

12.33 (a) For a $\text{Cu}^{2+}\text{O}^{2-}$ compound in which a small fraction of the copper ions exist as Cu^+ , for each Cu^+ formed there is one less positive charge introduced (or one more negative charge). In order to maintain charge neutrality, we must either add an additional positive charge or subtract a negative charge. This may be accomplished by either creating Cu^{2+} interstitials or O^{2-} vacancies.

(b) There will be two Cu^+ ions required for each of these defects.

(c) The chemical formula for this nonstoichiometric material is Cu_{1+x}O or CuO_{1-x} , where x is some small fraction.

Brittle Fracture of Ceramics

12.38 (a) There may be significant scatter in the fracture strength for some given ceramic material because the fracture strength depends on the probability of the existence of a flaw that is capable of initiating a crack; this probability varies from specimen to specimen of the same material.

(b) The fracture strength increases with decreasing specimen size because as specimen size decreases, the probability of the existence of a flaw of that is capable of initiating a crack diminishes.

12.42 We are asked to calculate the maximum radius of a circular specimen of MgO that is loaded using three-point bending. Solving for R from Equation 12.7b

$$R = \left[\frac{F_f L}{\sigma_f \pi} \right]^{1/3}$$

which, when substituting the parameters stipulated in the problem statement, yields

$$R = \left[\frac{(5560 \text{ N})(45 \times 10^{-3} \text{ m})}{(105 \times 10^6 \text{ N/m}^2)(\pi)} \right]^{1/3}$$
$$= 9.1 \times 10^{-3} \text{ m} = 9.1 \text{ mm} \text{ (0.36 in.)}$$

Mechanisms of Plastic Deformation

12.45 Crystalline ceramics are harder yet more brittle than metals because they (ceramics) have fewer slip systems, and, therefore, dislocation motion is highly restricted.

Miscellaneous Mechanical Considerations

12.46 (a) This portion of the problem requests that we compute the modulus of elasticity for nonporous spinel given that $E = 240$ GPa for a material having 5 vol% porosity. Thus, we solve Equation 12.9 for E_0 , using $P = 0.05$, which gives

$$E_0 = \frac{E}{1 - 1.9P + 0.9P^2}$$

$$= \frac{240 \text{ GPa}}{1 - (1.9)(0.05) + (0.9)(0.05)^2} = 265 \text{ GPa} \quad (38.6 \times 10^6 \text{ psi})$$

(b) Now we are asked to determine the value of E at $P = 15$ vol% (i.e., 0.15). Using Equation 12.9 we get

$$E = E_0(1 - 1.9P + 0.9P^2)$$

$$= (265 \text{ GPa}) [1 - (1.9)(0.15) + (0.9)(0.15)^2] = 195 \text{ GPa} \quad (28.4 \times 10^6 \text{ psi})$$