PY2N20
Material Properties and Phase Diagrams
Lecture 1

P. Stamenov, PhD

School of Physics, TCD

Text Books

- *Materials Science & Engineering An Introduction*
  William D **Callister**, Jr.
  S-LEN 620.11 53*5;1 …. 10

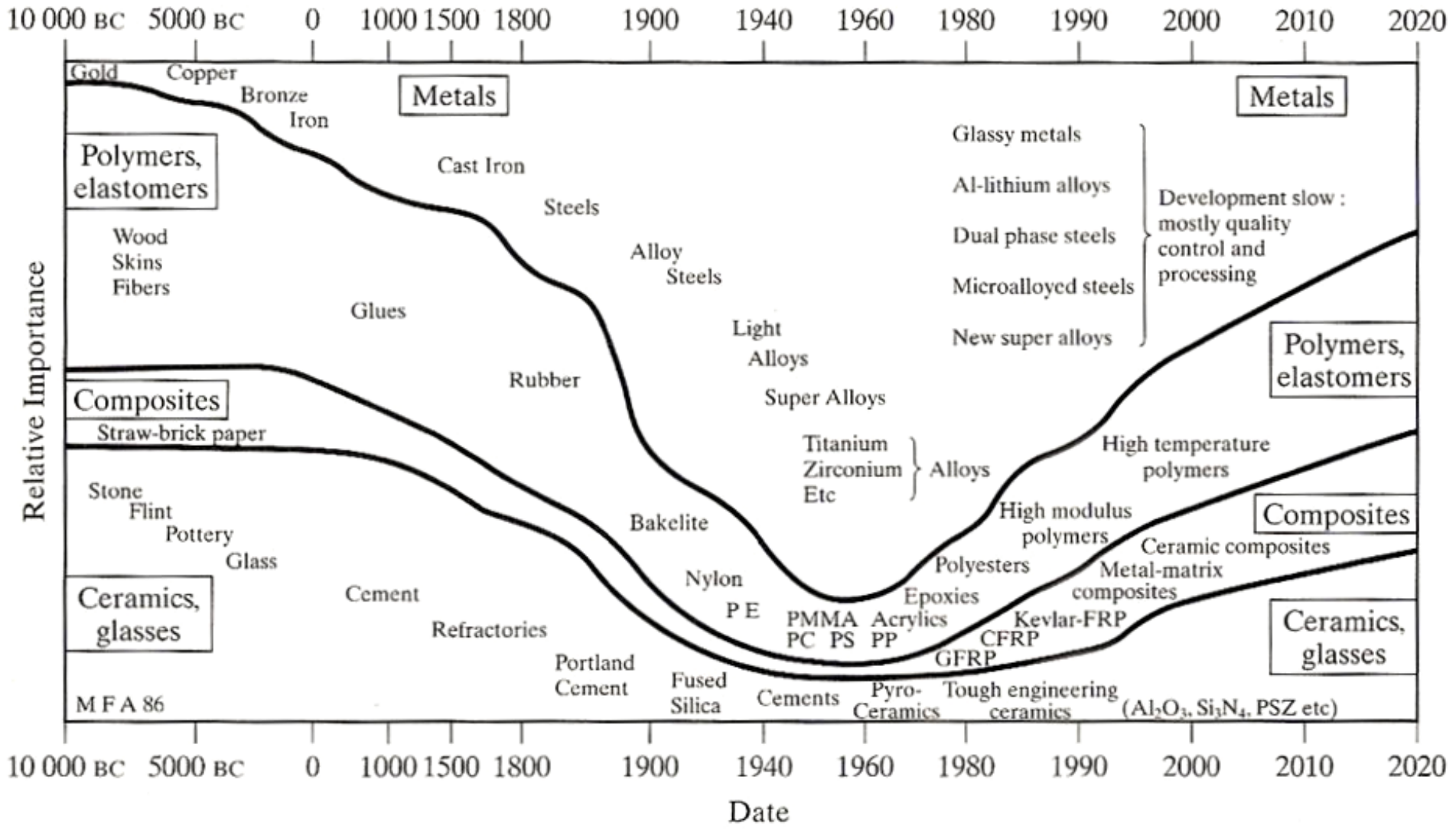
- *Introduction to Materials Science for Engineers*
  James F **Shackelford**
  620.11 M56*5

Handouts, Notes, Tutorials, etc.

- Handouts will be distributed at each of the lectures
- After the lectures electronic copies of the corresponding handouts will be uploaded at:

  http://physics.tcd.ie/people/Plamen.Stamenov/Courses/
- The examination questions are already fixed
- Voluntary tutorials to be organised...

Historical Perspective

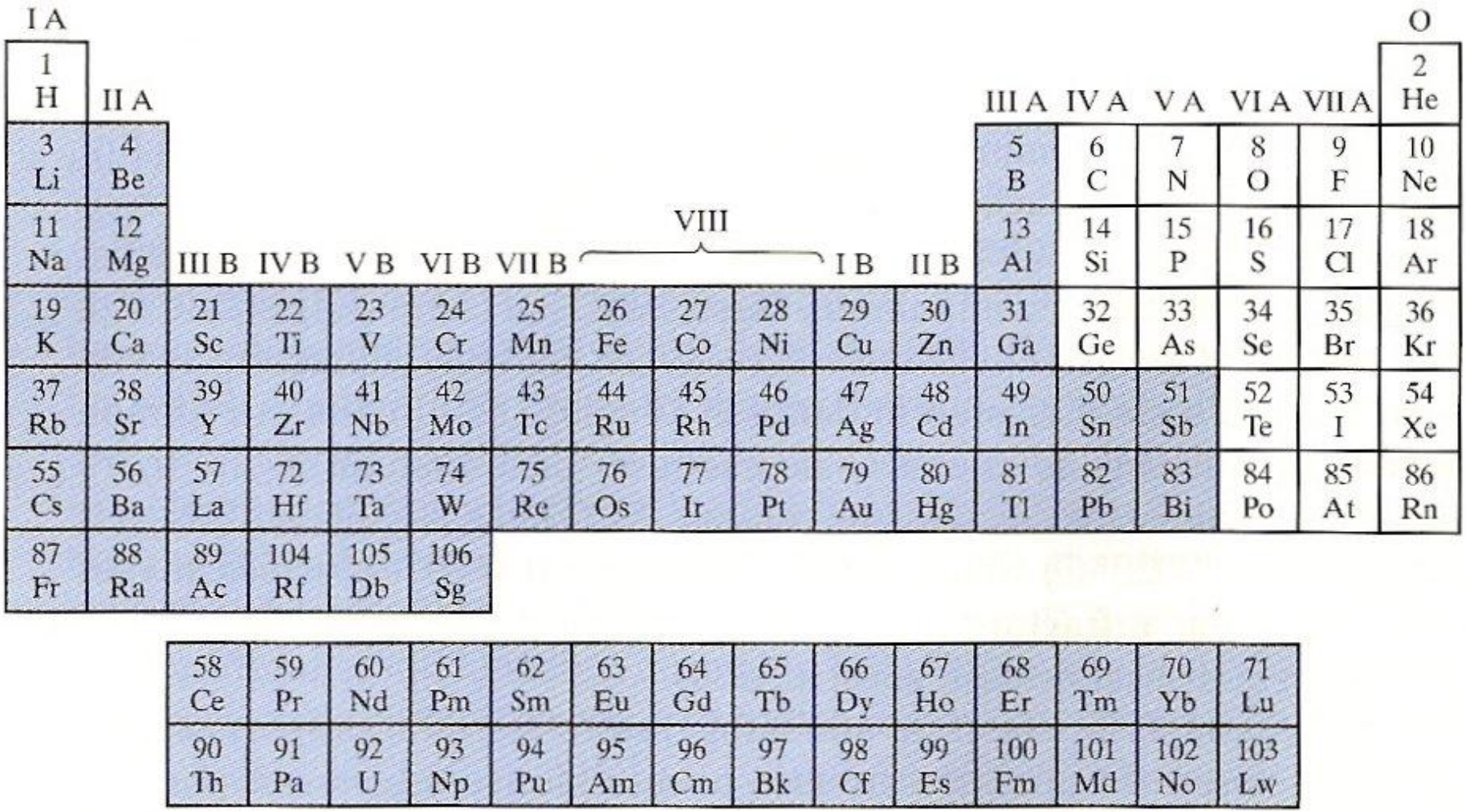


- Metals, Polymers, Composites, Ceramics, Glasses

Types of Materials

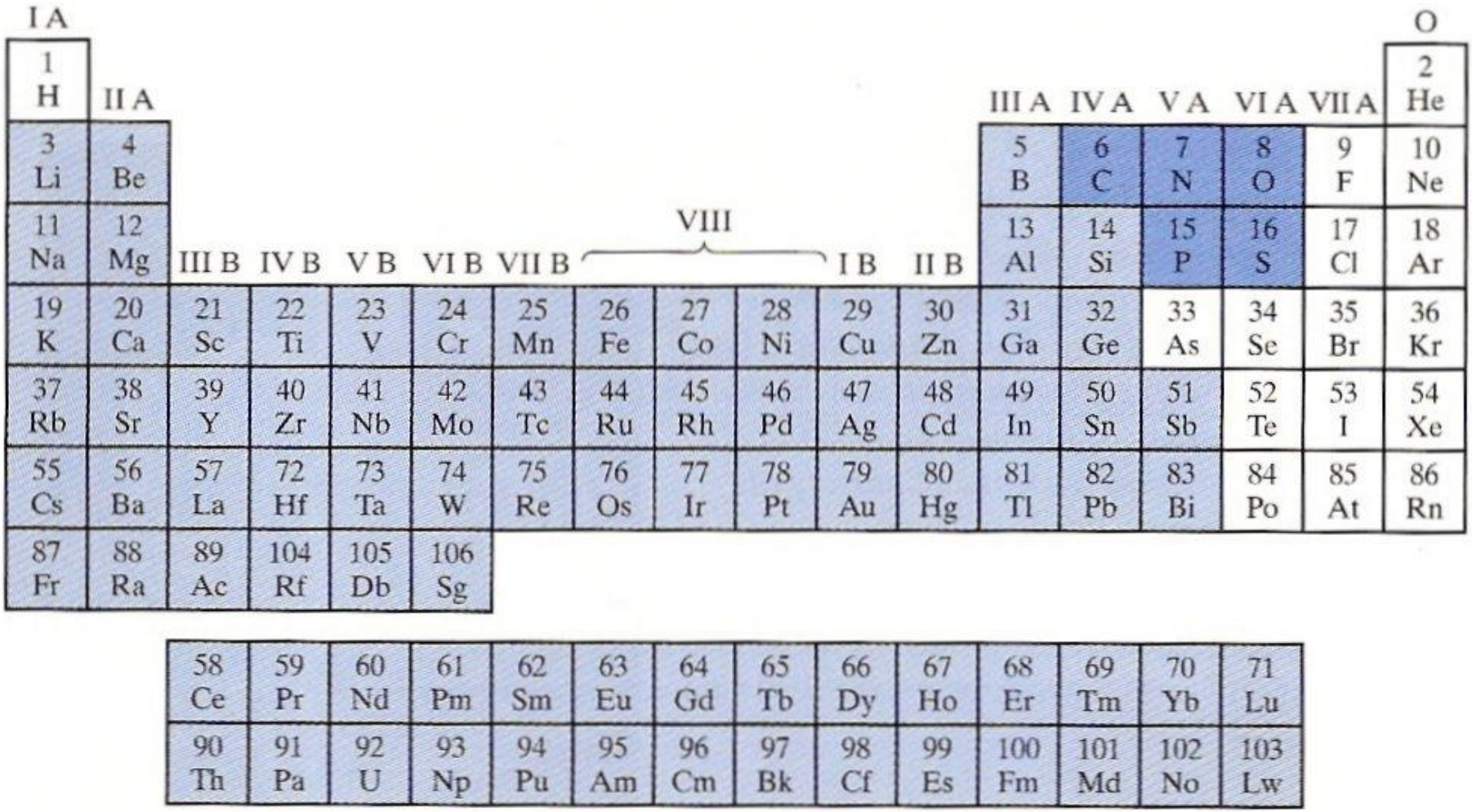
- Metals
- Ceramics
- Semiconductors
- Polymers
- Composites

Metals



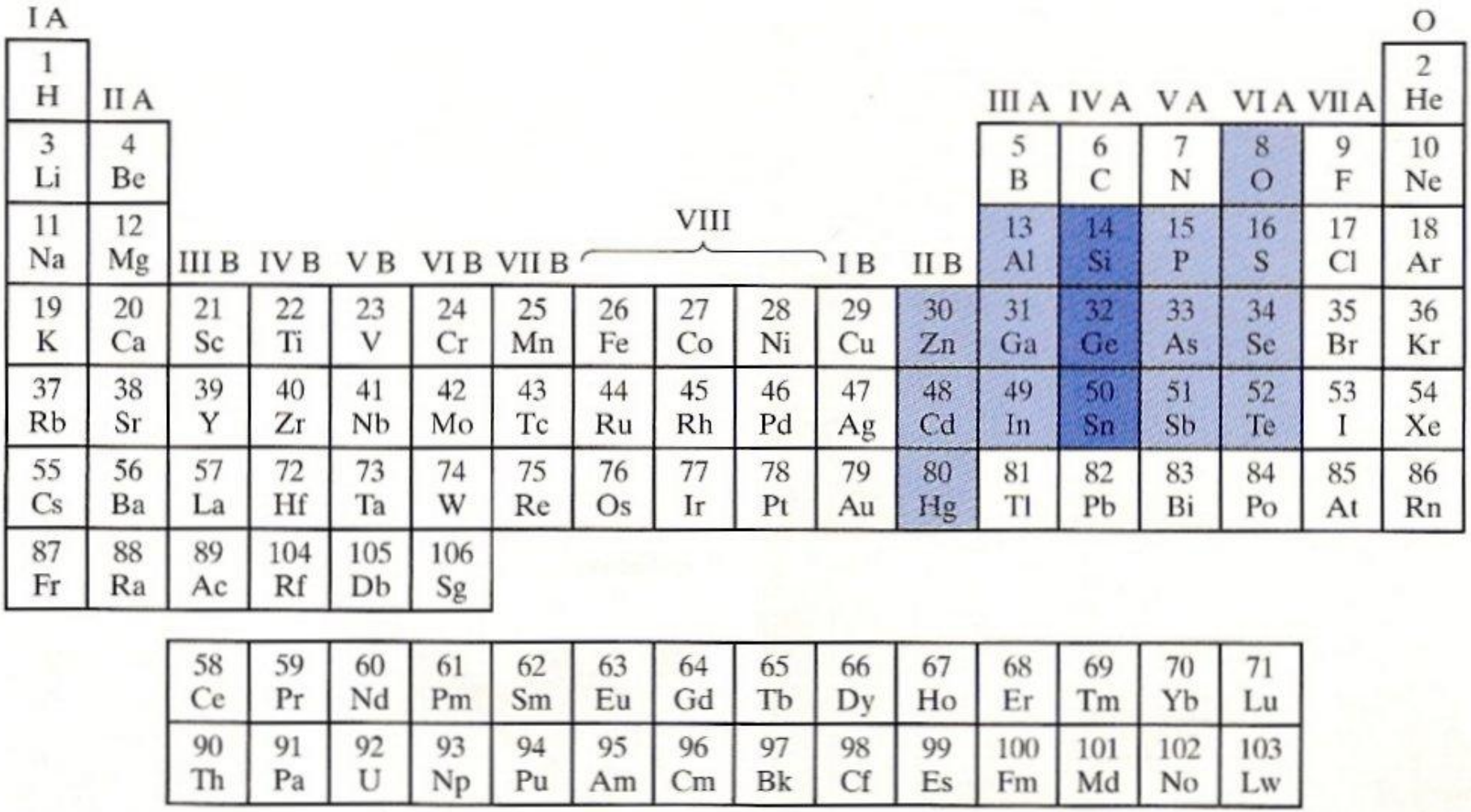
- Most elemental compounds are metals – rules of QM!

Ceramics



- Based on oxides, sulphides, nitrides, but not only!

Semiconductors

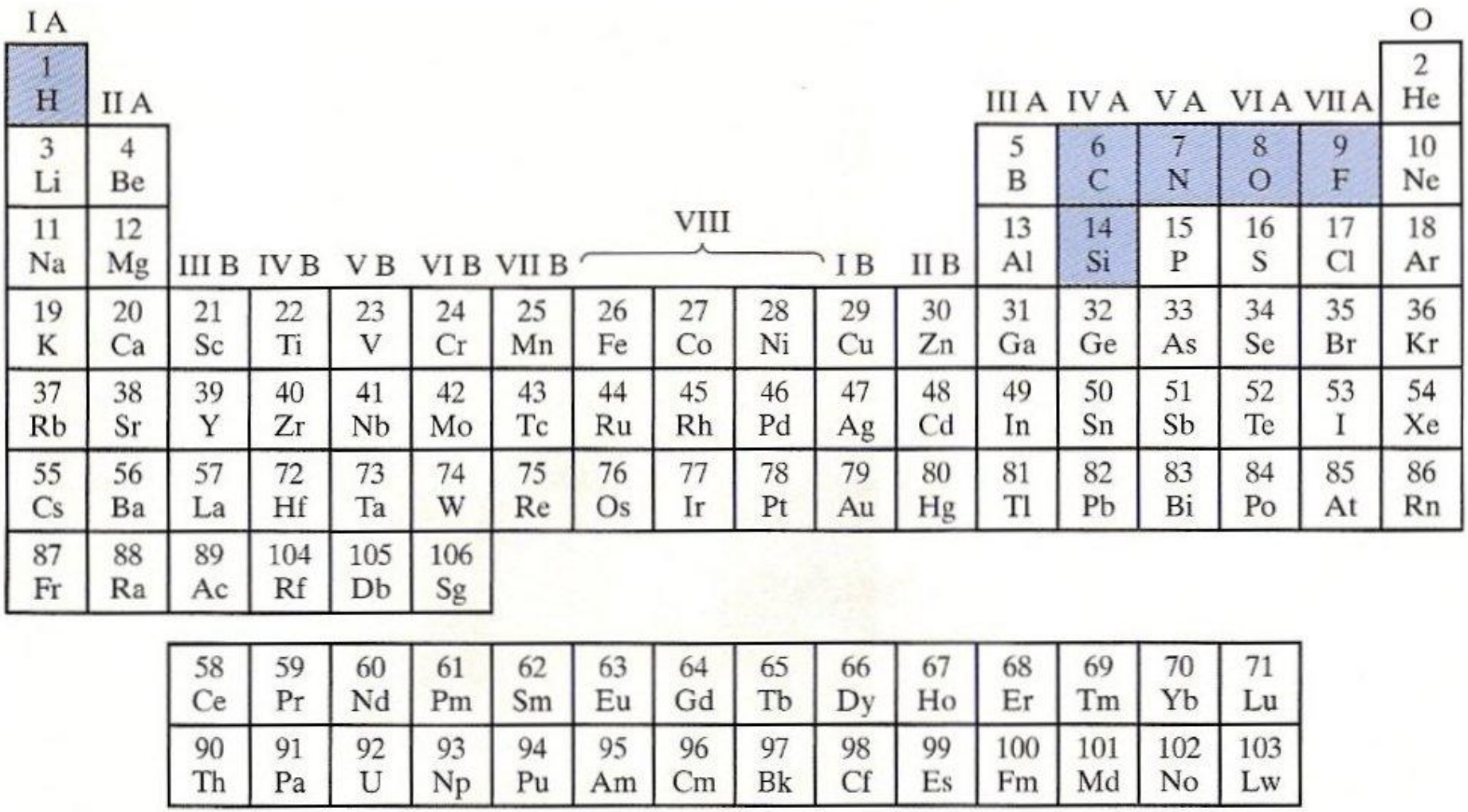


I A																	O
1 H	II A											III A	IV A	V A	VI A	VII A	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	III B	IV B	V B	VI B	VII B	VIII			I B	II B	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg												

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lw

- Group IV (elemental), III-V's, II-VI's, others...

Polymers



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- Mainly organics, but not only...

What determines a material's performance?

Properties of Materials

- Mechanical
- Physical
  - Electrical
  - Thermal
  - Magnetic
  - Optical
  - Deteriorative
- Chemical
- Others

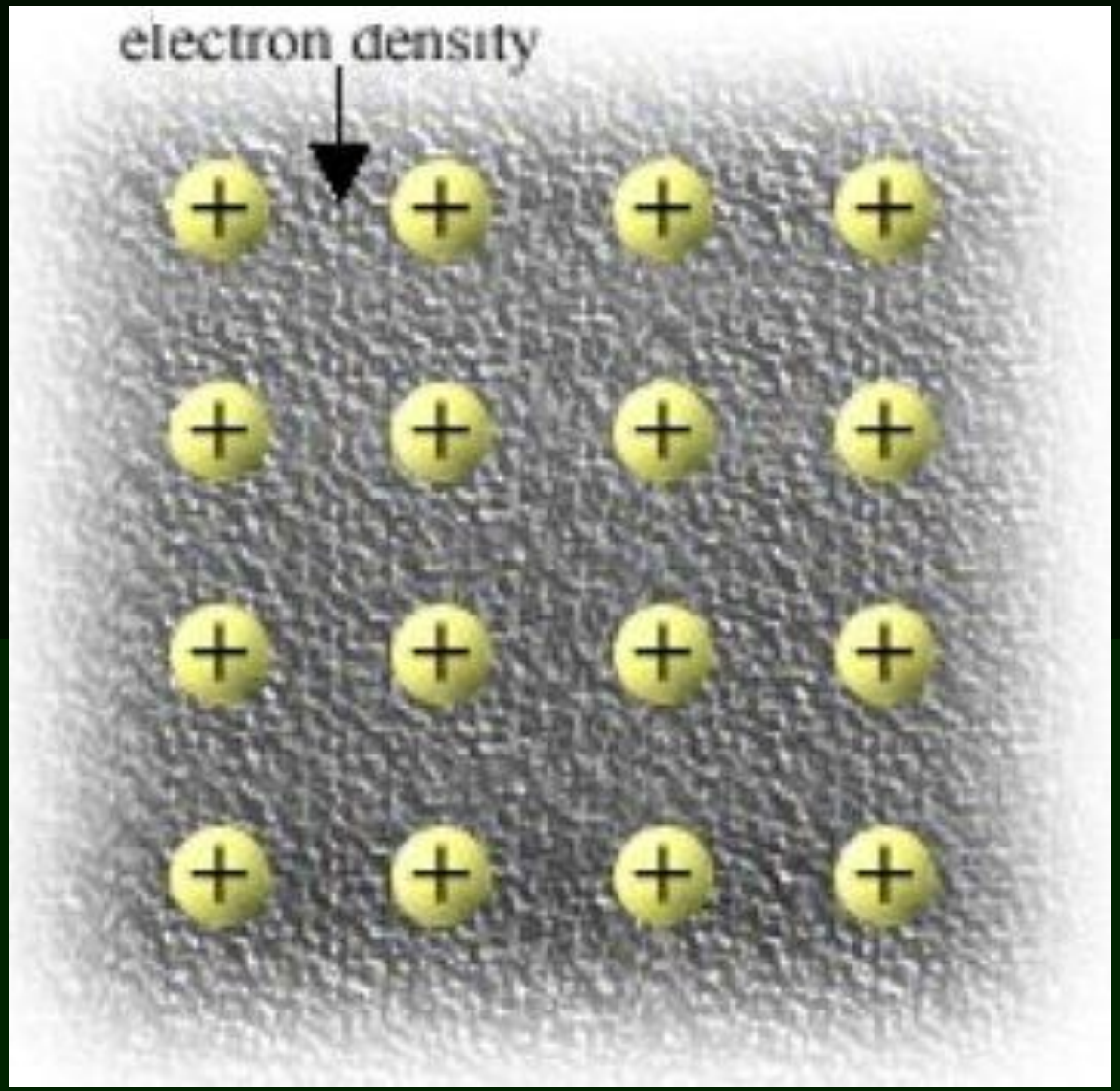
What determines a material's performance?

What do we mean by structure?

- Macroscopic
- Microscopic
- Mesoscopic
- Nanoscopic
- Atomic level

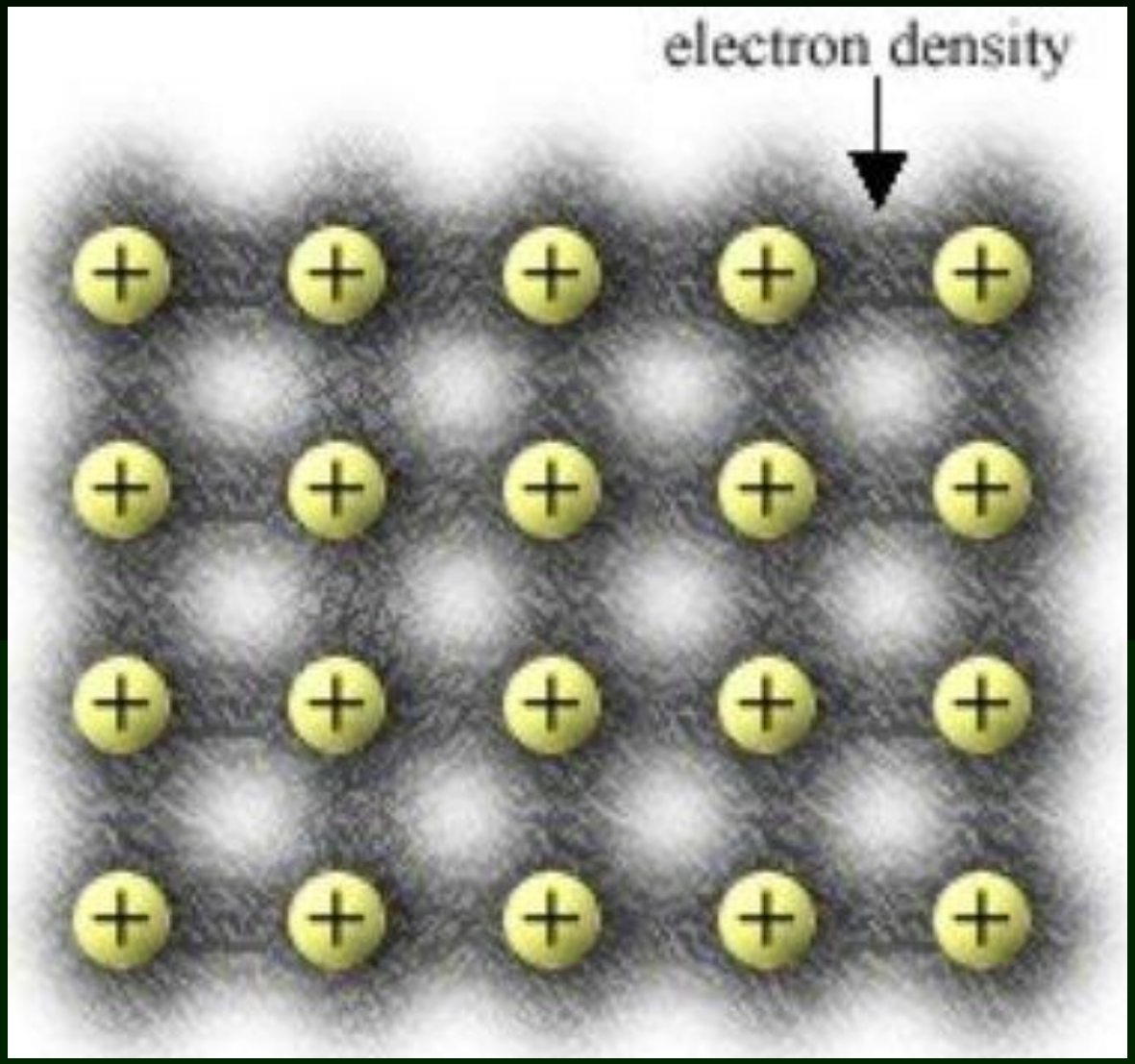
Bonding

- Metallic Bonding
  - Conductivity
  - Ductility
  - Heat capacity
  - Reactivity



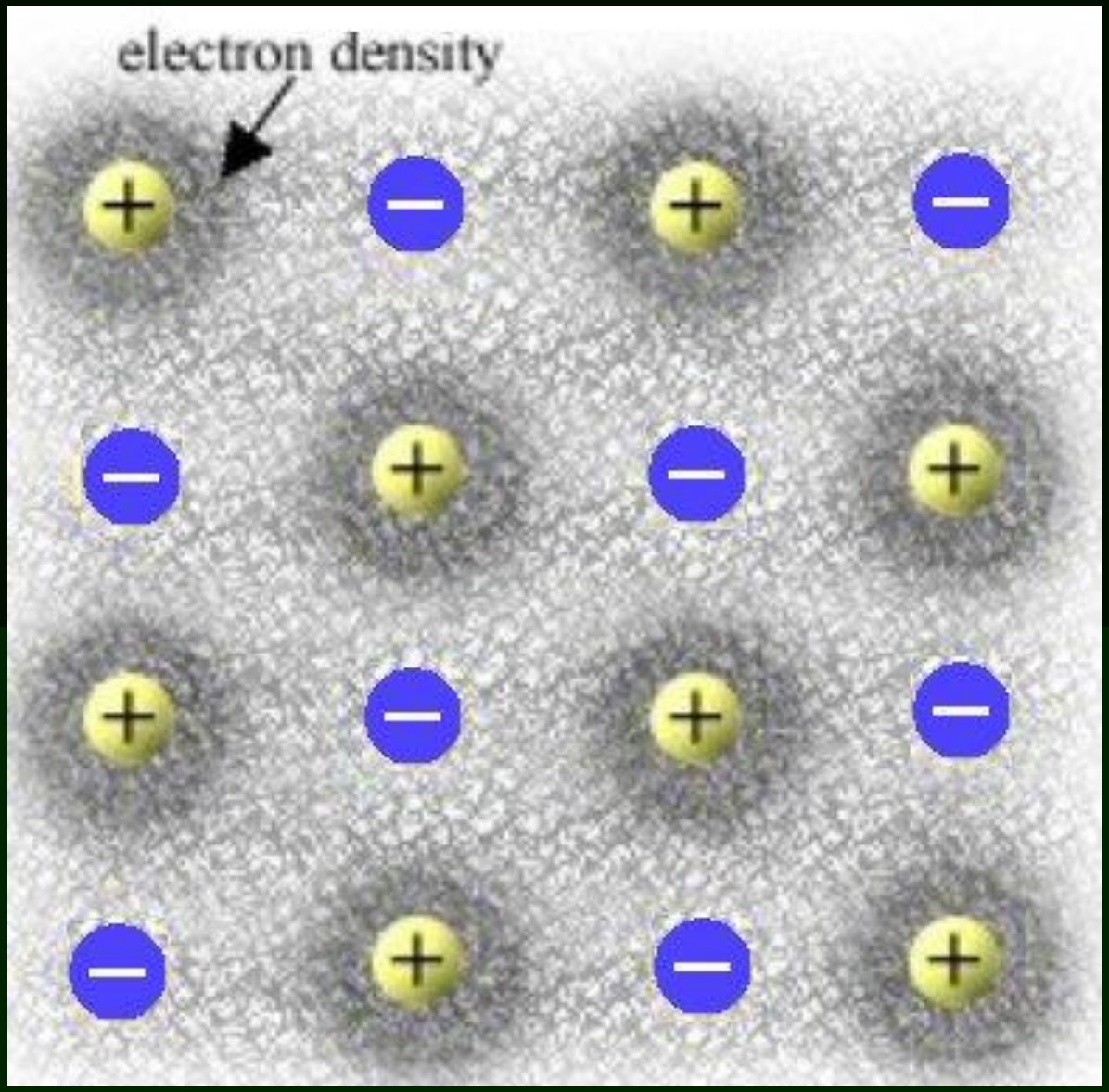
Bonding

- Covalent Bonding
  - Toughness
  - Brittleness
  - Insulation
  - Refractivity
  - Inactivity



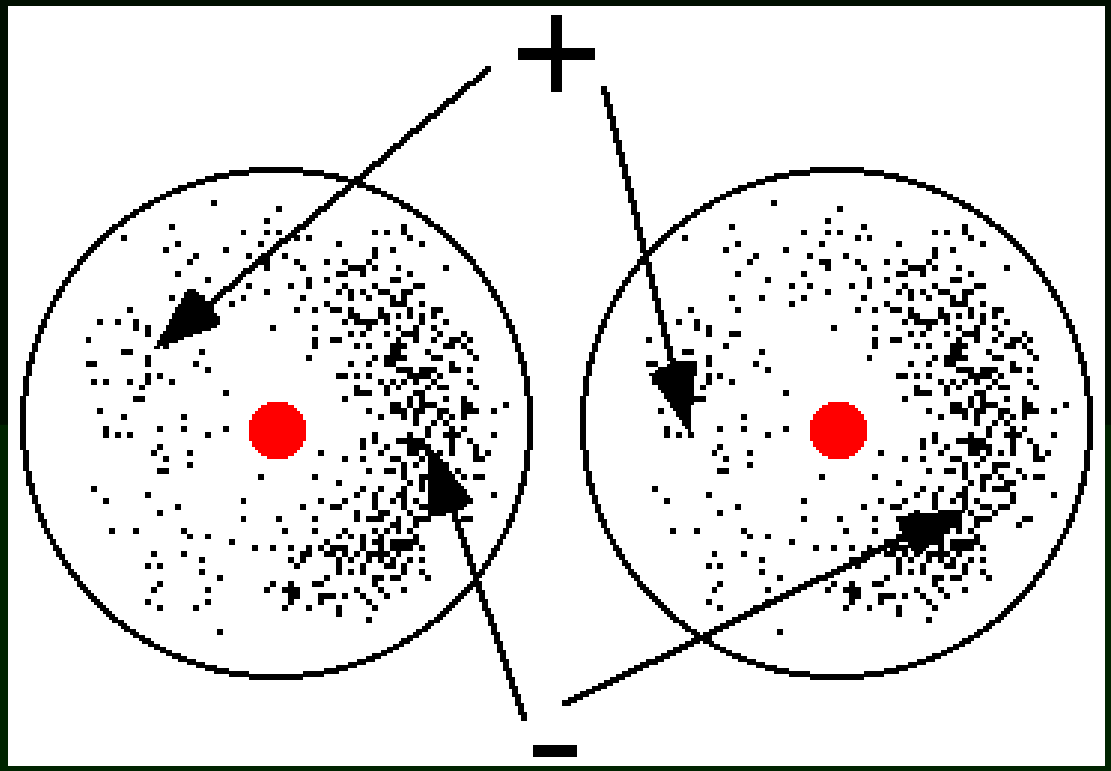
Bonding

- Ionic Bonding
  - Brittleness
  - Insulation
  - Reactivity



Bonding

- Van der Waals Bonding
  - Weakness
  - Insulation
  - Inactivity



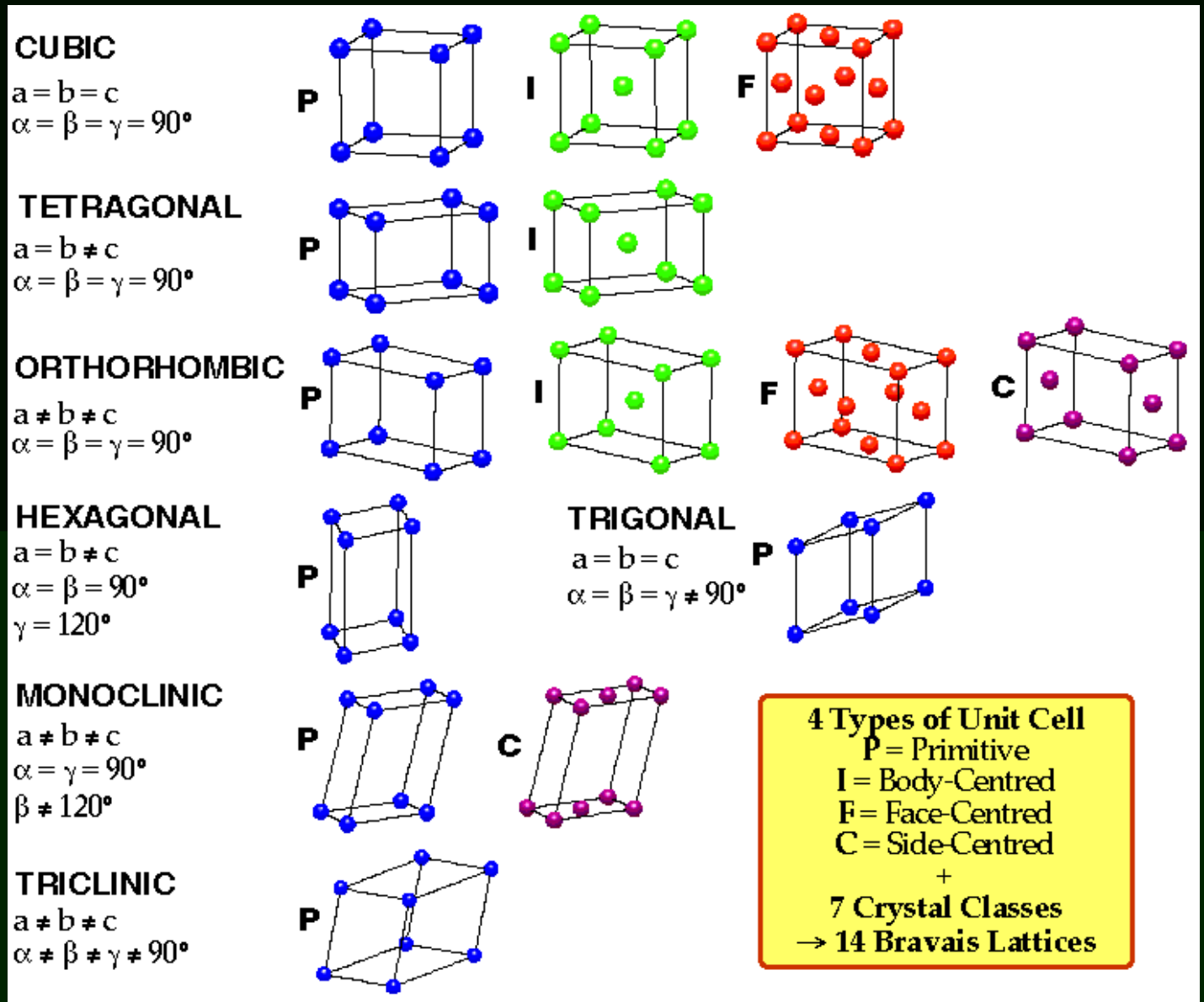
Types of bonding in engineering materials

Material Type	Bonding Character	Example
Metal	Metallic	Iron, Cu
Ceramics and Glasses	Ionic/covalent	Silica (crystalline and amorphous)
Polymers	Covalent and secondary	Polyethlyne
Semiconductors	Covalent or ionic/covalent	Si, CdS

Representation of Crystal Structures

- Atomic hard sphere model
- Packing density
- Lattices
- Unit cells
- Coordination spheres and polyhedra
- Point groups (of symmetry)
- Space groups
- ‘Colour’ groups

7 Crystal Systems
14 Crystal (Bravais) Lattices



Atomic Packing Factor

$$APF = \frac{Volume\ of\ atoms\ in\ a\ unit\ cell}{Total\ volume\ of\ unit\ cell}$$

Homework

Calculate the APF for

- (Primitive) cubic
  - BCC
  - FCC

Crytallographic Points, Directions and Planes

- Set up right-handed set of axes x, y, and z
  - x, y, and z along the edges of a unit cell
  - Origin at a lattice point
  - x, y, and z not always mutually perpendicular!
  - a, b, and c are the unit length of the three corresponding unit cell edges
- Labelling conventions

	Points	Directions	Planes
	$10\bar{1}$	$[110]$	(110)
	$1\bar{1}1$	$[1\bar{1}1]$	(100)
Families		$\{001\}$	$\langle 011 \rangle$

What determines a material's performance?

Basic aim of this short course

- Understand how processing affects the
  - ➔Structure
    - ➔Properties
      - ➔Performance

  of materials

- Concentrate (focus and emphasis) on metals, semiconductors, oxides...