PHYSICS OF MATERIALS

Physics School Autumn 2024

Series 2 **20 September 2024**

Exercise 1: FCC structure

1.1 Draw the face-centered cubic structure (FCC). Draw the base of the direct and the reciprocal lattice. Does a primitive cell exist?

1.2 Indicate the dense planes and directions on the drawing and express them with the Miller indices. What is the distance between dense planes?

1.3 Why are dense planes called octahedral planes? Can we, with these planes, build a tetrahedron?

1.4 Indicate on the drawing the directions <112>

1.5 Calculate the APF for an FCC structure, showing all steps in your calculation.

1.6 What is the coordination number for an FCC crystal structure? Explain why certain metals have FCC structure and coordination number.

1.7 Consider a material with an FCC structure, with atomic weight (M) and density (ρ). Write an expression for calculating the density of the material in terms of the lattice parameter a, the number of atoms in the unit cell, and M.

1.8 Calculate the density of copper (Cu) assuming its atomic radius is 0.128 nm and its atomic weight is 63.55 g/mol. The Avogadro's number is 6.022×10^{23} atoms/mol.

Exercise 2: Phase transformation of zirconium dioxide

At about 1000°C, zirconium dioxide transforms from the high-temperature tetragonal to the low-temperature monoclinic phase.

The constants of the monoclinic lattice are: $a = 5.156\ \mathring{A}, b = 5.191\ \mathring{A}, c = 5.304\ \mathring{A}$

The angle β is about 98.9°.

The constants of the tetrahedral lattice are: $a = 5.094\ \mathring{A}$ and $c = 5.304\ \mathring{A}$

Is there a contraction or an expansion during the transformation? What could be the advantage of the mechanical properties of this ceramic?

Exercise 3: Crystalline polyethylene

Polyethylene crystallizes in an orthorhombic structure. How many carbon (and hydrogen) atoms will be in one cell, knowing that the PE s density is ρ=0.9972 g/cm^3?

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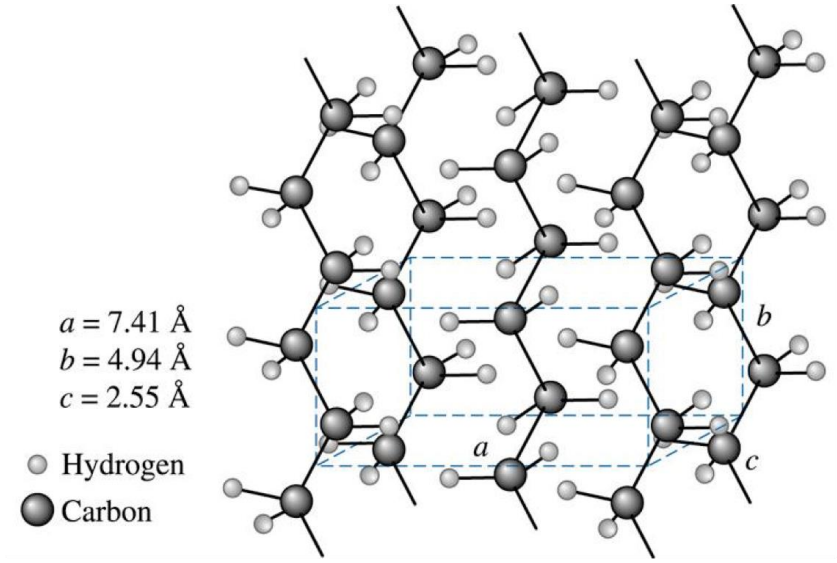

Fig. 3.1 Representation of the cell of crystalline polyethylene