PHYSICS OF

MATERIALS

Physics School Autumn 2025

Series 6 **17 October 2025**

Exercise 1: Density of dislocations and the Frank lattice

The dislocation density in a crystal is defined as the ratio between the total dislocation length and the crystal volume. The dislocations arriving at the surface of the crystal create local deformation (etch pits) that we can observe. Knowing the average distance between each etch-pit, i.e., plastic deformation is uniform, we can calculate the density of the dislocations in the crystal.

In general, etch pits are produced by screw dislocations. We observe the surface of an aluminum sample (1 cm^3) perpendicularly to the direction $[\bar{1}10]$, and we measure an average distance between etch pits of 10 µm.

Calculate the maximum plastic deformation due to the movement of dislocations with Burgers vector $b = \frac{b}{2}[\bar{1}10]$ in the dense planes relative to this vector. We neglect dislocation sources. The lattice parameter of silicon is 5.43Å, and the atomic radius is 1.11Å.

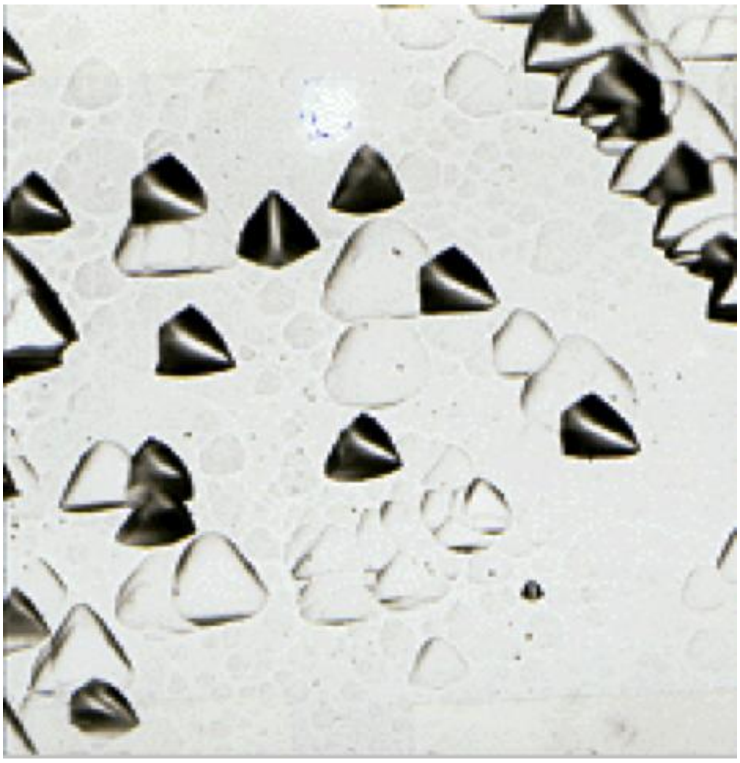

Figure 6.1 Etch-pits in silicon observed on a (111) plane

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Exercise 2: Nabarro-Herring creep

A cubic sample of dimension d is submitted to a constant tensile stress σ. Calculate the strain rate of the sample maintained at a constant temperature T due to the diffusion of the atoms (respectively of the vacancies) within the crystal.

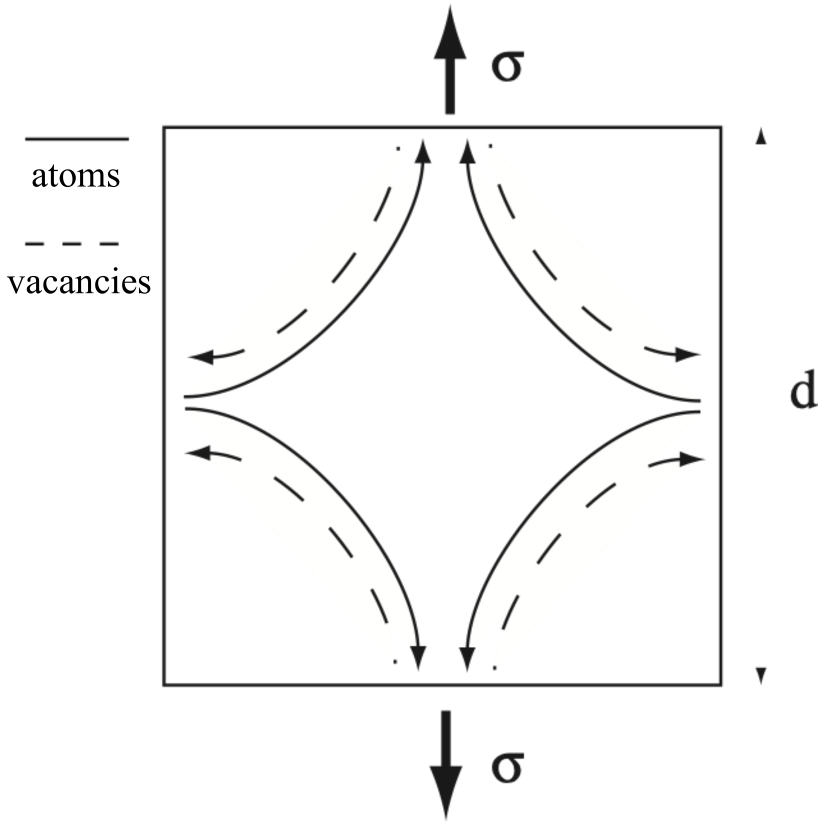

Figure 6.2 Scheme of the vacancy and atomic movement during creep