Engineering Materials (UES012)
School of Physics and Materials Science
Tutorial Sheet No 8-9

1. FCC lead has a lattice parameter of 0.4949 nm and contains one vacancy per 500 Pb atoms. Calculate (a) the density; and (b) the number of vacancies per gram of Pb.

2. Determination of the number of vacancies per cubic meter in gold at 900 °C. Given that the formation energy of the defect is 0.98 eV/atom, atomic weight is 197 g/mol and density of 19.32 g/cm^3.

3. Calculate the activation energy for vacancy formation in aluminum, given that the equilibrium number of vacancies at 500 C is 7.57 x 10^{23} m^{-3}. The atomic weight and density for aluminum are, respectively, 26.98 g/mol and 2.62 g/cm^3.

4. Consider the (111) slip plane and $[0\bar{1}1]$ slip direction for a single crystal of copper. A tensile stress of 3000 psi is applied to this crystal along the [001] direction. What is the resolved shear stress along the slip direction?

5. The yield strength of mild steel with an average grain size of 0.05 mm is 20,000 psi. The yield stress of the same steel with a grain size of 0.007 mm is 40,000 psi. What will be the average grain size of the same steel with a yield stress of 30,000 psi?

6. Consider a metal single crystal oriented such that the normal to the slip plane and the slip direction are at angles of 43.18 and 47.98, respectively, with the tensile axis. If the critical resolved shear stress is 20.7 MPa (3000 psi), will an applied stress of 45 MPa (6500 psi) cause the single crystal to yield? If not, what stress will be necessary?

7. A single crystal of aluminum is oriented for a tensile test such that its slip plane normal makes an angle of 28.18° with the tensile axis. Three possible slip directions make angles of 62.48°, 72.08°, and 81.18° with the same tensile axis. (a) Which of these three slip directions is most favored? (b) If plastic deformation begins at a tensile stress of 1.95 MPa, determine the critical resolved shear stress for aluminum.

8. A cylindrical specimen of steel having an original diameter of 12.8 mm is tensile-tested to fracture and found to have an engineering fracture strength of 460 MPa. If its cross-sectional diameter at fracture is 10.7 mm, determine the true stress at fracture.

9. A tensile stress is to be applied along the long axis of a cylindrical brass rod that has a diameter of 10 mm. Determine the magnitude of the load required to produce a 2.5 μm change in diameter if the deformation is entirely elastic. Poisson's ratio for brass is 0.34 and Young's modulus is 97 GPa.

10. For a bronze alloy, the stress at which plastic deformation begins is 275 MPa, and the modulus of elasticity is 115 GPa. **(a)** What is the maximum load that may be applied to a specimen with a cross-sectional area of 325 mm^2 without plastic deformation? **(b)** If the original specimen length is 115 mm, what is the maximum length to which it may be stretched without causing plastic deformation?

11. A cylindrical rod of copper (young's modulus of 110 GPa) having a yield strength of 240 MPa is to be subjected to a load of 6660 N. If the length of the rod is 380 mm, what must be the diameter to allow an elongation of 0.50 mm?

12. A single crystal of a metal that has the BCC crystal structure is oriented such that a tensile stress is applied in the [010] direction. If the magnitude of this stress is 2.75 MPa, compute the resolved shear stress in the [-1 11] direction on each of the (110) and (101) planes. (b) On the basis of these resolved shear stress values, which slip system(s) is (are) most favorably oriented?