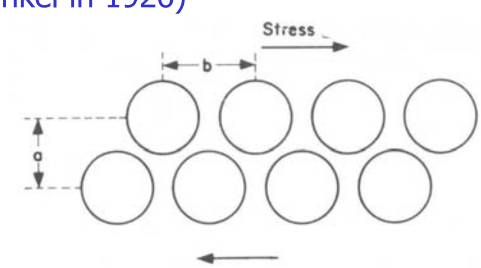
## Chapter 7: Dislocations and strengthening mechanisms

- Introduction
- Basic concepts
- Characteristics of dislocations
- Slip systems
- Slip in single crystals
- Plastic deformation of polycrystalline materials

## Theoretical stress

- Theoretical stress (Frenkel in 1926)



## Theoretical stress (*continue*)

- Hook's law

- Theoretical critical shear stress (maximum stress):

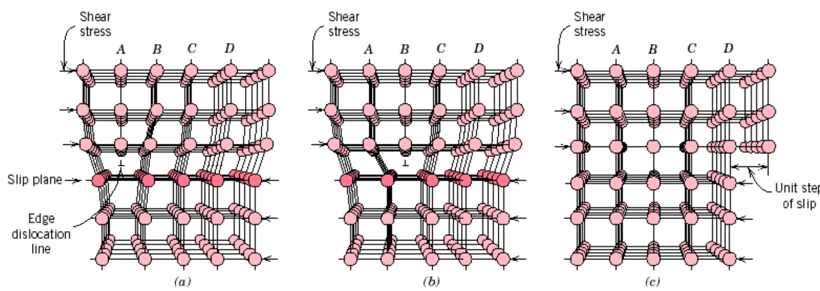
## Theoretical & experimental strength

There is much difference between theoretical and experimental strength

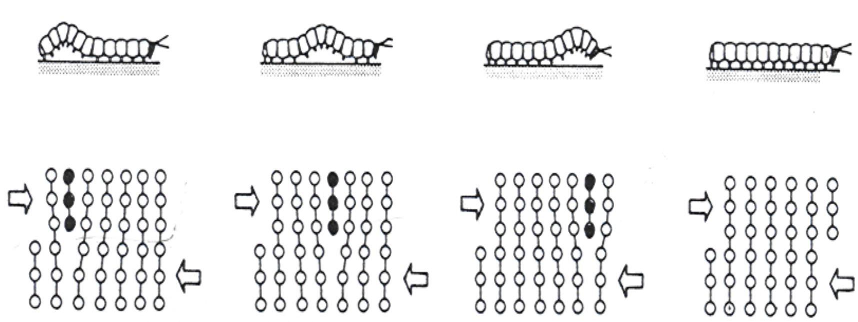
Reasons are:

- Defects are present in all perfect crystal
- Dislocation movement makes plastic deformation easier than that predicted by the Frenkel calculation

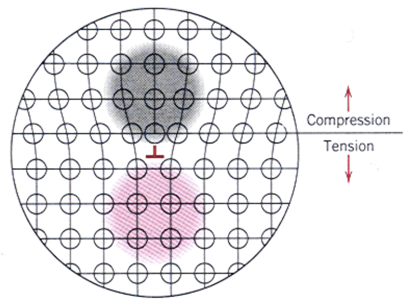
## Dislocation Motion




## Analogy between caterpillar and dislocation motion

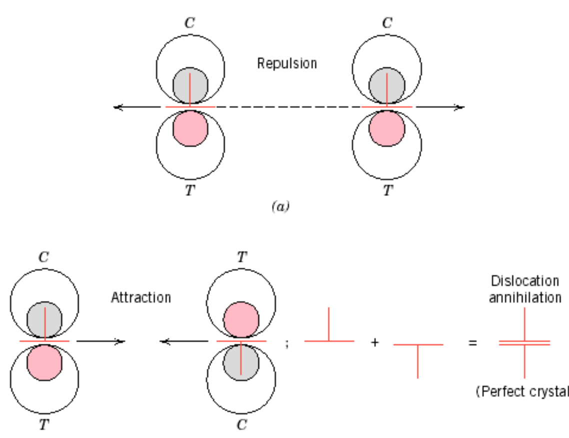


## Characteristics of dislocations




## Dislocation interaction

- Edge dislocation
- Positive sign
- Negative sign



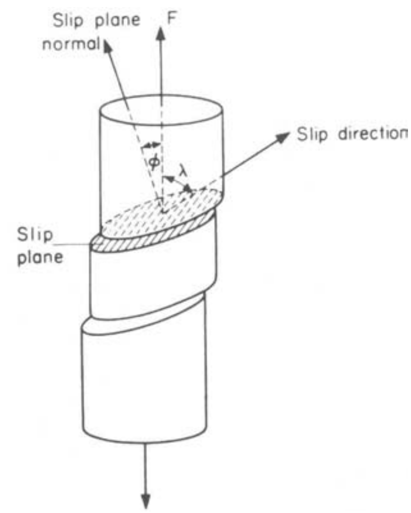
## Slip in single crystals

- Schmid's law

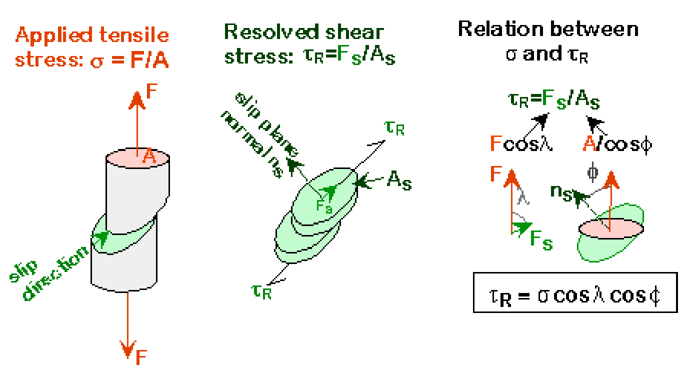
- Slip plane:
- Slip direction:

- Slip system:

- Schmid's factor:

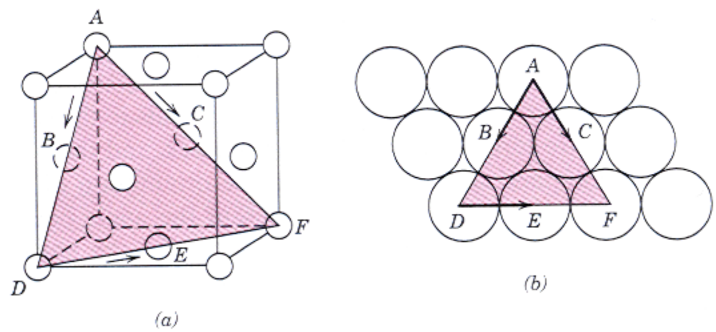



## Slip in single crystals (*continue*)



## Slip system

- A {111}<110> slip system for in Fcc unit cell



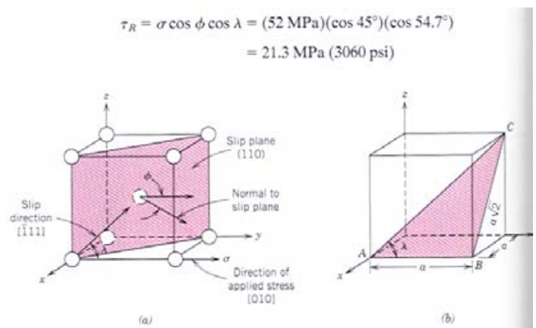

## Slip planes and directions for common crystal structure

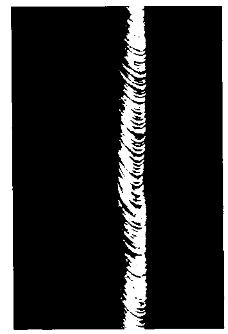
**Table 7.1** Slip Systems for Face-Centered Cubic, Body-Centered Cubic, and Hexagonal Close-Packed Metals

| *Metals* | *Slip Plane* | *Slip Direction* | *Number of Slip Systems* |
|---|---|---|---|
| | **Face-Centered Cubic** | | |
| Cu, Al, Ni, Ag, Au | {111} | $\langle 1\bar{1}0\rangle$ | 12 |
| | **Body-Centered Cubic** | | |
| $\alpha$-Fe, W, Mo | {110} | $\langle \bar{1}11\rangle$ | 12 |
| $\alpha$-Fe, W | {211} | $\langle \bar{1}11\rangle$ | 12 |
| $\alpha$-Fe, K | {321} | $\langle \bar{1}11\rangle$ | 24 |
| | **Hexagonal Close-Packed** | | |
| Cd, Zn, Mg, Ti, Be | {0001} | $\langle 11\bar{2}0\rangle$ | 3 |
| Ti, Mg, Zr | $\{10\bar{1}0\}$ | $\langle 11\bar{2}0\rangle$ | 3 |
| Ti, Mg | $\{10\bar{1}1\}$ | $\langle 11\bar{2}0\rangle$ | 6 |

# Example

- Determine the resolved shear stress along (110) plane and in a [111] direction for Bcc iron. Tensile stress is 52 Mpa.



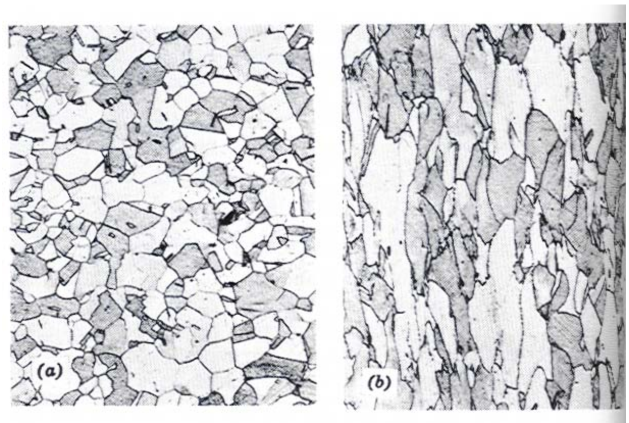
**Slip in a zinc crystal**

# Plastic deformation of polycrystalline materials

Slip lines on the surface of a polycrystalline specimen of copper

## Plastic deformation of polycrystalline materials

- Deformation and slip in polycrystalline materials




## DISLOCATIONS & MATERIALS CLASSES