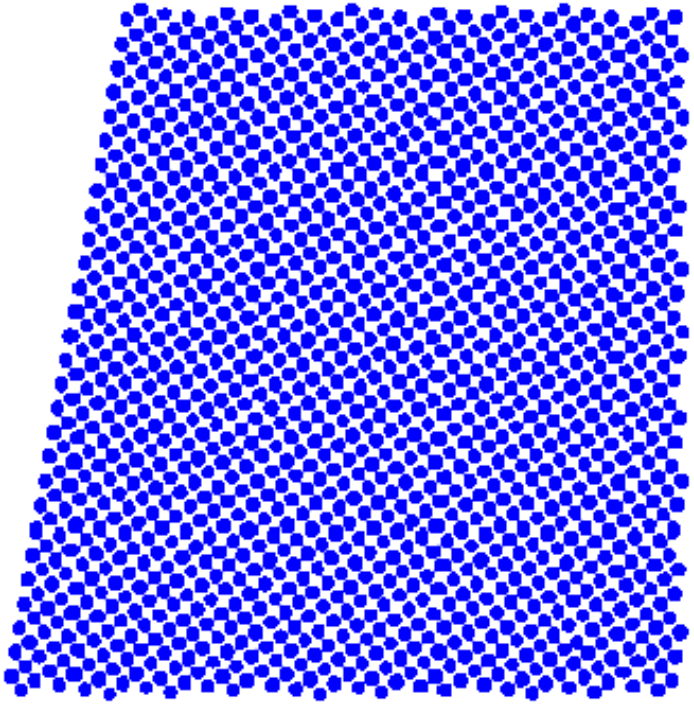


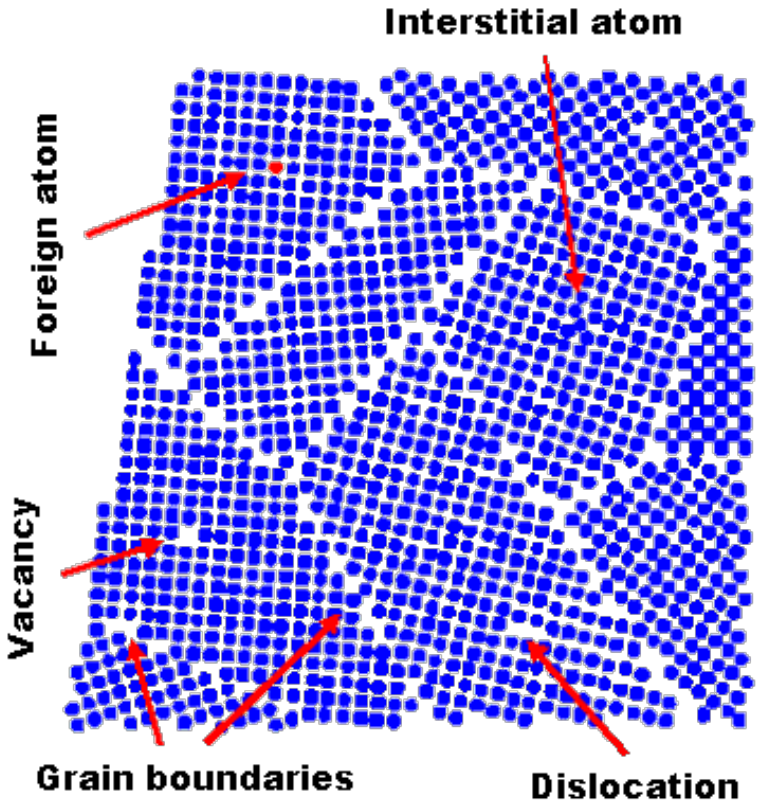


http://www.wou.edu/~rmiller09/superconductivity/

Phys. Rev. Lett. 104, 226401 (2010)

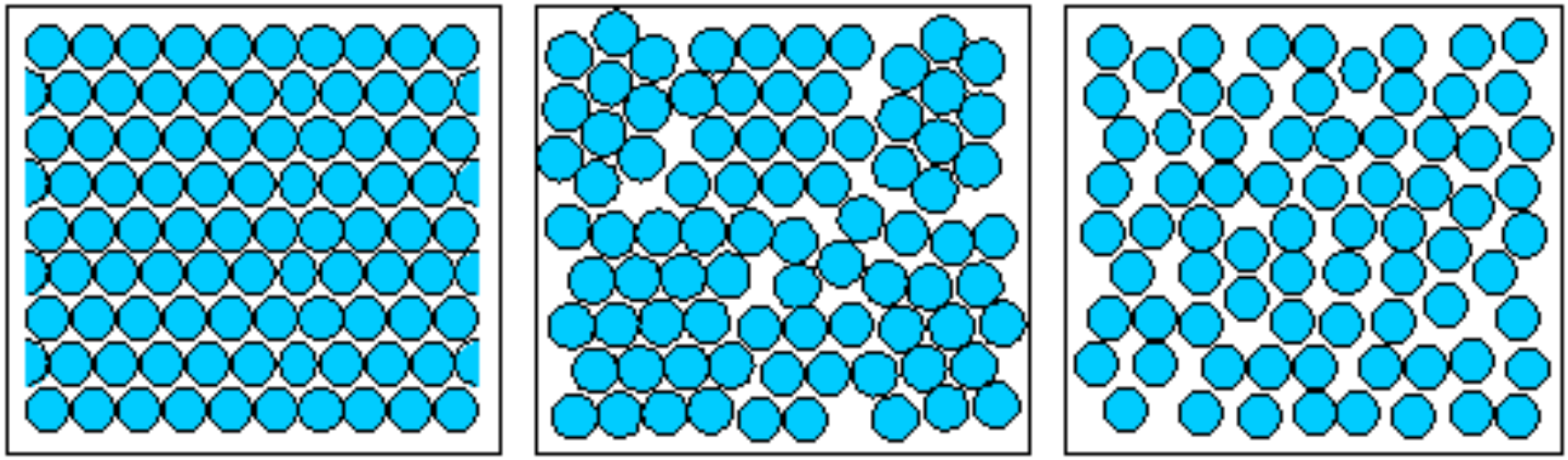
Single crystal versus Polycrystal





http://www.tf.uni-kiel.de/matwis/amat/iss/index.html

Amorphous solid



Single crystal

Periodic across the whole volume.

Polycrystal

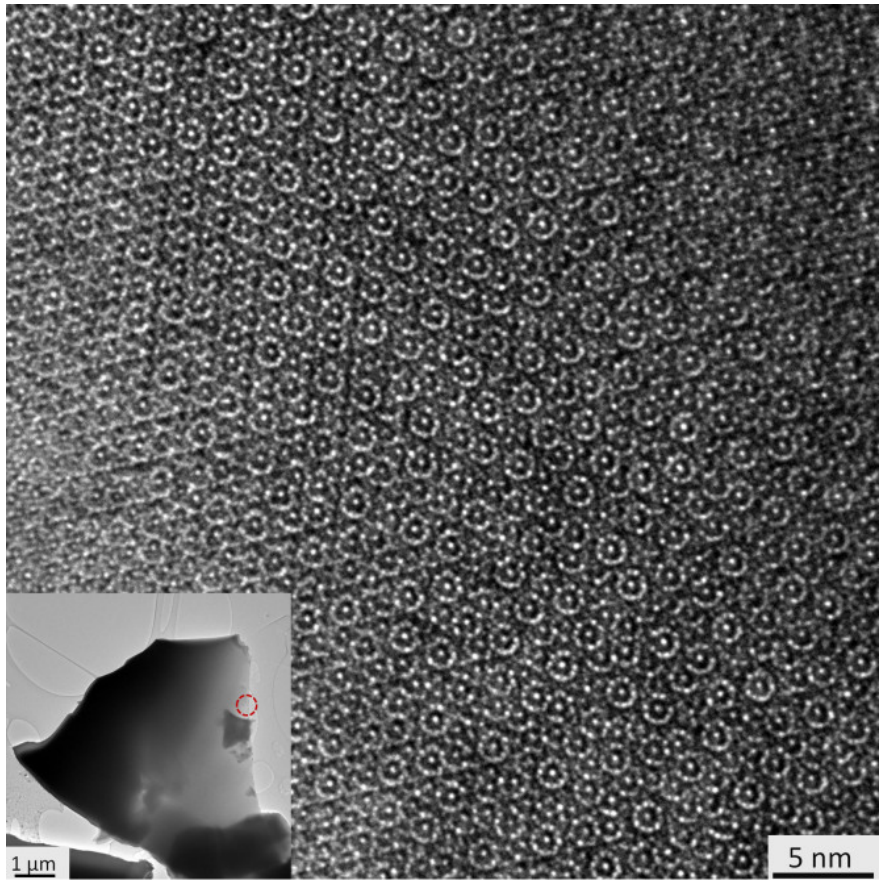
Periodic across each grain.

Amorphous solid

Not periodic.

http://www.doitpoms.ac.uk/tlplib/atomic-scale-structure/intro.php

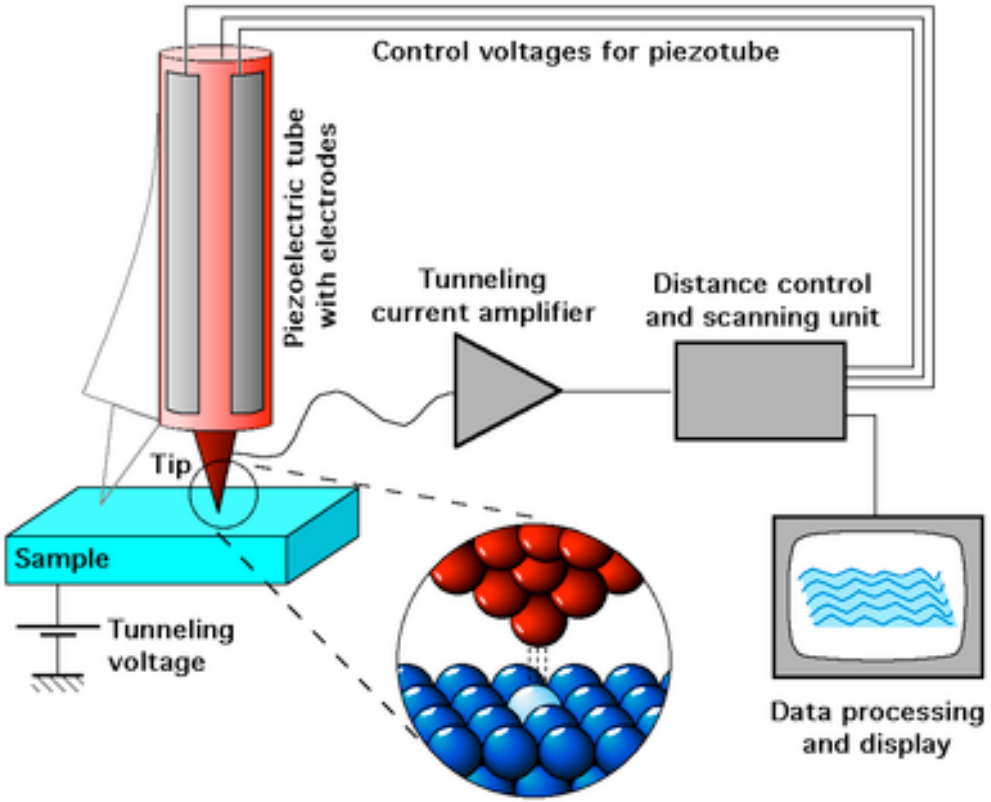
Quasi-crystals



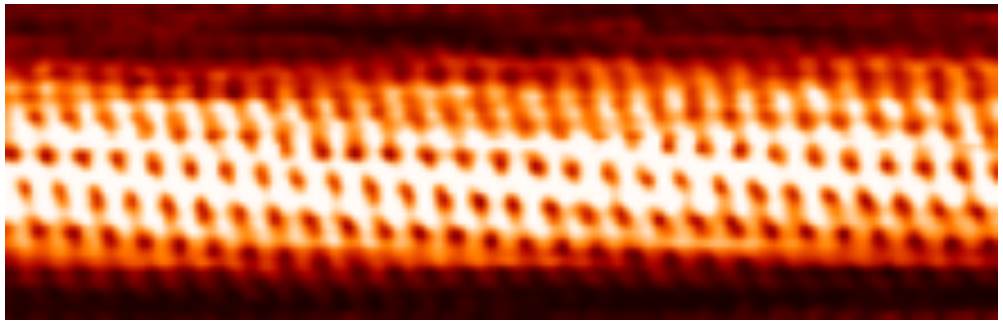
High-resolution transmission electron microscopy (HRTEM) image showing that the real space structure consists of a homogeneous, quasiperiodic and ten-fold symmetric pattern.

Sci Rep. 2015; 5: 9111

Scanning tunneling microscope (STM)

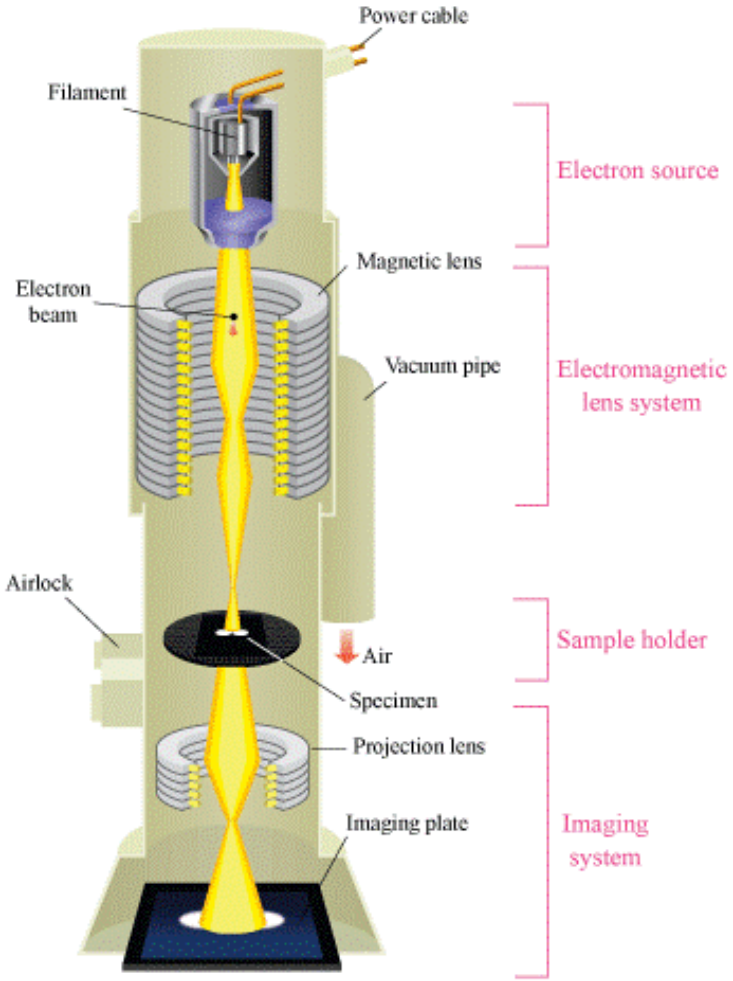


PRINCIPLES OF STM



Carbon Nano-type

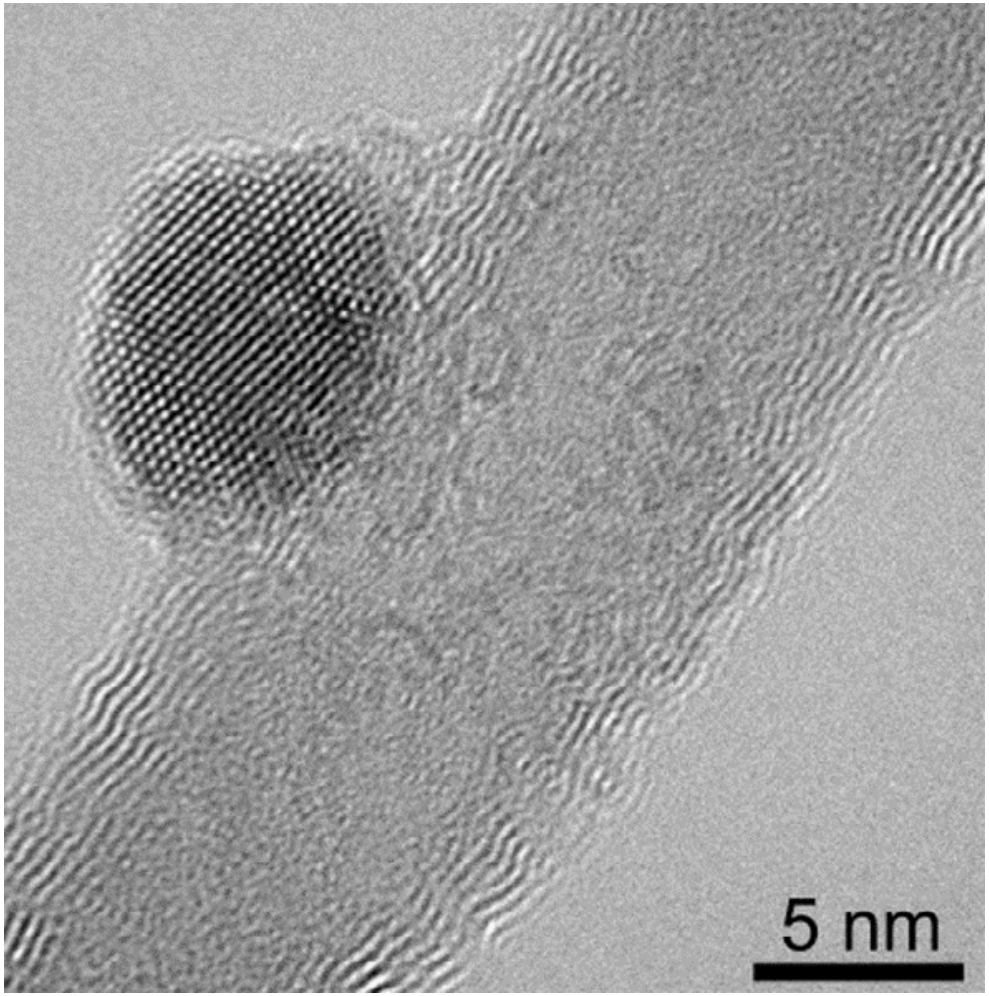
High-Resolution Transmission Electron Microscope (HRTEM)



http://www.hk-phy.org/atomic_world/tem/tem02_e.html

http://www.dstuns.iitm.ac.in/microscopy-instruments.php

High-Resolution Transmission Electron Microscope (HRTEM)



HRTEM image and focal series reconstruction of the MWCNTs with Fe_3O_4 nanoparticles attached.

https://www.int.kit.edu/1745.php

Tasks for next week

(1) Read chapter 2 :

Braggs Law
Scattering wave amplitude (read fast, don't spend time on the derivation)
Reciprocal Lattice vectors
Diffraction conditions
Laue Equations
Brillouin Zones
Reciprocal lattice (bcc, fcc)
Fourier Analysis of Basis (read fast, don't spend time on the derivation)
Structure factor (bcc,fcc)

(2) Read about: Fermi Golden rule & Fourier transforms

(3) Solve exercise sheet 1

Exercise 1 *Crystal lattice*

Why is there no tetragonal base-centred crystal lattice? (Draw a figure!)

Exercise 2 *Cubic lattice system*

For simple cubic, bcc, and fcc lattices with lattice constant a, calculate the following quantities expressed in units of a:

- Volume of the conventional unit cell
- Number of primitive lattice points per unit cell
- Volume of the primitive cell
- Number of nearest neighbours (coordination number)
- Distance between nearest neighbours
- Packing density for spherical and touching atoms

Exercise 3 *Lattice constant of silver*

Silver has a cubic fcc lattice and a density of $10.49\,\mathrm{g/cm^3}$. Calculate the lattice constant, the distance between nearest neighbours, and the radius of a silver atom if they were touching spheres.

Exercise 4 *Wigner-Seitz cell*

Construct the Wigner-Seitz cell of the orthorhombic base-centred lattice for $a_1 : a_2 : a_3 = 4 : 2 : 3$.

Exercise 5 *Sphere packings*

Calculate the ratio c/a of an ideal hexagonal dense sphere packing (hcp) and its packing density. Compare the packing density to that of an fcc lattice and explain your findings.