

Tutorial sheet 6



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1. In an FCC lattice, the largest interstitial voids occur at positions like $(\frac{1}{2}, 0, 0)$, $(0, \frac{1}{2}, 0)$, $(0, 0, \frac{1}{2})$ etc. γ -iron crystallizes in FCC structure. Find atomic radius of the largest interstitial void in γ -iron.

Ans1. In FCC lattice: voids = Tetrahedral voids
= Octahedral voids

The radius of largest interstitial void (octahedral void) is
 $R = 0.414r$

Where radius of γ -iron crystallizes in FCC structure is
 1.292 \AA

$$R = 0.414 \times 1.292 \text{ \AA} \\ = 0.534 \text{ \AA}$$

2. An optical microscope can resolve a step of aluminum width 300 nm. A slip band was observed in a simple cubic crystal ($a = 3 \text{ \AA}$). How many (minimum) dislocations must have slipped out of the crystal?

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Ans 2. Width of slip band, $w = 300 \text{ nm}$

lattice parameter, $a = 3 \text{ \AA}$

No. of dislocations have slipped out of the crystal =
(Width of slip band - No. of dislocations) / No. of
dislocations

$$= (3000 - 3) / 3 \text{ \AA}$$

$$= 999 \text{ \AA}$$

3. Does the burger vector change with the size of the burger circuit? Explain.

Ans 3. No, it depends on no. of dislocation not on the circuit.

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4. Distinguish between the direction of the dislocation line, the burgers vector and the direction of motion for both the edge and screw dislocations. Differentiating between positive and negative types.

- An *edge* dislocation has its Burgers vector perpendicular to the dislocation line. A *screw* dislocation, the Burgers vector is parallel to the dislocation line.
- For an edge dislocation, the Burgers vector is parallel to dislocation motion. For a screw dislocation, the Burgers vector is parallel to the dislocation. The Burgers vector is always parallel to slip.
- During **positive** climb, the crystal shrinks in the direction perpendicular to the extra half plane of atoms because atoms are being removed from the half plane. Since **negative** climb involves an addition of atoms to the half plane, the crystal grows in the direction perpendicular to the half plane.

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5. An aluminum crystal has a dislocation density of 10^{10} m^{-2} . The sheer modulus of aluminum is 25.94 GNm^{-2} . Calculate the elastic energy of line imperfections stored in the crystal.

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Ans 5. Density of aluminum crystal, $\rho = 10^{10} \text{ m}^{-2}$

Shear modulus of aluminum is $\mu = 25.94 \text{ GNm}^{-2}$

$E = ?$

$\rho = 1/l^2$, length of dislocation line

shear stress $= \mu b/l$

For perfect crystal, shear stress $= \mu/6$

$$b/l = 1/6$$

$$b = l/6 = 1.67 \text{ } \mu\text{m}$$

$$E = \mu b^2/2$$

$$= 36.17 \text{ J/m}$$

- 6. Average energy required to create Frenkel defect in an ionic crystal is 1.4 eV . Calculate the ratio of Frenkel defects at 20°C and 300°C in 1 gram of crystal.

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- Ans6. For ionic crystal, no. of point imperfections

$$n = N \exp(-\Delta H_f / 2RT)$$

Where H_f is enthalpy of formation of one mole of each of cation=anion

$$R = 8.62 \times 10^{-5} \text{ eV/K}$$

N = Avogadro No.

$$H_f = 1.4 \text{ eV}$$

$$n_1/n_2 = \exp(-\Delta H_f / 2RT_1) / \exp(-\Delta H_f / 2RT_2)$$

$$= \exp(-\Delta H_f / 2R(1/T_1 - 1/T_2)) = 1.65 \times 10^{-4}$$