Lesson 02: Structure of metals

Exercise 02.1: Cubic crystal lattices

Complete the wanted posters for the two cubic crystal lattices (body-centered cubic and face-centered cubic) in the same manner as for the simple cubic lattice during the lecture.

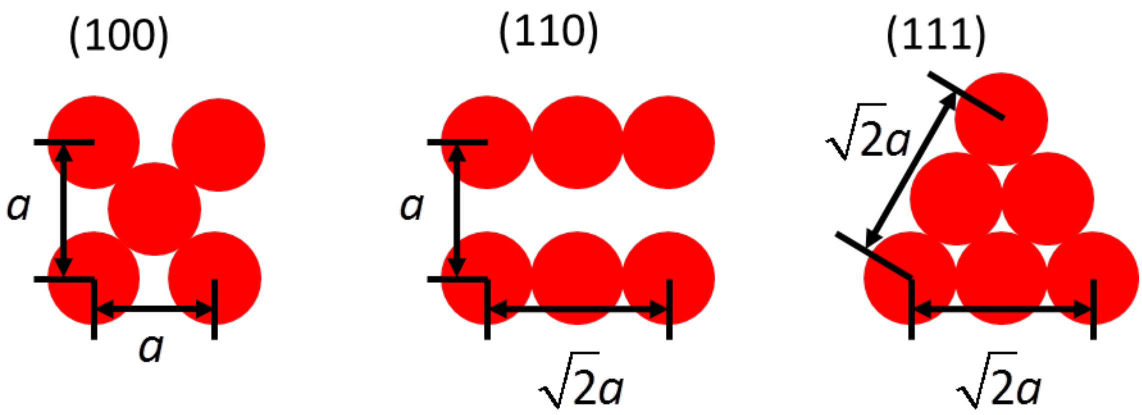
The completed wanted posters can be found in the updated lecture slides.

Exercise 02.2: Crystallographic lattices, points, directions and planes

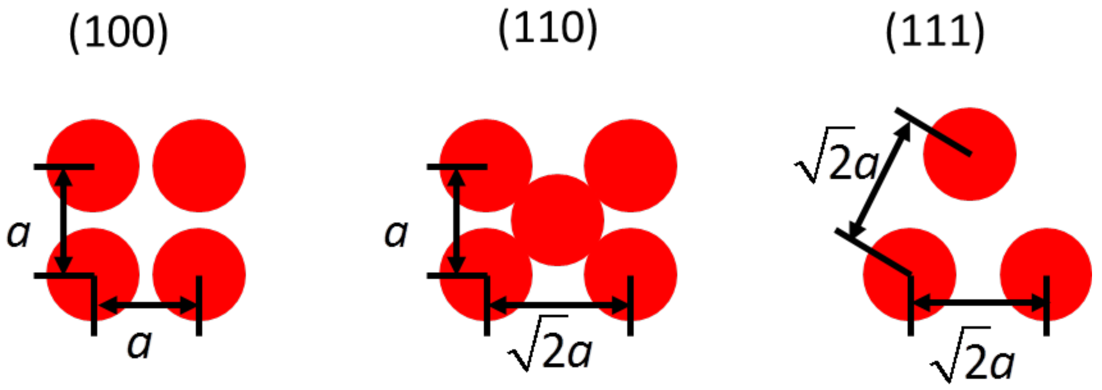
a) How many atoms are required to describe the unit cell of the fcc lattice and the bcc lattice? Find the coordinates of the positions of all atoms in the basis of an fcc lattice and a bcc lattice.
fcc (4 atoms) 0,0,0 0,½,½ ½,0,½ ½,½,0
bcc (2 atoms) 0,0,0 ½,½,½

b) Sketch the arrangement of atoms in the lattice planes (111), (110), (100) of an fcc lattice and a bcc lattice, as shown below for the simple cubic lattice (*a* is the lattice constant). Focus on the directions along which the atoms touch each other.

fcc



bcc



c) How many crystallographic equivalent <110> directions are in a (111) plane?
There are 3 (6) equivalent <110> directions in a (111) plane.

d) Find the closest packed directions and planes for the fcc and the bcc lattice. Are they close packed? In how many directions do the atoms touch each other?

	Closest packed	
	planes {hkl}	directions <uvw>
sc	{100}, not close-packed	<100>, close-packed
bcc	{110}, not close-packed	<111>, close-packed
fcc	{111}, close-packed	<110>, close-packed

Exercise 02.3: Density

Calculate the density for Fe crystallizing in a bcc structure (α-Fe) and Fe crystallizing in an fcc structure (γ-Fe) assuming an atomic radius of 0.124 nm.

The densities can be calculated from the molar mass (55.85 g/mol) or the atomic mass / atomic weight (55.85 amu) and the Avogadro constant ($N_A = 6.022 \cdot 10^{23}\ \text{mol}^{-1}$) as

$$\rho = \frac{m}{V} = \frac{N_{at} m_{at}}{V_{unitcell}} = \frac{m_{at}}{\frac{V_{at}}{APF}} = APF\,\rho_{theo} = APF \frac{\frac{55.85\ \text{g/mol}}{6.022 \cdot 10^{23}/\text{mol}}}{\frac{4\pi\left(124 \cdot 10^{-12}\text{m}\right)^3}{3}}$$

$$= APF \times 11.6 \cdot 10^{6}\ \text{g/m}^3 = APF \times 11.6\ \text{g/cm}^3$$

$$\rho_{bcc} = 7.9\ \text{g/cm}^3$$

$$\rho_{fcc} = 8.6\ \text{g/cm}^3$$