Lesson 03: Lattice defects

Exercise 03.1: Interstitial sites

The number and size of interstitial sites are different for fcc and bcc lattices. Explore them by inspecting your sketches of lattice planes from exercise 02.2, the wanted posters from lecture 02 and using Unit Cell Visualizer or ChemTube3D.

- How large are the interstitial sites in relation to the size of the host atoms?
- How many interstitial sites are there in a unit cell of each lattice?
- Which lattice can host the largest foreign atoms on interstitial sites?

These findings are relevant for interstitial solid solutions of smaller atoms in a metal, in particular for steel where carbon atoms dissolve in an iron lattice. Fe is bcc at room temperature (α-Fe), but fcc at elevated temperatures (γ-Fe), e.g. at 950 °C. The radius of a carbon atom is R_C = 0.077 nm and the radius of an iron atom R_{Fe} = 0.124 nm. Discuss the possibility of having carbon atoms in (a) a bcc Fe lattice and (b) an fcc Fe lattice. Which interstitial lattice sites will fit carbon atoms best?

Exercise 03.2: Point defects

- How to get an increased vacancy concentration? Why are vacancies relevant?
- How can foreign atoms get into the crystal lattice of an initially pure metal without melting that metal? (consider both substitutional and interstitial atoms)
- What is the difference between a pure metal, a metal with impurities and an alloy?

Exercise 03.3: Properties of lattice defects

Discuss whether lattice defects are beneficial or detrimental for materials properties; or can they be both? Consider various materials properties and explain your arguments.

Exercise 03.4: Dislocations

What is the total length of all dislocations in a rolled plate of size 100 x 20 x 1 mm^3 containing a dislocation density of $2 \cdot 10^{14}$ m^{-2}?

Exercise 03.5: Lattice defects

Classify each of the following defects as point, line, planar or volume defects

	Point defect	Line defect	Planar defect	Volume defect
Edge dislocation				
Grain boundary				
A single vacancy				
A cluster of about 50 vacancies				
A local region of atoms with a bcc structure in an fcc matrix				
The boundary between the bcc and fcc region above				
Some Ni-atoms in a Cu lattice				
An Fe-particle in copper				

Relevant exercises from the Callister Rethwisch book (10th Global edition) 4.2, 4.4, 4.12, 4D1