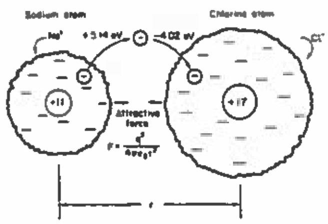
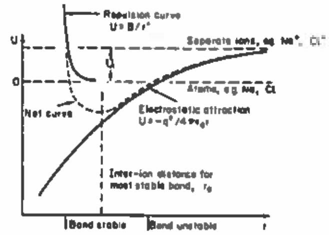
SA 1. Describe the three types of primary bonding found in engineering materials. Compare and contrast the key characteristics for these types of bonds and how they relate to material properties.

Ionic Bonds –

2





Attractive energy arises from the electrostatic attraction between the Na^+ and Cl^- ions. Repulsive energy derives from the overlap of the electron clouds around atoms. Bond is non-directional.

Covalent Bonds –

2

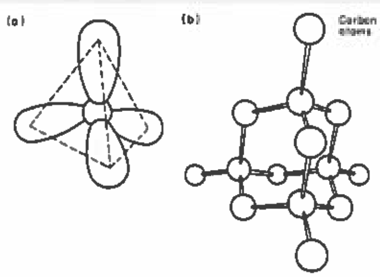
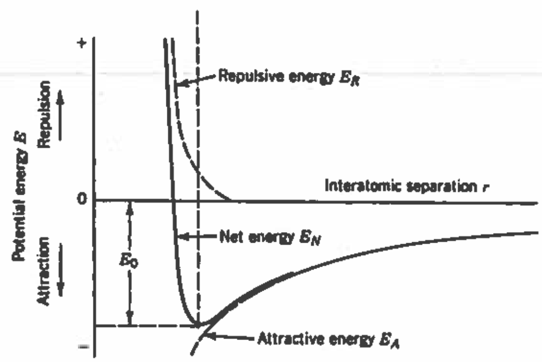


Fig. 4.7. Directional covalent bonding in diamond.



(b)

Attractive energy arises from the sharing of electrons between two atoms. Repulsive energy derives from the overlap of the electron clouds around atoms. Bond is highly directional which controls how the atoms pack together to make a solid.

Metallic Bonds

2

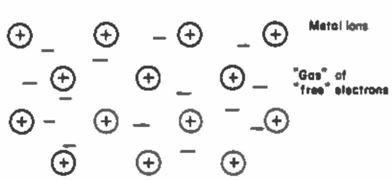
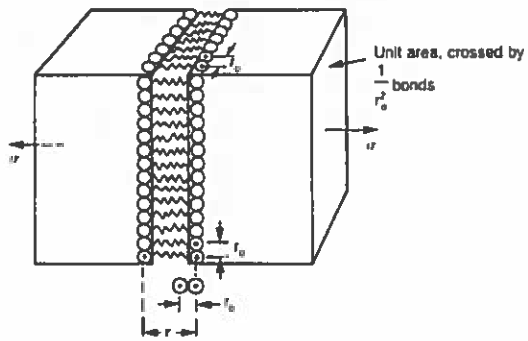


Fig. 4.8. Bonding in a metal—metallic bonding.

Attractive energy arises from the sharing of electrons amongst all the atoms. Can be viewed as a gas of free electrons. Repulsive energy derives from the overlap of the electron clouds around atoms. Bond is non-directional. Free electrons contribute to good electrical and thermal conductivity.

SA2. Discuss the two main factors which control the Young's modulus (Modulus of Elasticity) of a material and the relationship of Young's modulus to the bond energy diagram.

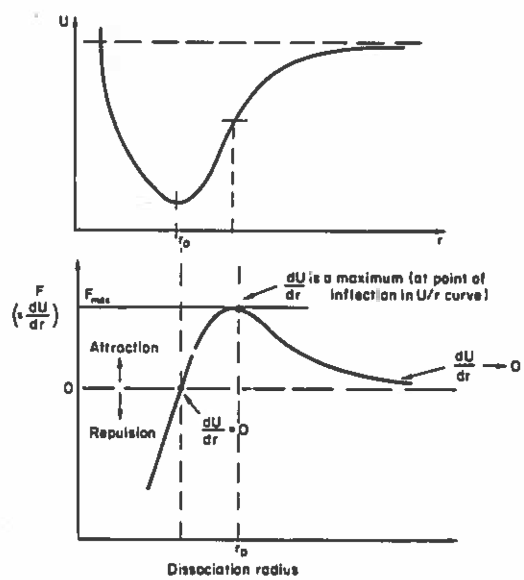
1



2 The two factors which control the Young's modulus are i) the stiffness of the bonds and ii) the density of bonds in the cross-section of the material.

The stiffness of the bond is related to the second derivative of the bond energy diagram as shown below. The first derivative gives the Force – displacement diagram. The slope of the force displacement diagram is the bond stiffness.

2

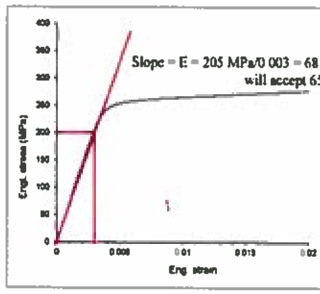


LA2. a) Given the stress-strain diagram for the aluminum alloy AA6111 on page 14 and that the initial dimensions of the tensile sample were : gauge length of 25 mm, width = 6.3 mm and thickness = 1.1 mm

Determine the following:

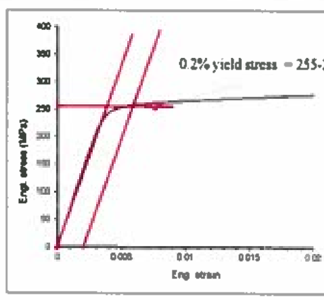
(9) i) the modulus of elasticity

3



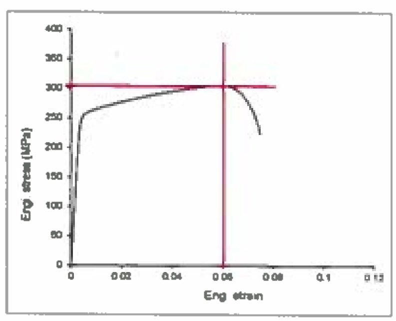
ii) 0.2% offset yield stress

3



iii) change in length at necking point (units mm)

1.5



The necking strain is approximately a strain of 0.06. Therefore,

$$\varepsilon = \frac{\Delta L}{L_o}$$

$$\Delta L = \varepsilon \times L_o$$

$$\Delta L = 0.06 \times 25\text{mm} = 1.5\text{ mm}$$

iv) maximum breaking load in Newtons

UTS ≈310 MPa

1.5

$$F = \sigma \times A_o$$
$$F = 310\text{MPa} \times 6.3\text{ mm x } 1.1\text{ mm} = 2\,148\text{ N}$$

(3) b) Determine the modulus of resilience for this alloy

$$U_r = \frac{1}{2}\sigma_y \times \varepsilon = \frac{\sigma_y^2}{2E}$$

$$U_r = \frac{(260\text{ MPa})^2}{68\,000\text{ MPa}} = 0.99\frac{\text{J}}{\text{m}^3}$$

3

(4) c) Given that a subsize sample with gauge length of 25 mm was used, estimate the % elongation to failure if a standard sample with a 50 mm gauge length was used.

The total elongation strain is approximately a strain of 0.075. Therefore,

$$\varepsilon = \frac{\Delta L}{L_o}$$

$$\Delta L = \varepsilon \times L_o$$

$$\Delta L = 0.075 \times 25\text{mm} = 1.875\text{ mm}$$

Change in length prior to necking = 1.5 mm Change in length prior to necking = 3 mm
Change in length after necking = 0.375 mm Change in length after necking = 0.375 mm

Dependence of % Elongation on Gauge Length

4

- on a 25 mm gauge length

$$\%\,\text{Elongation} = \left(\frac{L_f - L_o}{L_o}\right)\times 100 = \frac{26.875\text{-}25}{25}\times 100 = 7.5\%$$

- on a 50 mm gauge length

$$\%\,\text{Elongation} = \left(\frac{L_f - L_o}{L_o}\right)\times 100 = \frac{53.375\text{-}50}{50}\times 100 = 6.75\%$$

(4) d) prove that the true stress is related to the engineering stress by the following relationship.

$$\sigma_T = \sigma(1+\varepsilon)$$

Since plastic deformation occurs at constant volume

$$\sigma_T = \sigma(1+\varepsilon)$$ 1

4

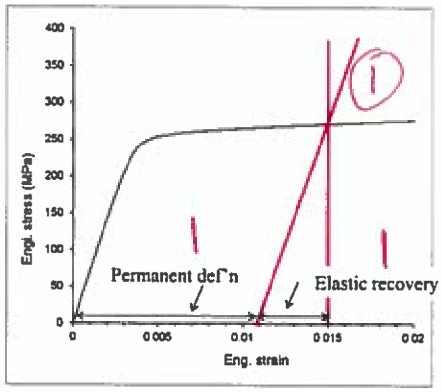
$$A_o l_o = A_i l_i$$

substituting

$$\sigma_T = \frac{F}{A_i} = \frac{F l_i}{A_o l_o}$$

$$\frac{l_i}{l_o} = \frac{l_i - l_o + l_o}{l_o} = \varepsilon + 1 = 1 + \varepsilon$$

(4) e) calculate the permanent tensile strain after unloading if the total strain under load was 0.015.



As shown in the figure above, the permanent plastic deformation is approximately a strain of 0.0108.

1

4