Metal Forming Processes (ME5807)

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Elastic and Plastic deformation

Covered under Module 01

Mechanism of Plastic deformations

- Computation of the theoretical strengths of perfect crystals (early materials studies).
- The theoretical strengths of perfect crystals was many times greater than those actually measured.
- The discrepancy in mechanical strengths could be explained by a type of linear crystalline defect that has come to be known as a dislocation.

Mechanism of Plastic deformations–Dislocation

The discrepancy in mechanical strengths could be explained by a type of linear crystalline defect that has come to be known as a dislocation.

Edge and screw are the two fundamental dislocation types.

Mechanism of Plastic deformations–Edge dislocation

In an edge dislocation, localized lattice distortion exists along the end of an extra half-plane of atoms, which also defines the dislocation line.

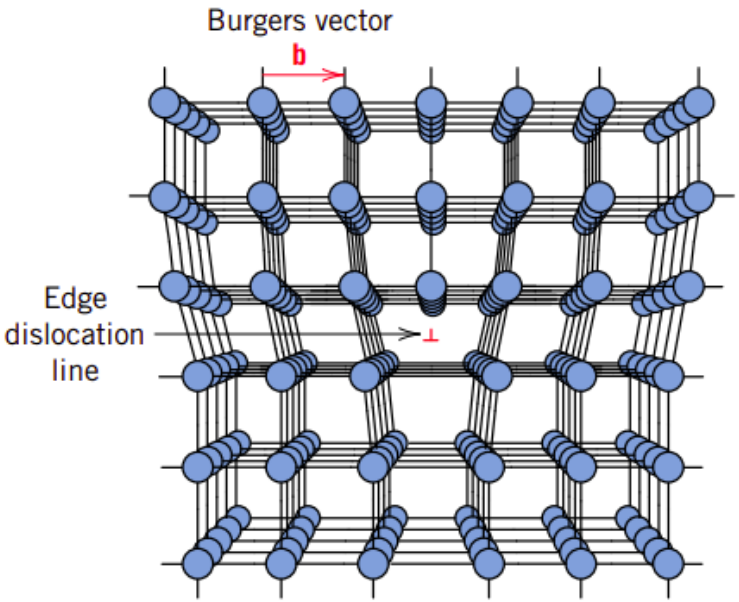

Figure: Edge Dislocation

Mechanism of Plastic deformations–Screw dislocation

A screw dislocation may be thought of as resulting from shear distortion; its dislocation line passes through the center of a spiral, atomic plane ramp.

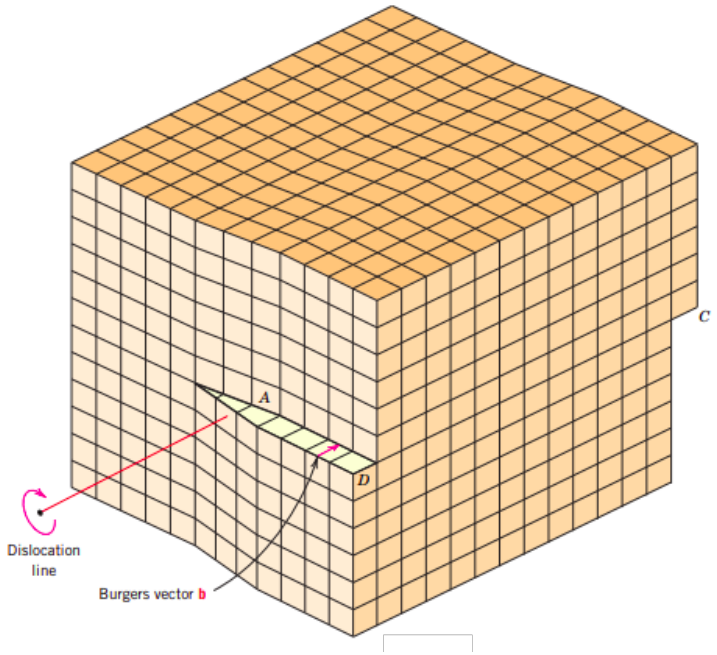

Figure: Screw Dislocation

Mechanism of Plastic deformations–Dislocation

Many dislocations in crystalline materials have both edge and screw components; these are mixed dislocations.

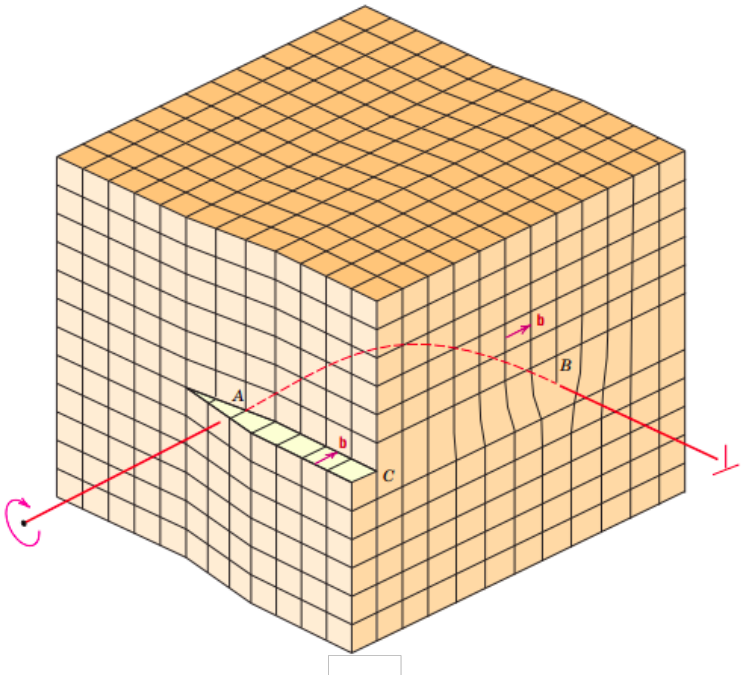

Figure: Dislocation with Edge & Screw (Mixed)

Mechanism of Plastic deformations

Two prominent mechanisms of plastic deformation, namely **slip** and **twinning**.

Mechanism of Plastic deformations–Slip

Slip is the prominent mechanism of plastic deformation in metals. It involves sliding of blocks of crystal over one other along definite crystallographic planes, called slip planes.

- It is analogous to a deck of cards when it is pushed from one end. Slip occurs when shear stress applied exceeds a critical value.
- During slip each atom usually moves same integral number of atomic distances along the slip plane producing a step, but the orientation of the crystal remains the same.

Mechanism of Plastic deformations–Slip

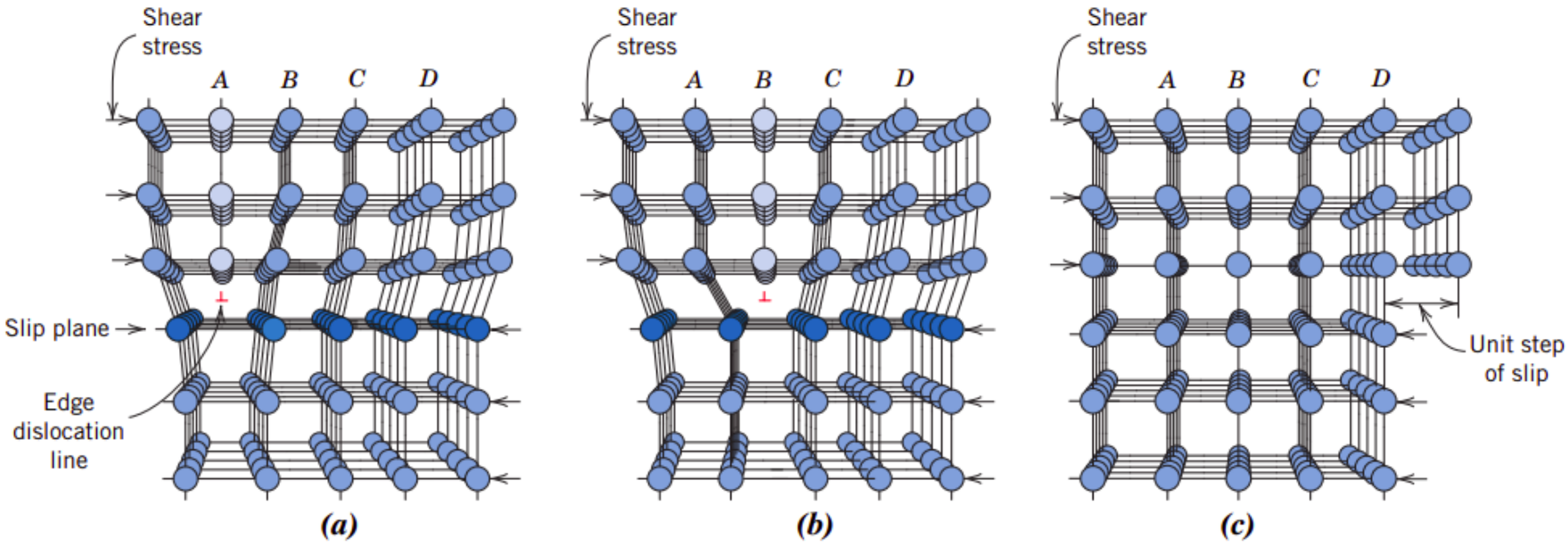

Figure: Dislocation Motion

Mechanism of Plastic deformations–Slip

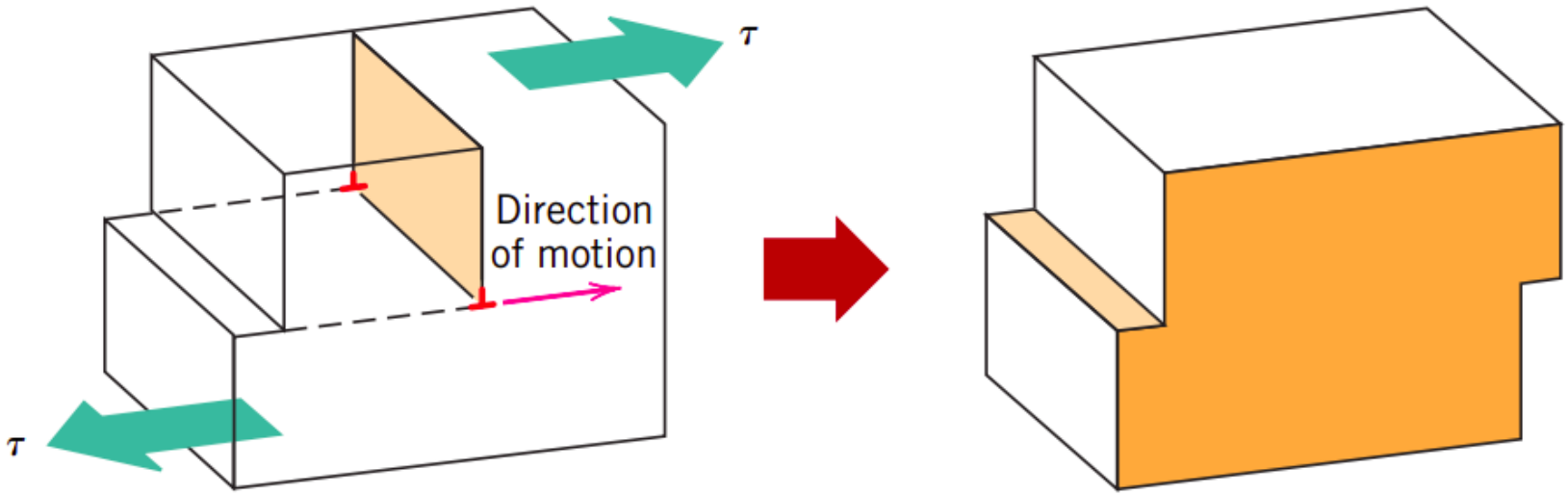

Figure: Dislocation Motion–Edge

Mechanism of Plastic deformations–Slip

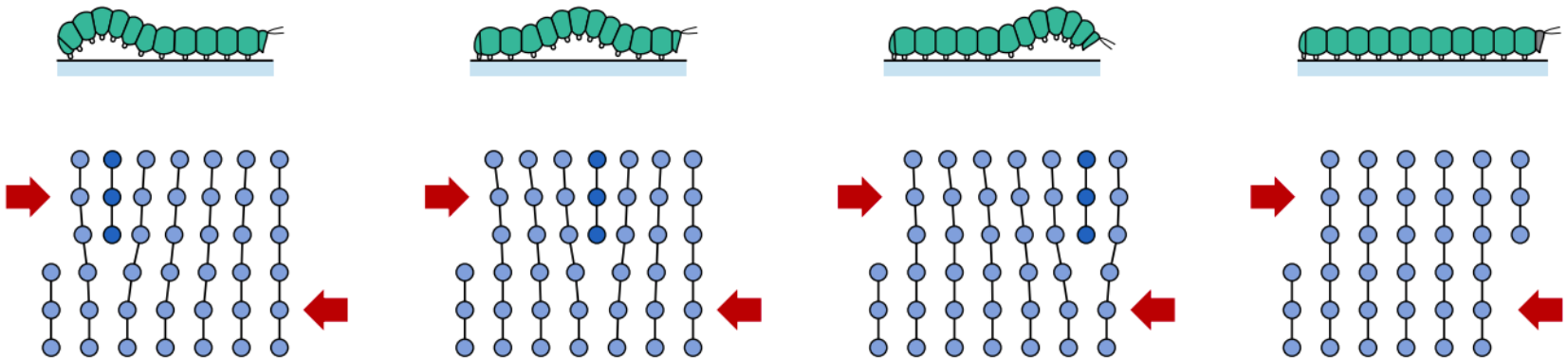

Figure: Analogy between Caterpillar and Dislocation motion

Mechanism of Plastic deformations–Slip

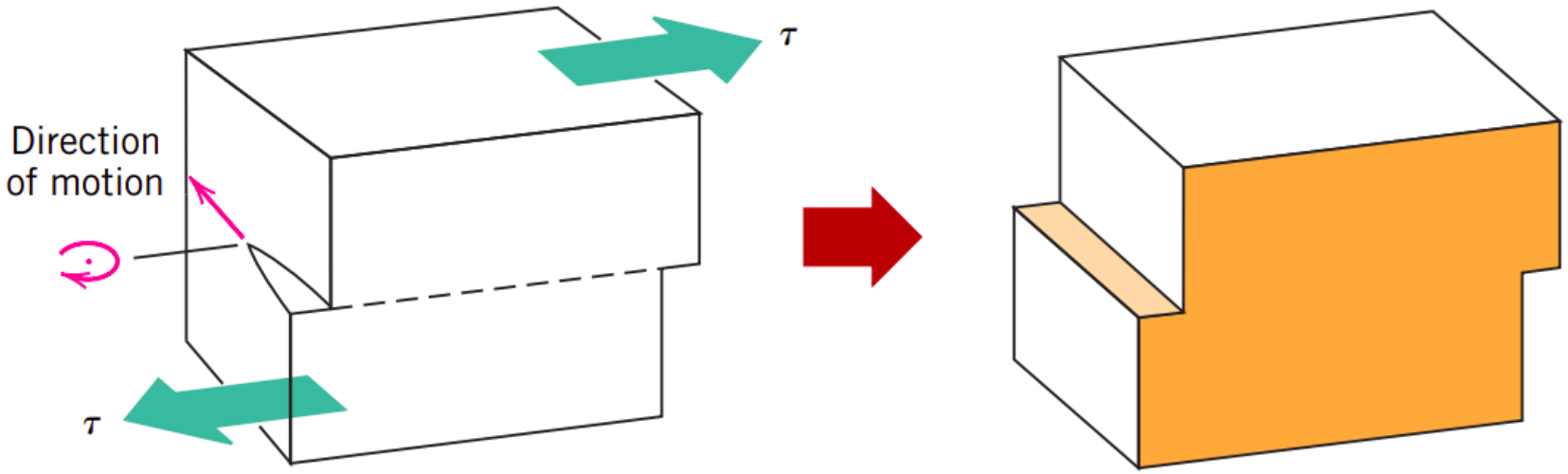

Figure: Dislocation Motion–Screw

Mechanism of Plastic deformations–Slip

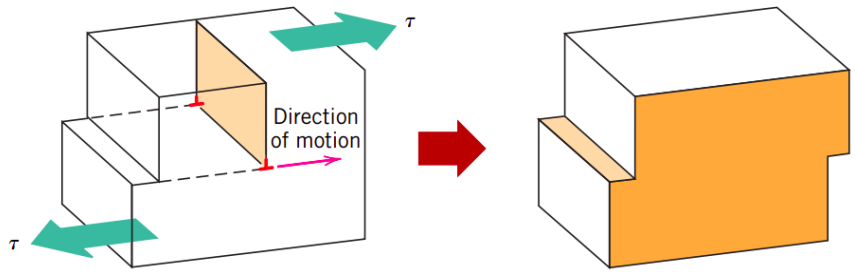

Figure: Dislocation Motion–Edge

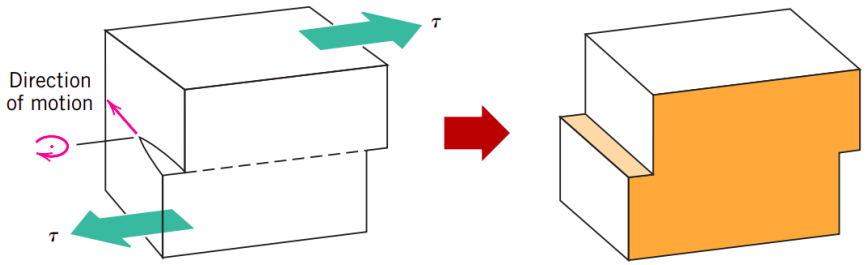

Figure: Dislocation Motion–Screw

Mechanism of Plastic deformations–Twinning

The portion of crystal takes up an orientation that is related to the orientation of the rest of the untwined lattice in a definite, symmetrical way.

- The twinned portion of the crystal is a mirror image of the parent crystal.
- The plane of symmetry is called twinning plane.
- The important role of twinning in plastic deformation is that it causes changes in plane orientation so that further slip can occur.

Mechanism of Plastic deformations–Twinning

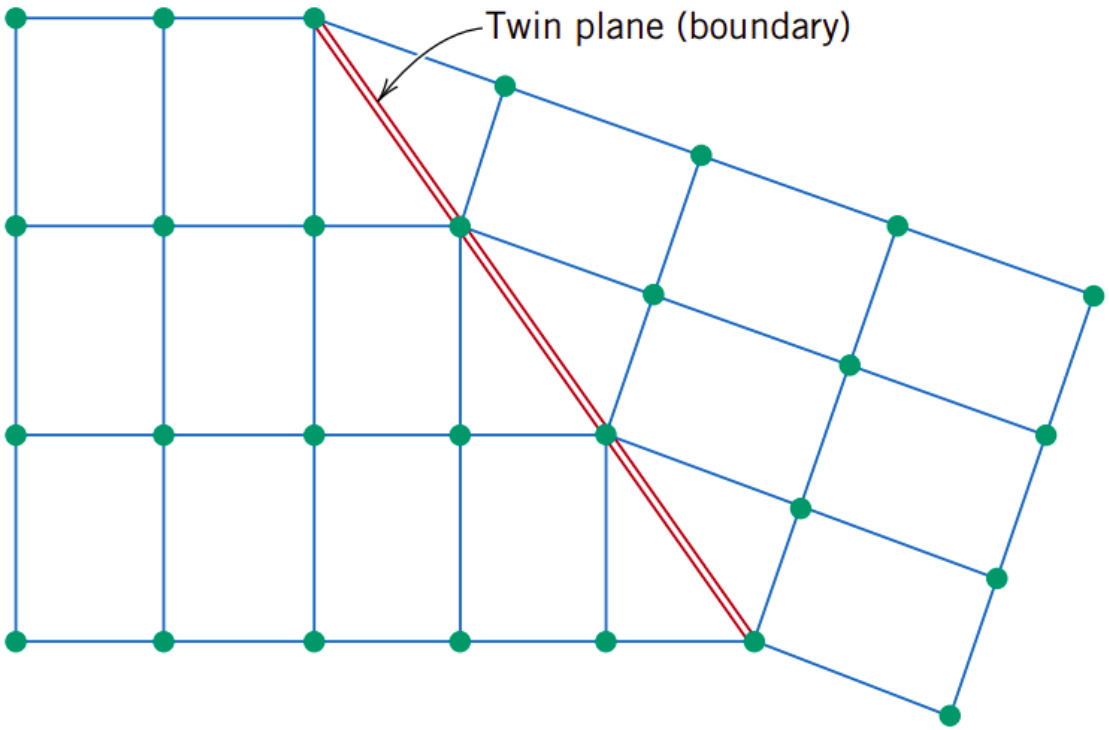

Figure: Twin Plane

Mechanism of Plastic deformations–Twinning

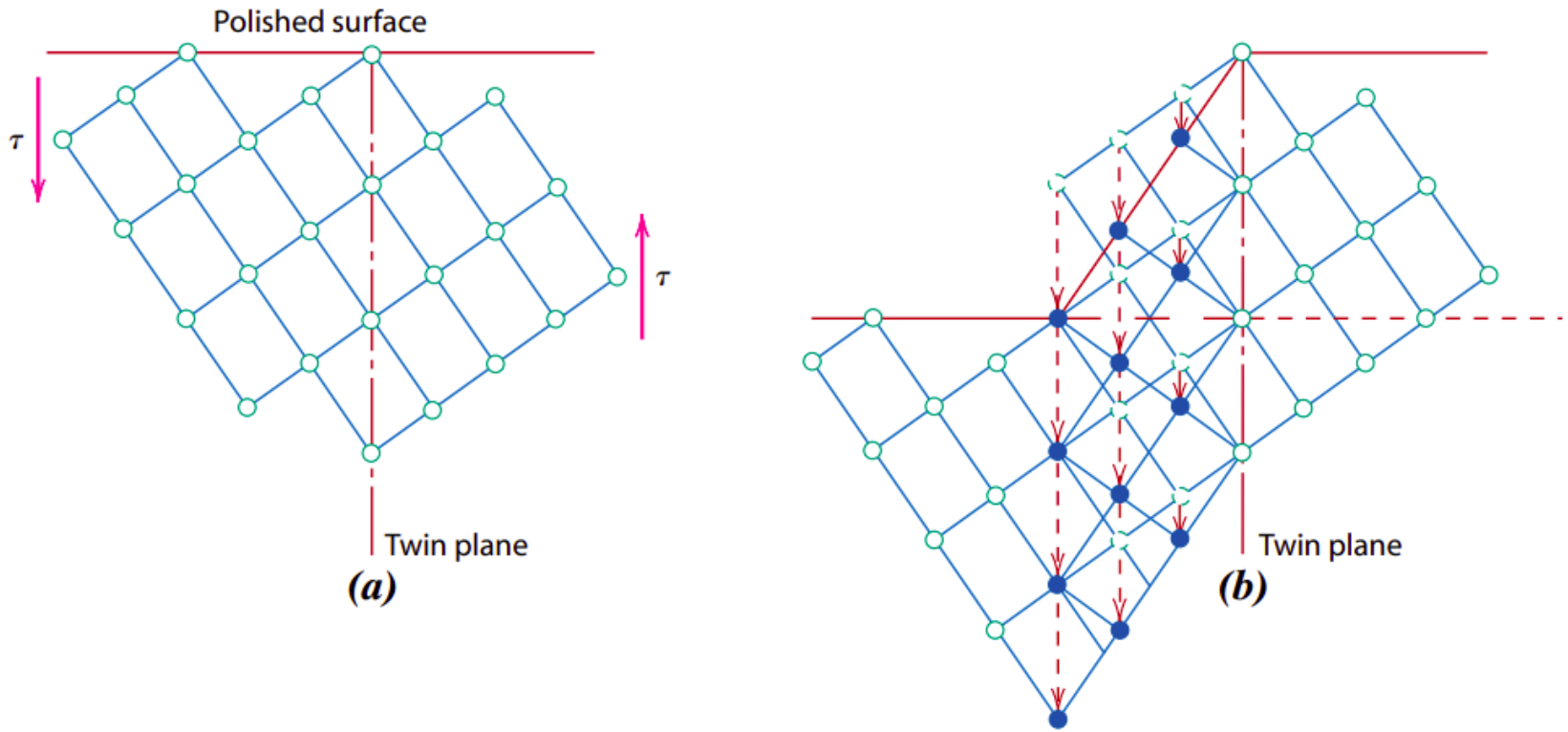

Figure: Twinning

Mechanism of Plastic deformations–Slip and Twinning

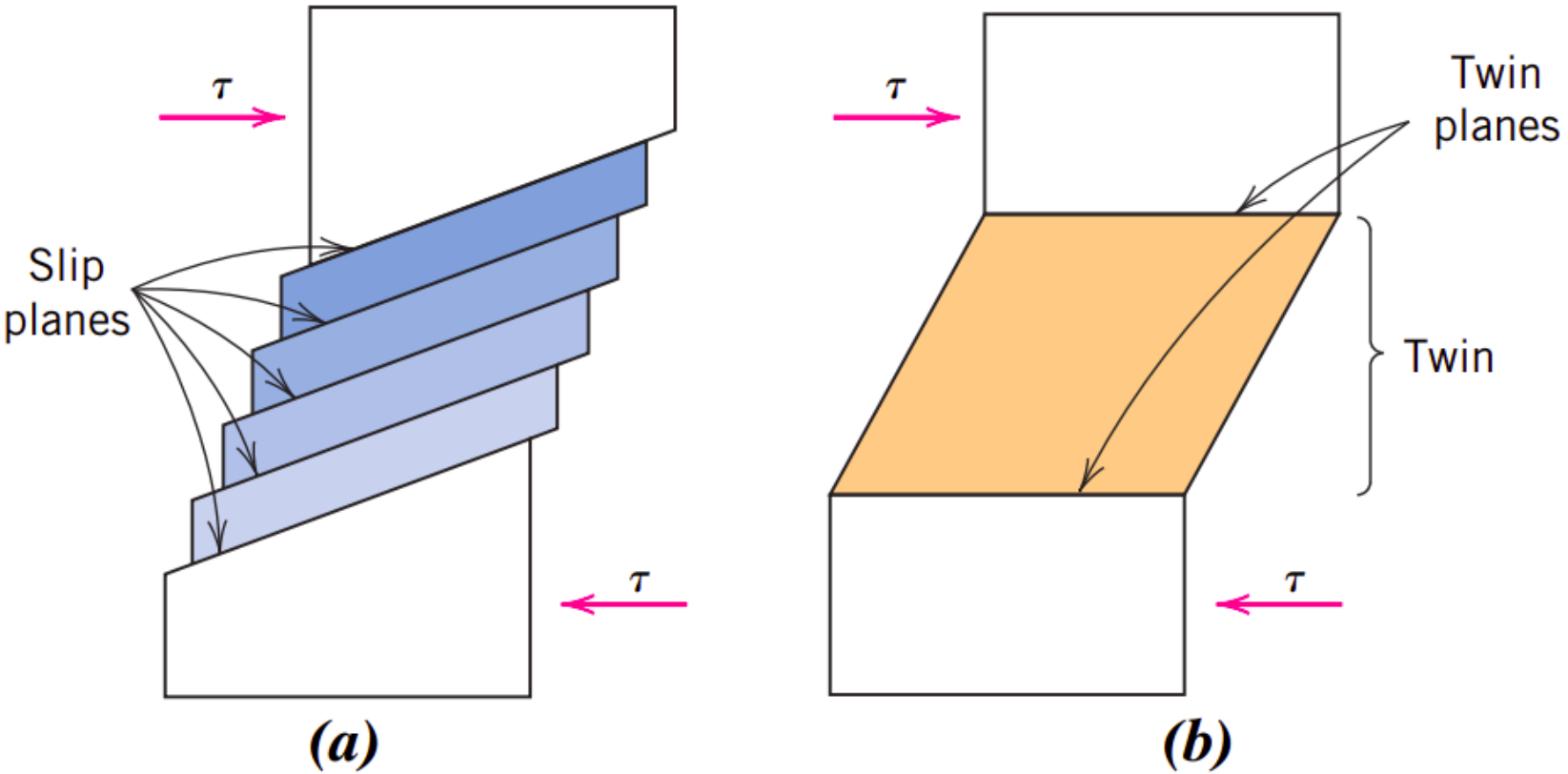

Figure: Slip and Twinning

Thank You