PHYSICS OF MATERIALS

Physics School Autumn 2025

Series 4 **03 October 2025**

Exercise 1 Interstitials: Fe-C

What is the maximum elastic distortion of the body-centered cubic iron network (iron) from introducing a carbon interstitial (atomic radius of iron = 1.24 Å)? Compare it with the distortion in the face-centered cubic iron (atomic radius of iron is 1.27 Å) and qualitatively deduce the respective carbon solubility in the two phases.

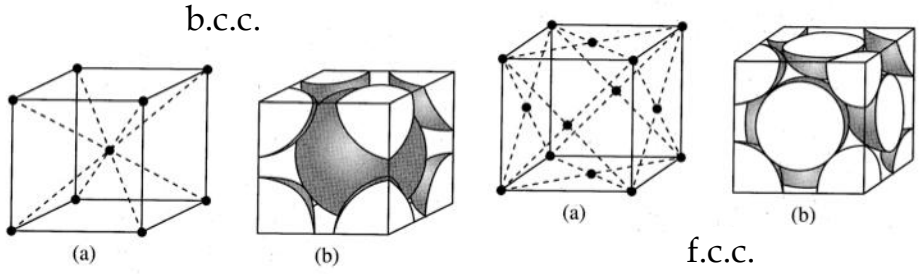

Fig. 4.1 Compact packing

Exercise 2: Equilibrium concentration of vacancies

Calculate the equilibrium concentration of vacancies in a metal at constant pressure and temperature.

Exercise 3: Thermal expansion of aluminum

We measure the thermal expansion of aluminum by two methods: 1) by measuring the dilatation strain $\frac{\Delta L}{L}$ of a sample and 2) by measuring the relative variation of the lattice parameter $\frac{\Delta a}{a}$ by X-ray diffraction. The slopes of the curves obtained with these two methods do not coincide (see Figure 4.1). Why?

The difference between these measurements at 400°C is $\left(\frac{\Delta L}{L}-\frac{\Delta a}{a}\right)=7.633\cdot10^{-6}$;

At 600°C, it is $\left(\frac{\Delta L}{L}-\frac{\Delta a}{a}\right)=2.94\cdot10^{-4}$.

Knowing these data, calculate the formation energy of vacancies in aluminum.

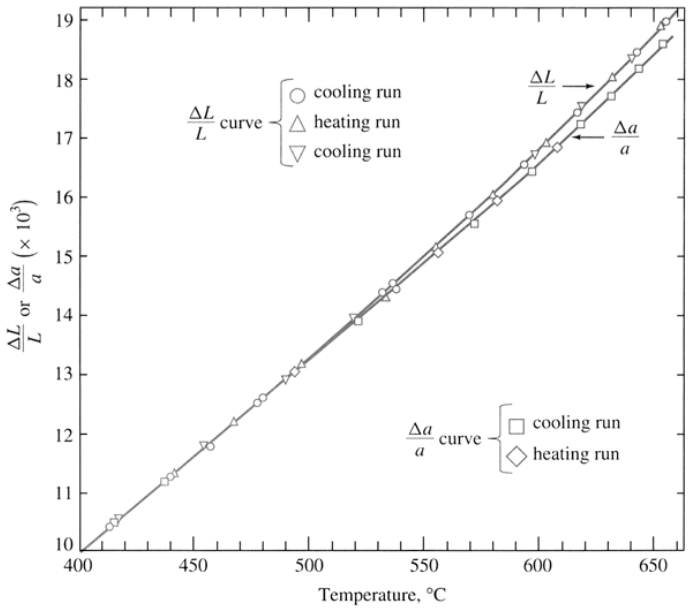

Fig. 4.1 Curves of the thermal expansion of aluminum measured by dilatometry and by x-ray diffraction.