

Material Science

Homework 5 Solution

1. (1)

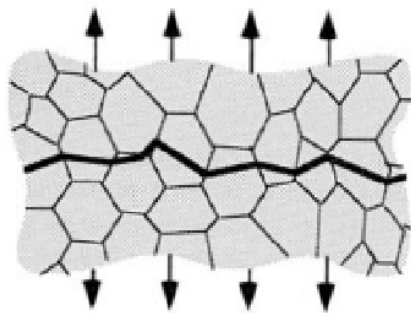
Ductile fracture:

- A. Extensive plastic deformation near an advancing crack .
- B. Crack growth is slow as the crack length extended(i.e. a stable crack).
- C. Needs an increase in the applied stress to propagate the crack.

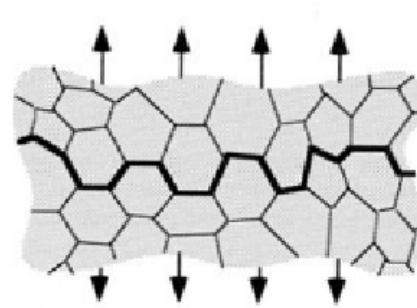
Brittle fracture:

- A. Very little plastic deformation near an advancing crack
- B. Crack growth is extremely rapid as the crack propagates (i.e. an unstable crack).
- C. Needs no increase in the applied stress to propagate the crack.

(2)

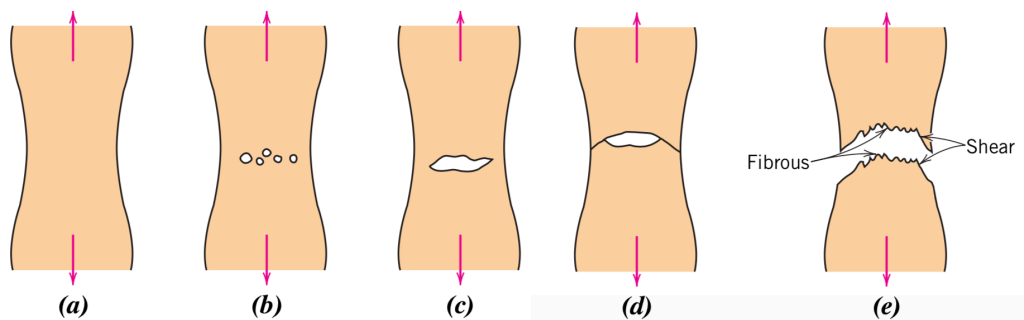


Transgranular fracture



Intergranular fracture

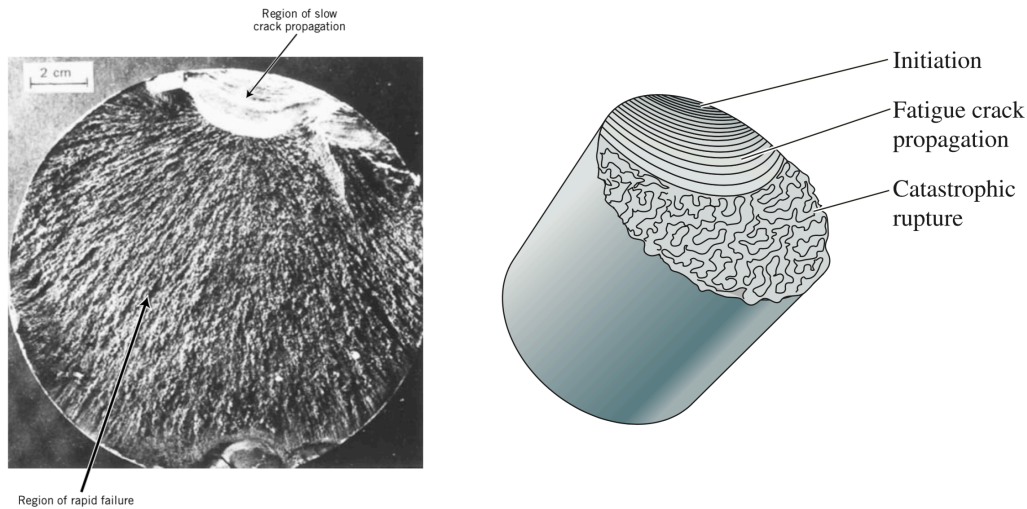
2. (1)



(2) The dimples are traces of the microvoids produced during fracture. Normally, these microvoids are round, or equiaxed, when a normal tensile stress produces the failure

3. (1) The process of fatigue failure is characterized by three distinct steps: (1) crack initiation, in which a small crack forms at some point of high stress concentration; (2) crack propagation, during which this crack advances incrementally with each stress cycle; and (3) final failure, which occurs very rapidly once the advancing crack has reached a critical size. The region of a fracture surface that formed during the crack propagation step may be characterized by two types of markings termed beachmarks and striations. Beach or clamshell marks are normally formed when the load is changed during service or when the loading is intermittent, perhaps permitting time for oxidation inside the crack. Striations, which are on a much finer scale, show the position of the crack tip after each cycle. Beach marks always suggest a

fatigue failure, but—unfortunately—the absence of beach marks does not rule out fatigue failure.



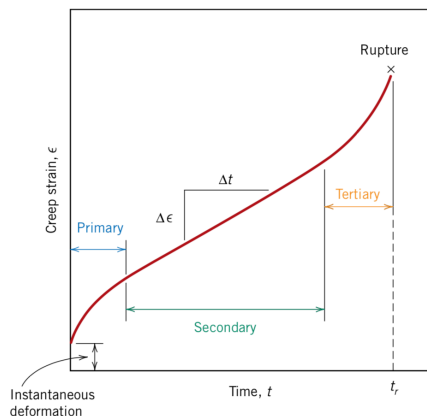
(2) Number of cycles to fail at a specified stress level

(3) (a)specimen fabrication and surface preparation, (b)metallurgical variables, (c)specimen alignment in the test apparatus, (d)variation in mean stress, and (e)variation in test cycle frequency.

4. (a) With regard to size, beachmarks are normally of macroscopic dimensions and may be observed with the naked eye; fatigue striations are of microscopic size and it is necessary to observe them using electron microscopy.

(b) With regard to origin, beachmarks result from interruptions in the stress cycles; each fatigue striation is corresponds to the advance of a fatigue crack during a single load cycle.

5. (1)



(2)(a) solid solution alloying, (b) dispersion strengthening by using an insoluble second phase, and (c) increasing the grain size or producing a grain structure with a preferred orientation.

6.

$$Y = \frac{K_{Ic}}{\sigma\sqrt{\pi a}} = \frac{35\text{MPa}\sqrt{m}}{(251\text{MPa})\sqrt{(\pi)\left[\frac{2.2 * 10^{-3}m}{2}\right]}} = 2.37$$

The following is the plane strain fracture toughness of the test condition

$$Y\sigma\sqrt{\pi a} = (2.37) \times (326\text{MPa}) \times \left(\sqrt{\pi \times 0.6 \times 10^{-3}m}\right) = 33.54 \text{MPa}\sqrt{m}$$

$$\therefore 33.54 \text{MPa}\sqrt{m} < K_{Ic} = 35\text{MPa}\sqrt{m}$$

∴ The fracture does **not** occur at stress level of 326 MPa when the maximum internal crack length is 1.2 mm