

Dislocations

Dislocations are line imperfections in an otherwise perfect crystal. They typically are introduced into a crystal during solidification of the material or when the material is deformed permanently. Although dislocations are present in all materials, including ceramics and polymers, and metallic materials. There are three types of dislocations: the screw dislocation, the edge dislocation, and the mixed dislocation.

1) Screw Dislocations

The screw dislocation (Figure 4-4) can be illustrated by cutting partway through a perfect crystal and then skewing the crystal by one atom spacing. If we follow a crystallographic plane one revolution around the axis on which the crystal was skewed, starting at point x and traveling equal atom spacings in each direction, we finish at point y one atom spacing below our starting point. The vector required to complete the loop is the Burgers vector b . The Burgers vector is parallel to the screw dislocation.

2) Edge Dislocations

An edge dislocation (Figure 4-5) can be illustrated by slicing partway through a perfect crystal, spreading the crystal apart, and partly filling the cut with an extra half plane of atoms. A “ \perp ” symbol is often used to denote an edge dislocation. Unlike an edge dislocation, a screw dislocation cannot be visualized as an extra half plane of atoms.

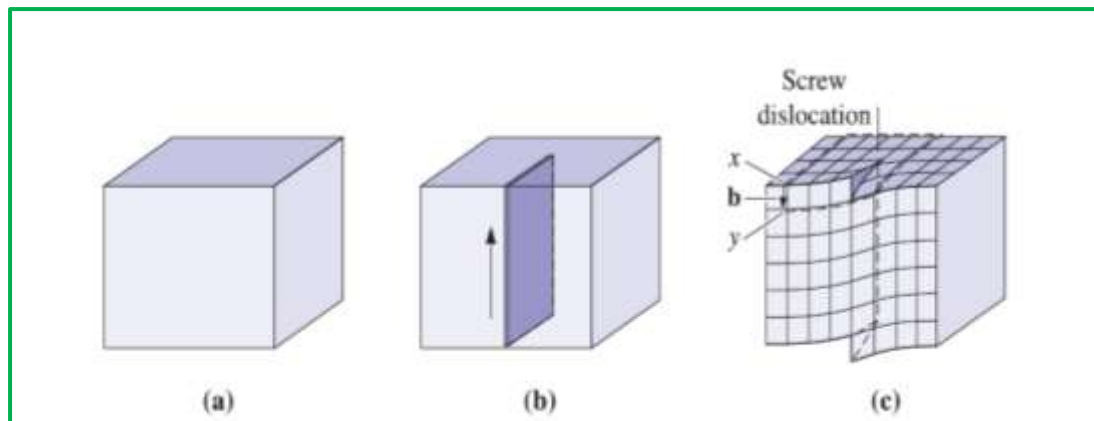


Figure 4-4 The perfect crystal (a) is cut and sheared one atom spacing, (b) and (c). The line along which shearing occurs is a screw dislocation. A Burgers vector \mathbf{b} is required to close a loop of equal atom spacings around the screw dislocation.

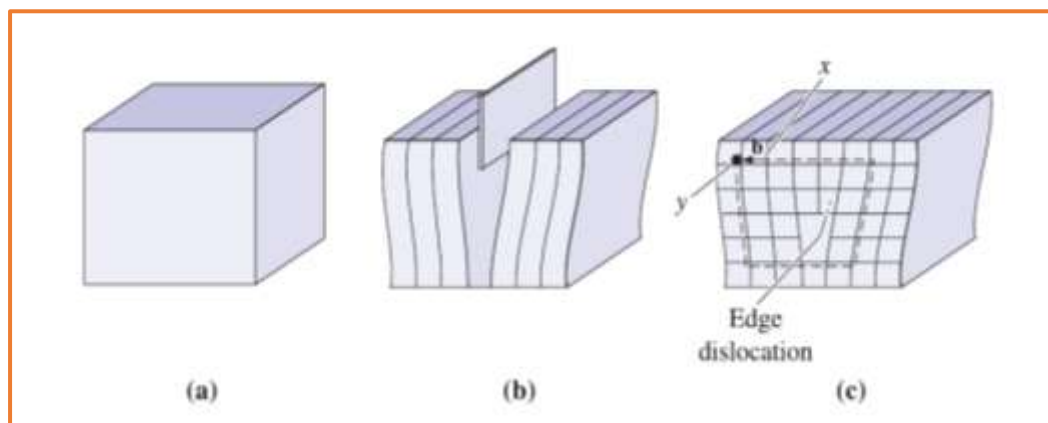


Figure 4-5 The perfect crystal in (a) is cut and an extra half plane of atoms is inserted (b). The bottom edge of the extra half plane is an edge dislocation (c). A Burgers vector \mathbf{b} is required to close a loop of equal atom spacings around the edge dislocation.

3) Mixed Dislocations

As shown in Figure 4-6, **mixed dislocations** have both edge and screw components, with a transition region between them. The Burgers vector, however, remains the same for all portions of the mixed dislocation.

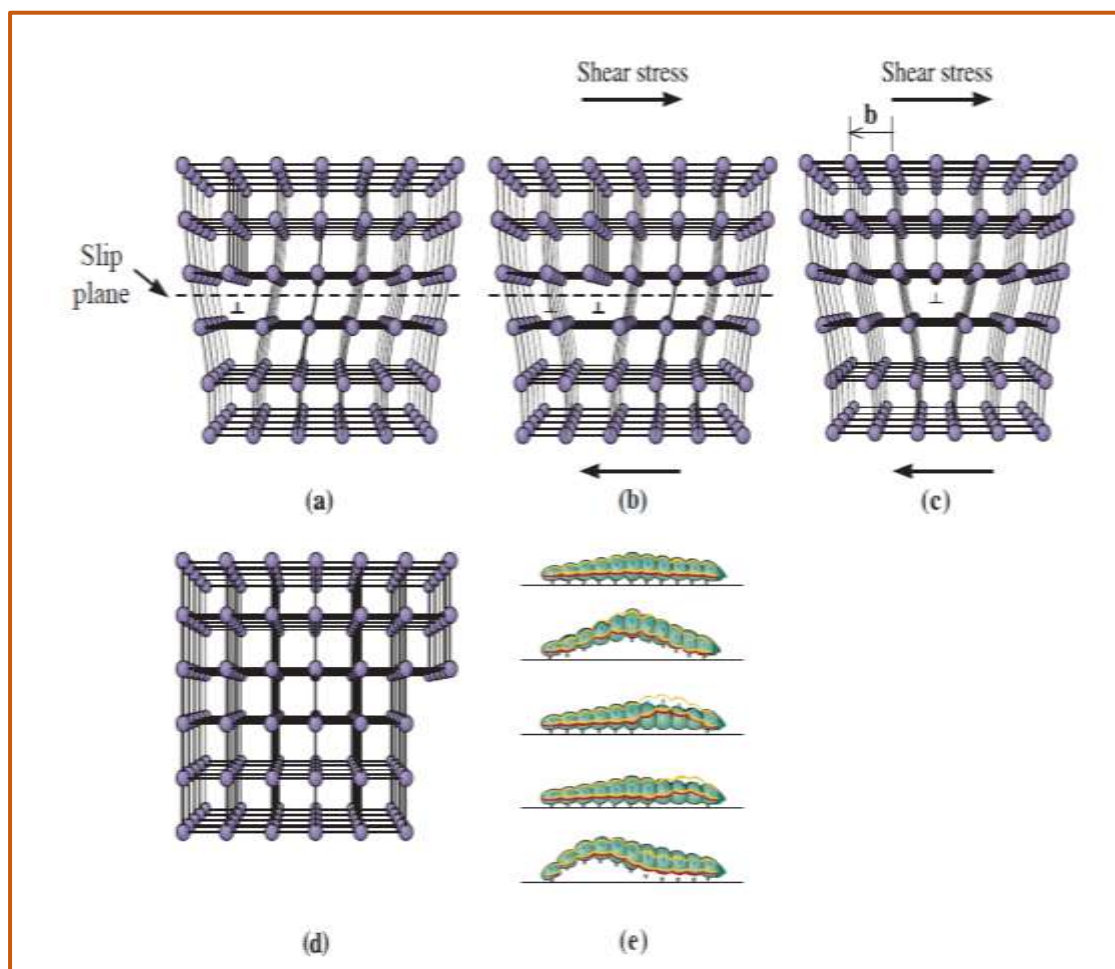
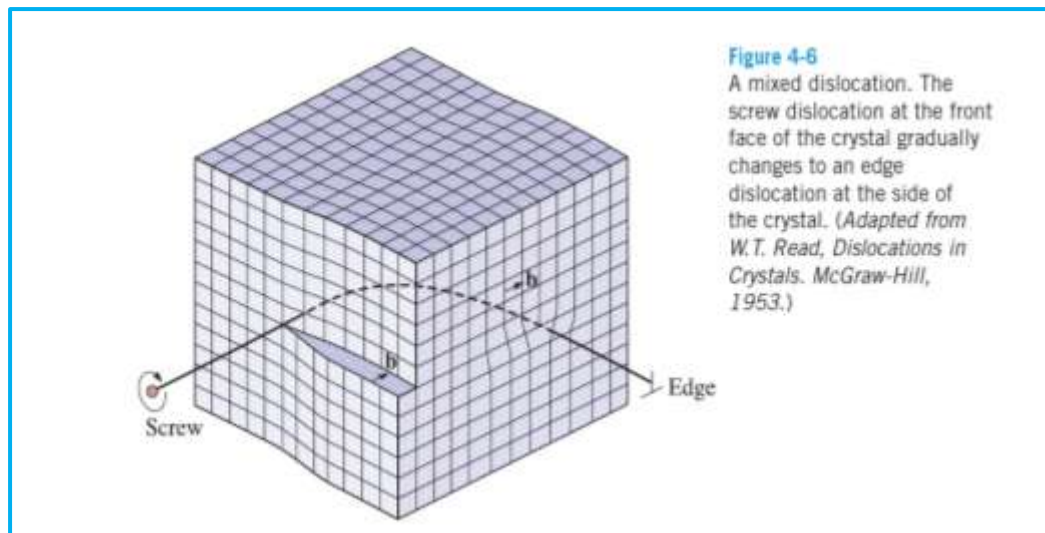


Figure 4-7 (a) When a shear stress is applied to the dislocation in (a), the atoms are displaced, (b) causing the dislocation to move one Burgers vector in the slip direction. (c) Continued movement of the dislocation eventually creates a step (d), and the crystal is deformed (e) The motion of a caterpillar is analogous to the motion of a dislocation.

- A plane that contains both the dislocation line and the Burgers vector is known as a **slip plane**.
- **slip direction** (which is parallel to the Burgers vector). (Note that the combination of a slip plane and a slip direction comprises a **slip system**.)

Plastic deformation refers to irreversible deformation or change in shape that occurs when the force or stress that caused it is removed. This is because the applied stress causes dislocation motion that in turn causes permanent deformation.

Surface Defects

Surface defects are the boundaries, or planes, that separate a material into regions. For example, each region may have the same crystal structure but different orientations.

Grain boundary

A **grain boundary**, the surface that separates the individual grains, is a narrow zone in which the atoms are not properly spaced.

Stacking Faults

Stacking faults represent an error in the stacking sequence of close-packed planes.

Twin Boundaries

A **twin boundary** is a plane across which there is a special mirror image misorientation of the crystal structure (Figure 4-19). Twins can be produced when a shear force, acting along the twin boundary, causes the atoms to shift out of position.

Twinning occurs during deformation or heat treatment of certain metals. The twin boundaries interfere with the slip process and increase the strength of the metal. Twinning also occurs in some ceramic materials such as monoclinic zirconia and dicalcium silicate.

ABC ABAB CABC

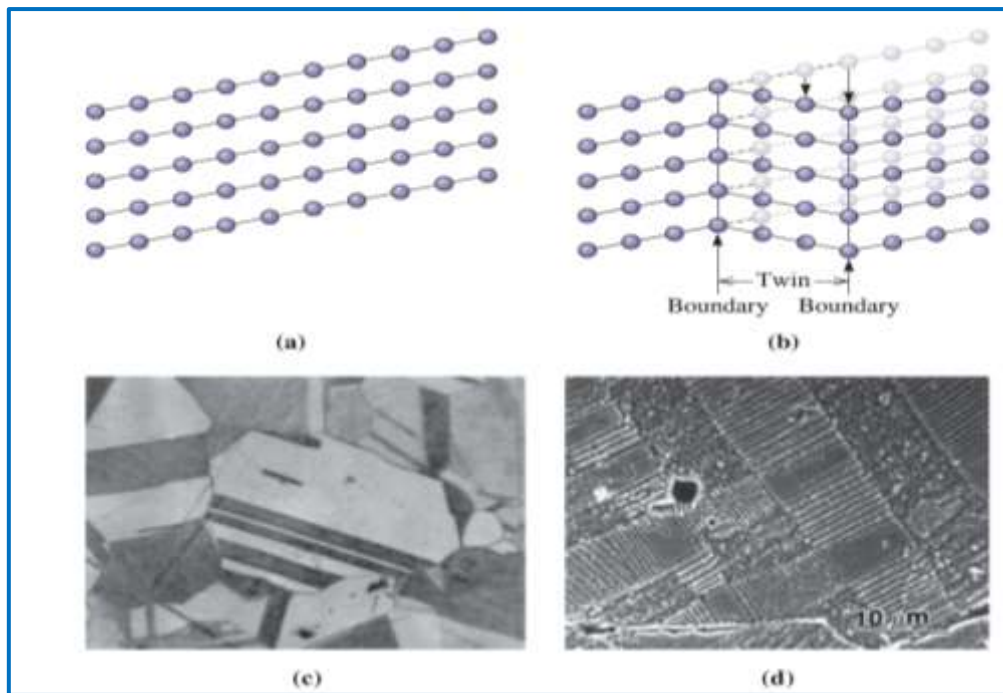


Figure 4-19 Application of stress to the (a) perfect crystal may cause a displacement of the atoms, (b) resulting in the formation of a twin. Note that the crystal has deformed because of twinning. (c) A micrograph of twins within a grain of brass (* 250). (d) Domains in ferroelectric barium titanate.