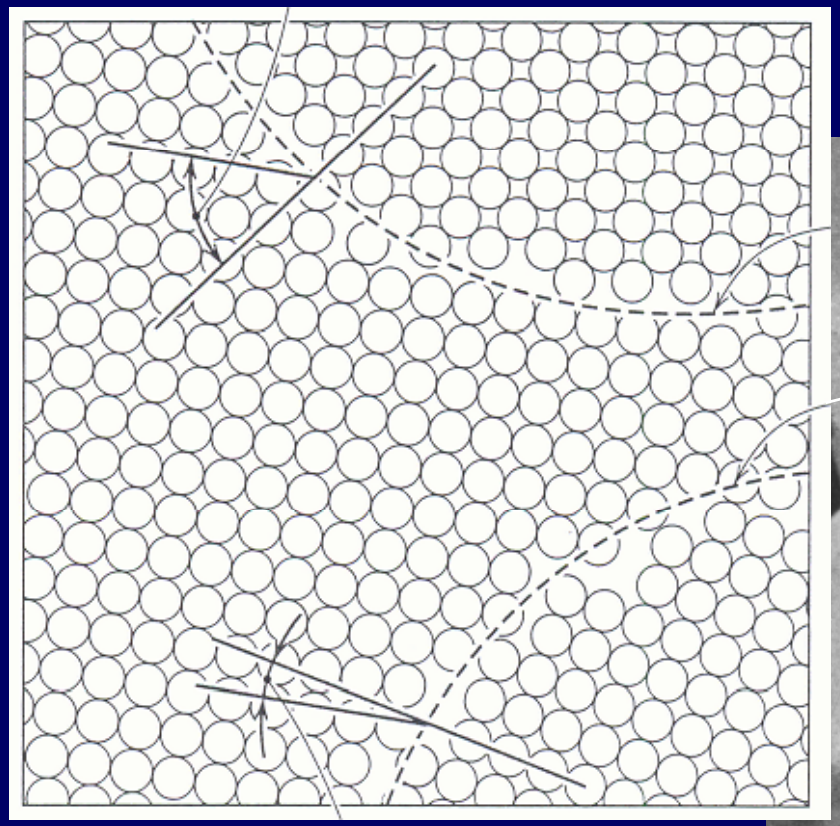
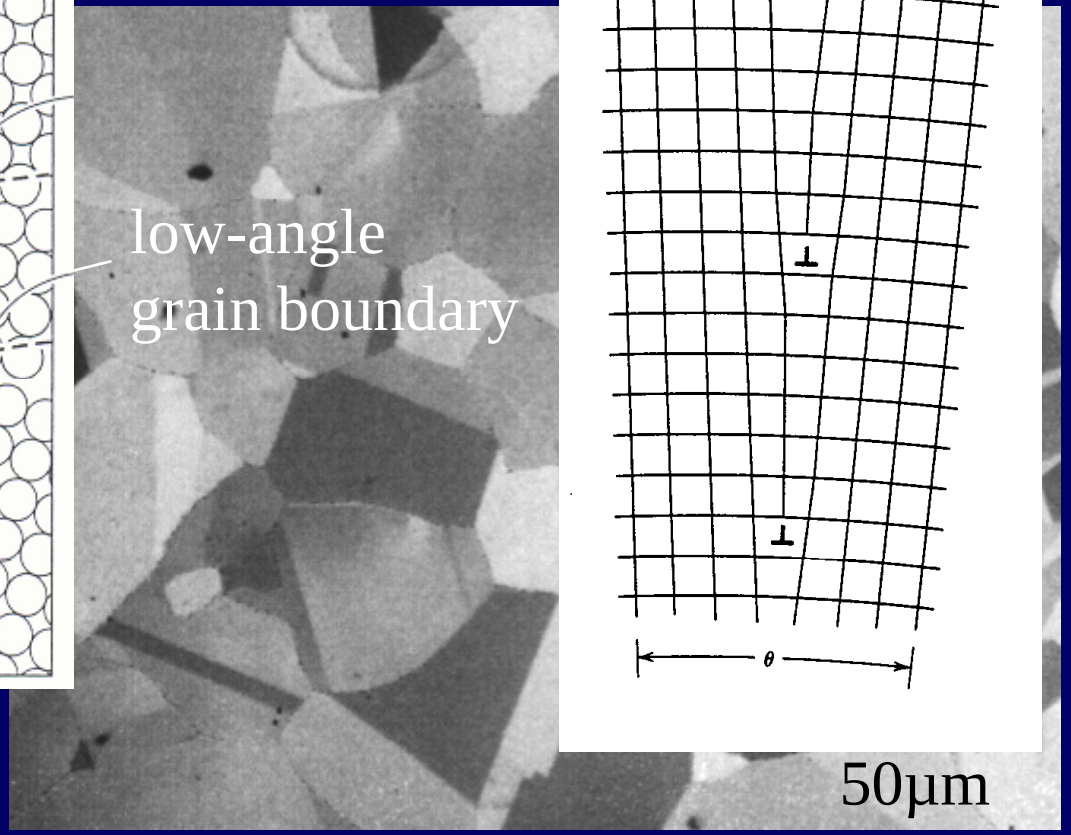
Grain Boundaries

high-angle grain boundary (Θ>15°)



Ni-Base Superallo

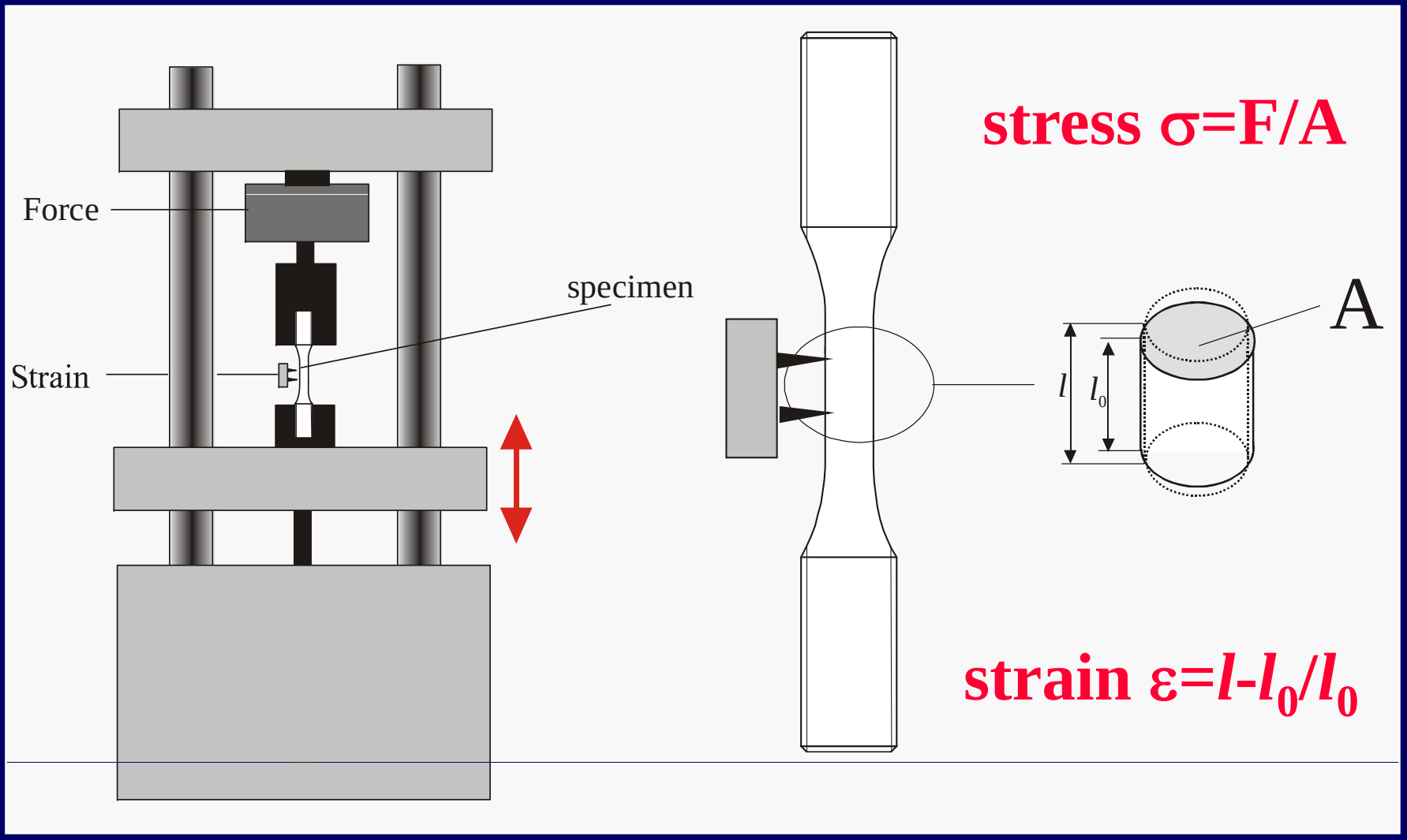
low-angle
grain boundary



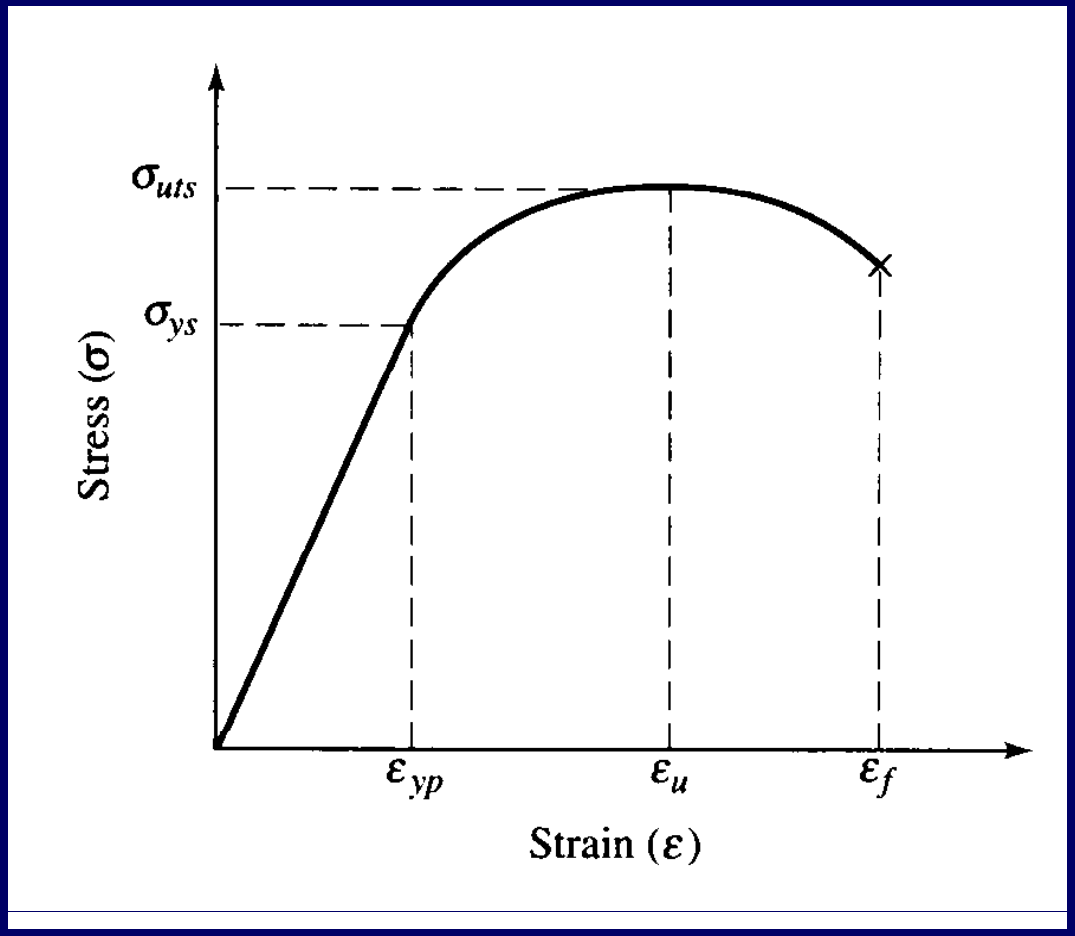
Properties of Materials

- Mechanical Properties
  - Elastic
  - Plastic
  - Viscoelastic
  - Creep
- Testing methods

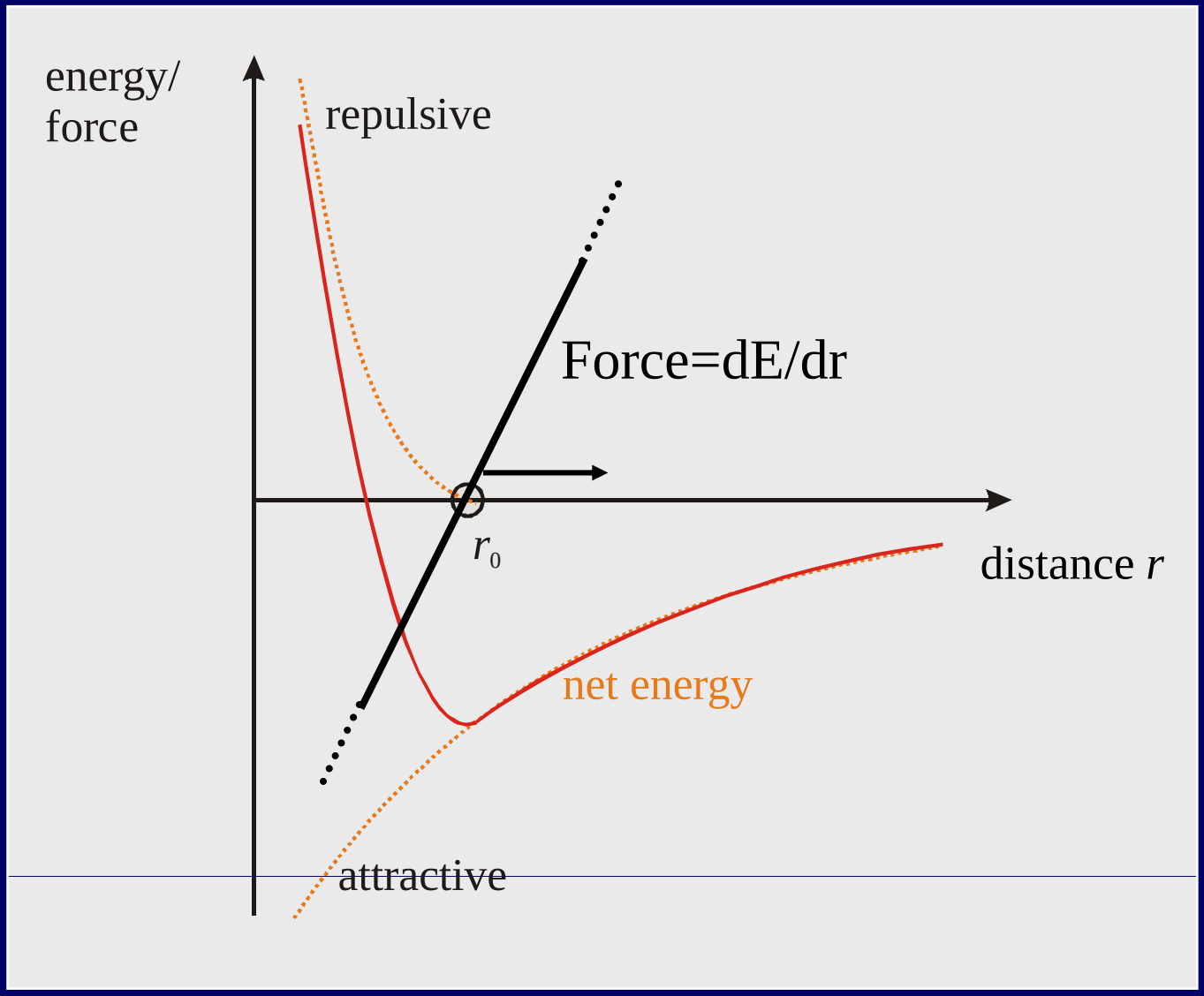
The Tensile Test

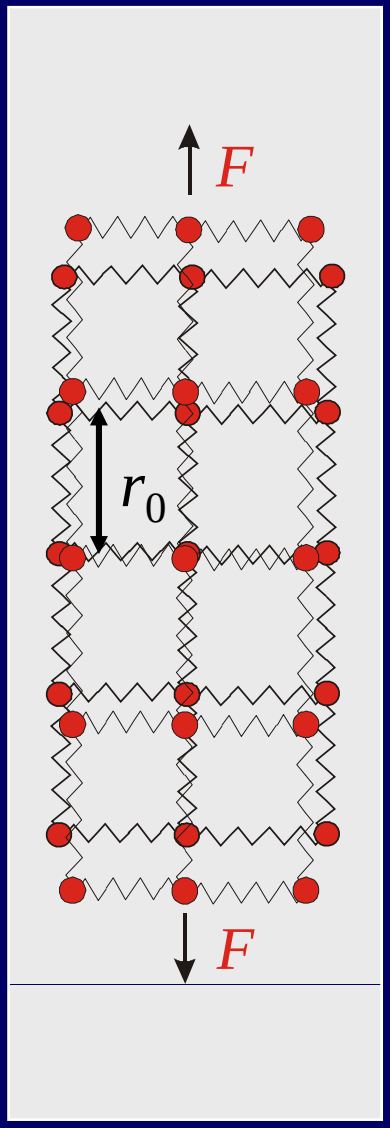


The Tensile Test



Elastic Deformation





Elastic constants (isotropic case)

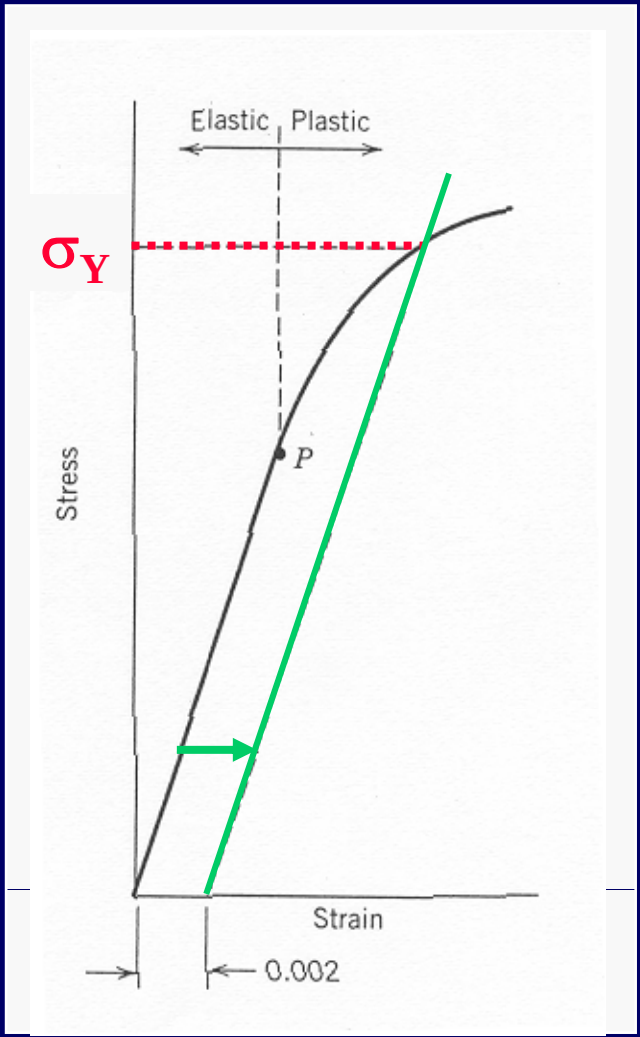
- Stress – strain / shear stress – shear strain
    - Young's modulus
    - Shear modulus
    - Poisson ratio

In order to completely describe the elastic behavior of a solid 2 of these constants need to be known!

$$E = 2G(1+\nu)$$

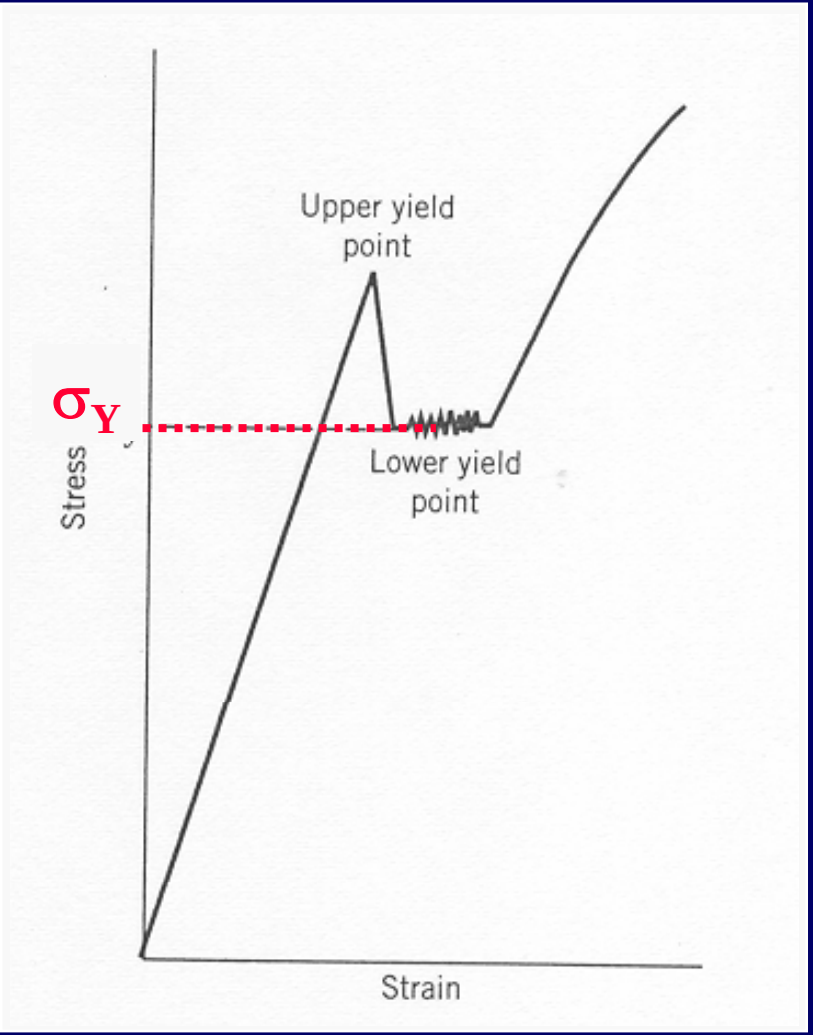
Yield Strength σ_Y

0.002 strain offset

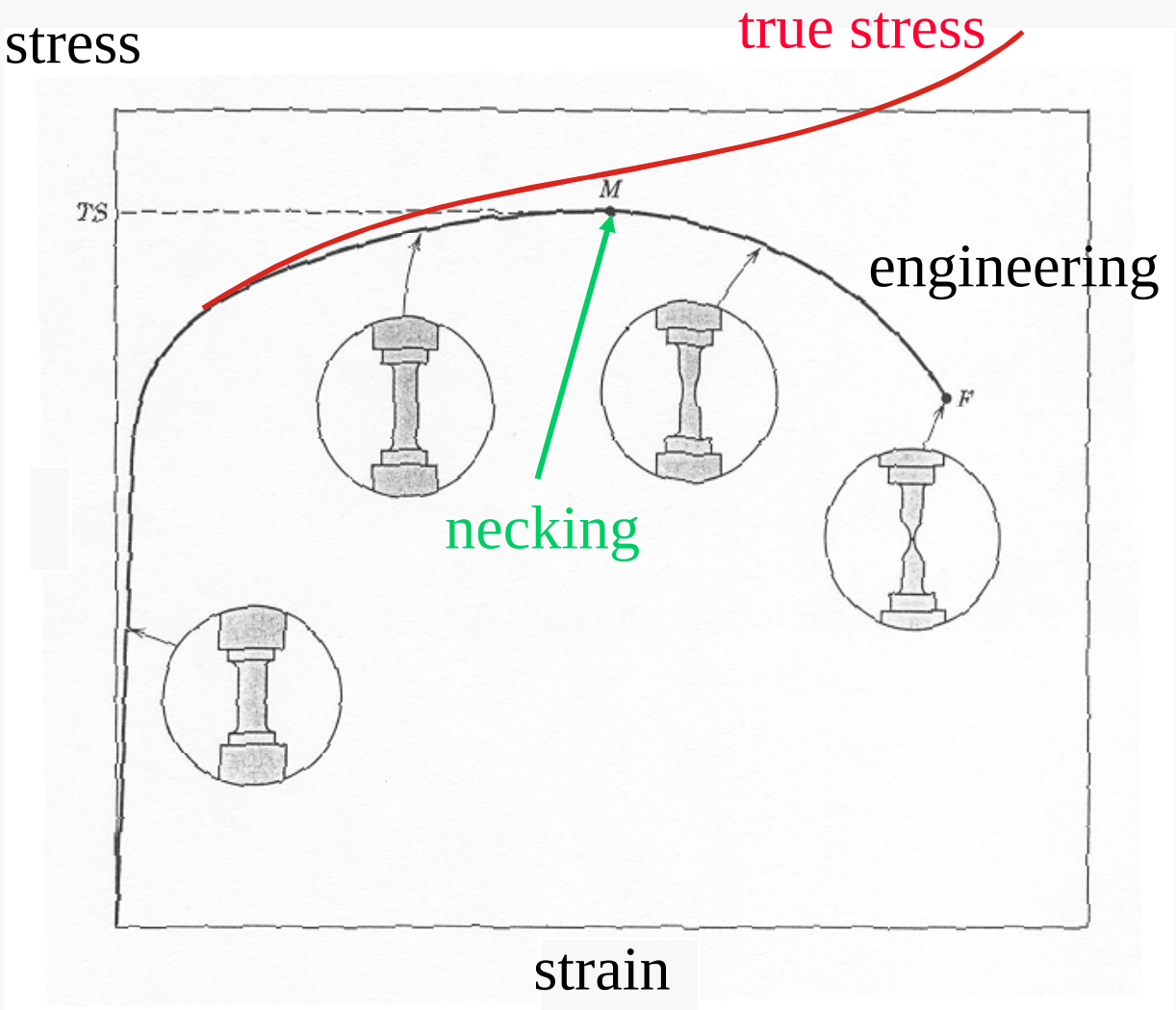


yield-point phenomenon

(C steels, dislocations are pinned by C)

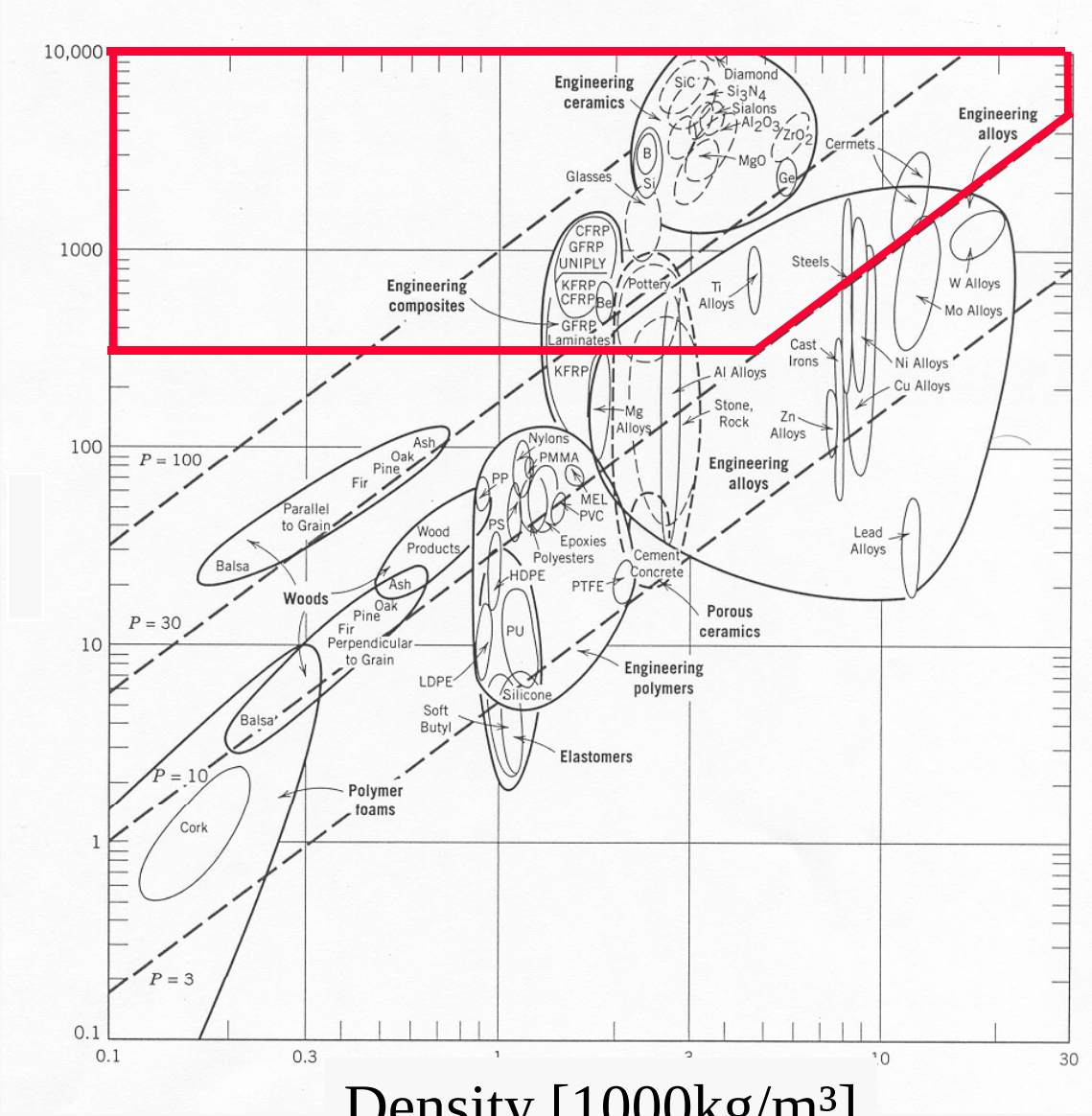


The Stress-Strain Curve



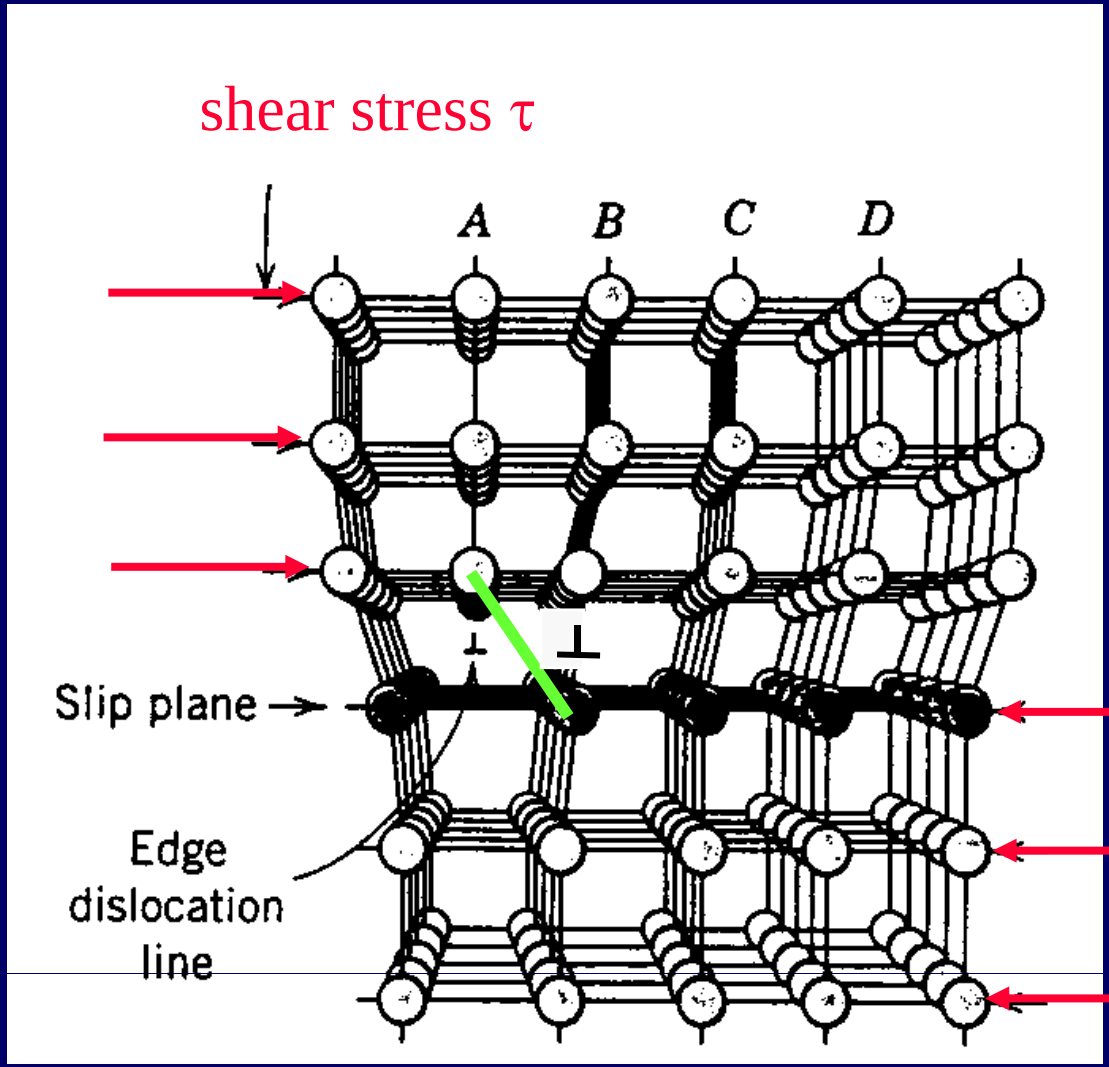
Materials Selection Charts

Strength [MPa]

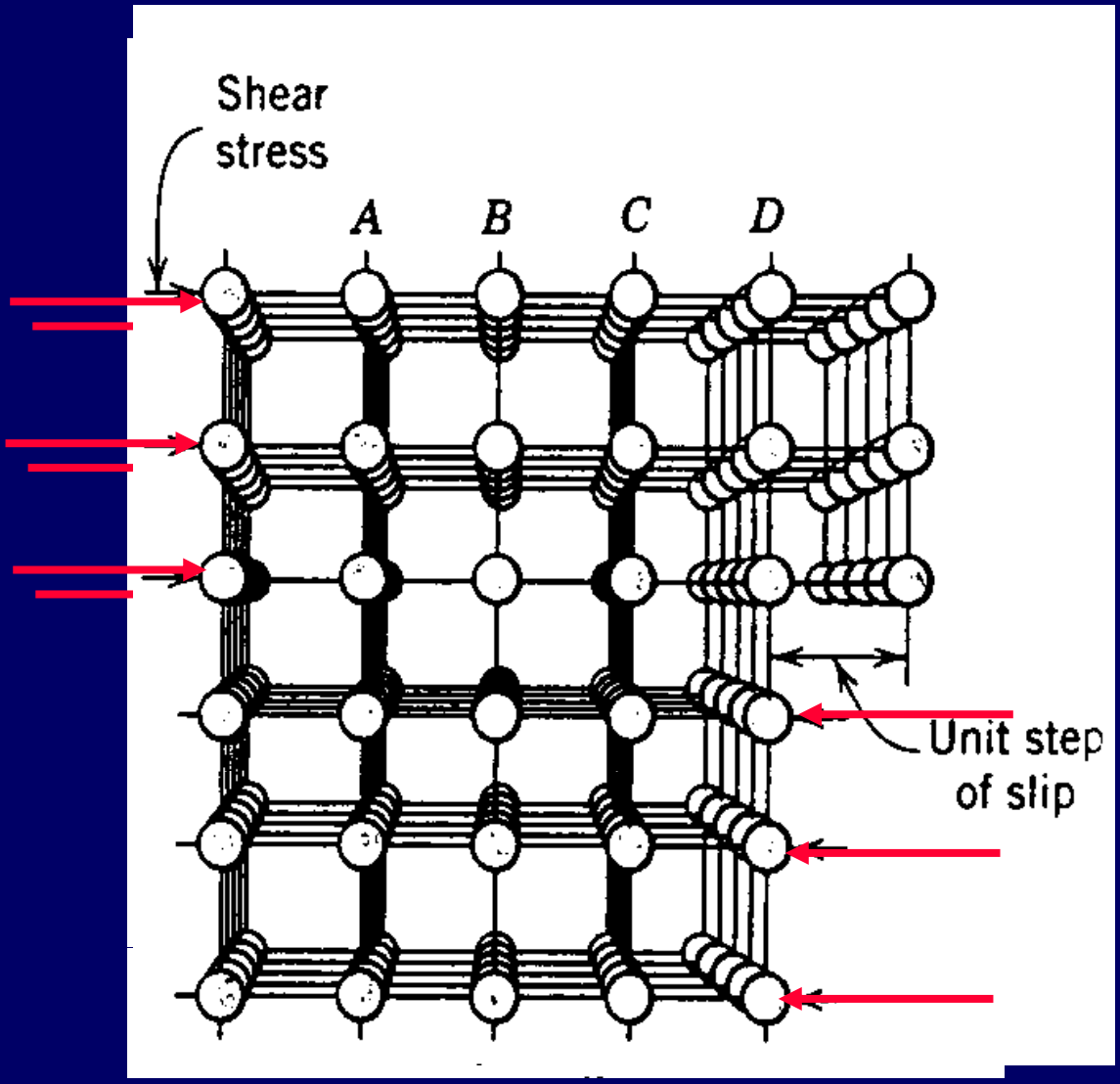


Density [1000kg/m³]

Plastic Deformation – Dislocation Glide

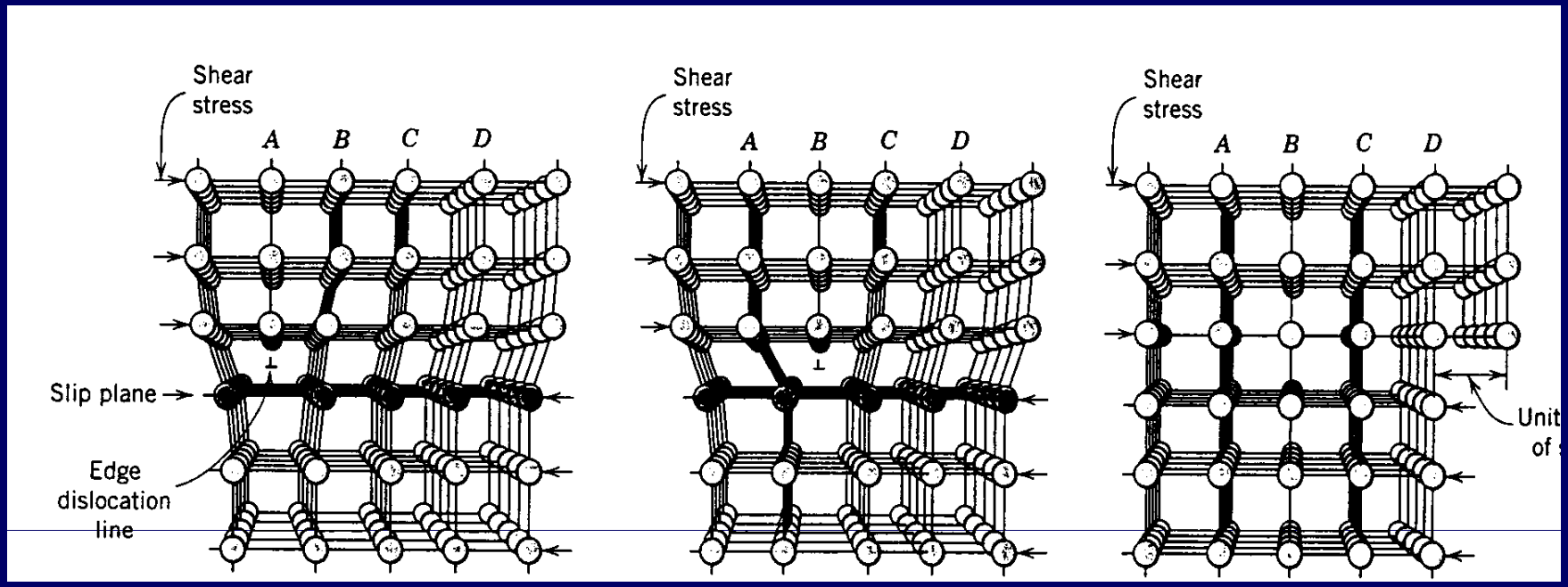


Plastic Deformation – Dislocation Glide



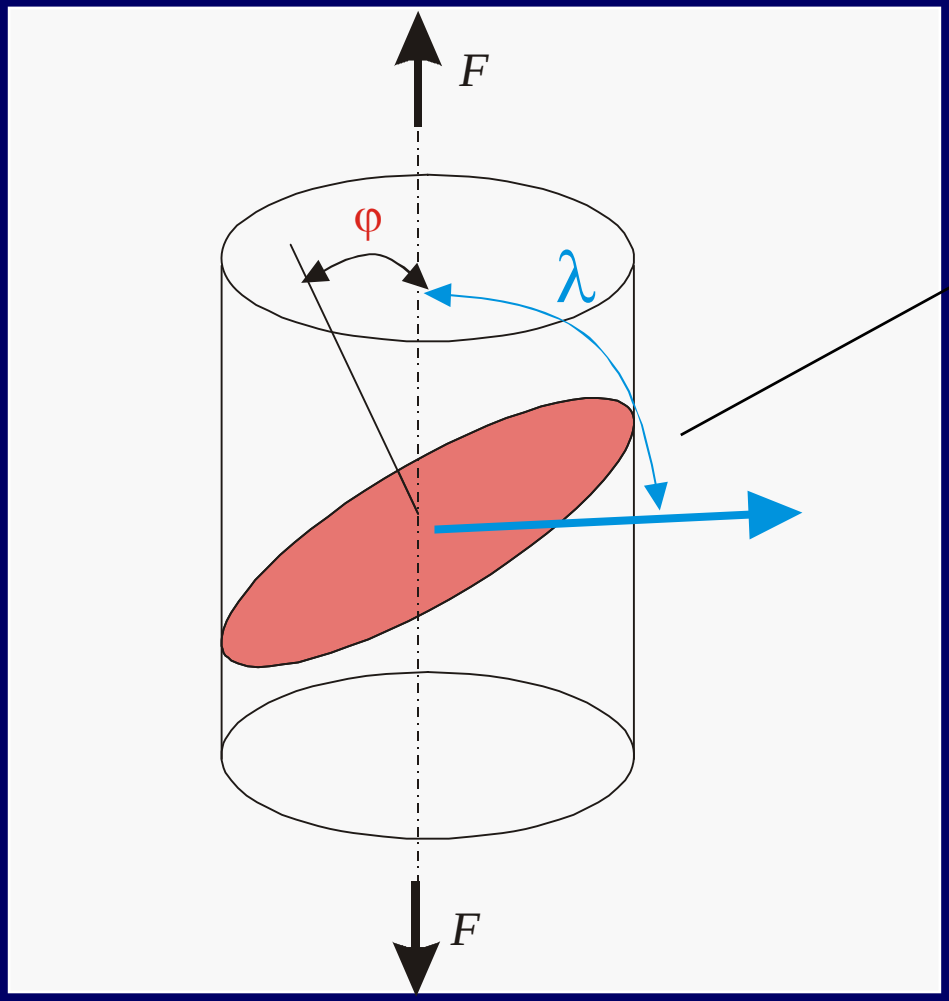
=>macroscopic deformation

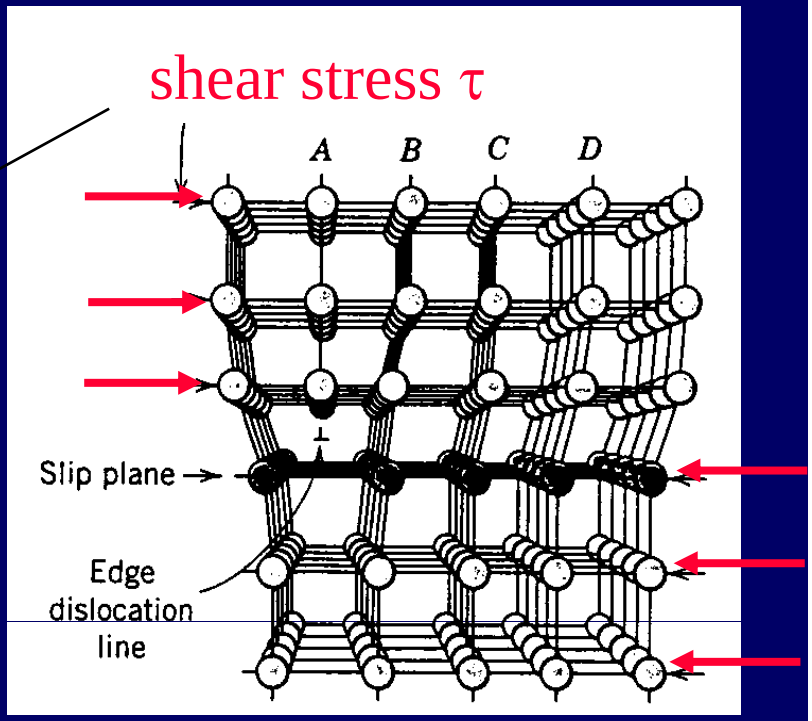
Plastic Deformation – Dislocation Glide



dislocation motion

Plastic Deformation





Some concluding words on dislocations

- Strengthening mechanisms
  - Grain size reduction (Hall-Petch equation)

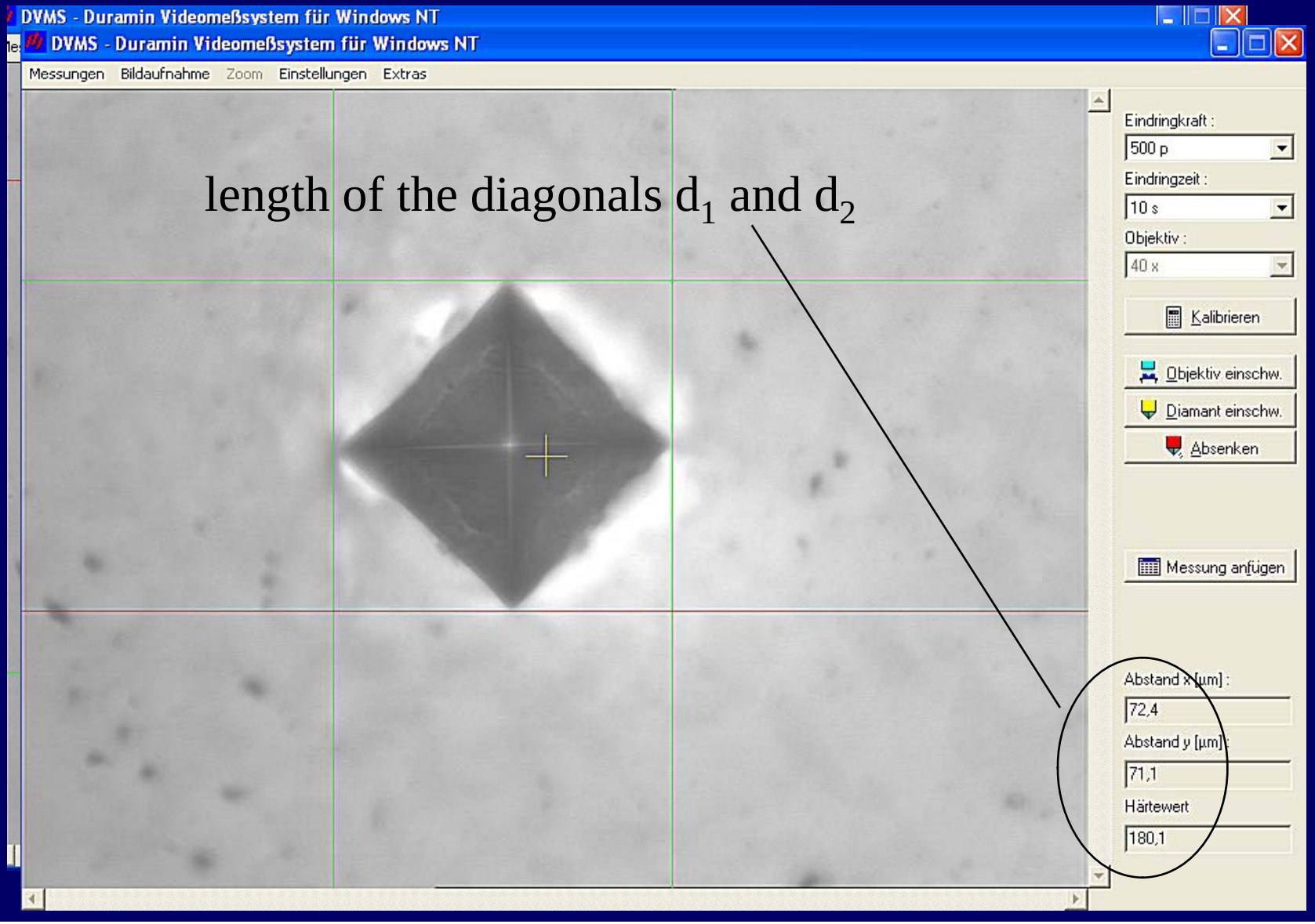
$$\sigma_y = \sigma_0 + k_y \sqrt{d}$$

  - Solid solution strengthening
  - Strain hardening

Mechanical testing

- Hardness
  - Vickers
  - Rockwell
  - … Nanoindentation
- Ductility
- Toughness
- Creep
- Fatigue

Vickers Microhardness Testing



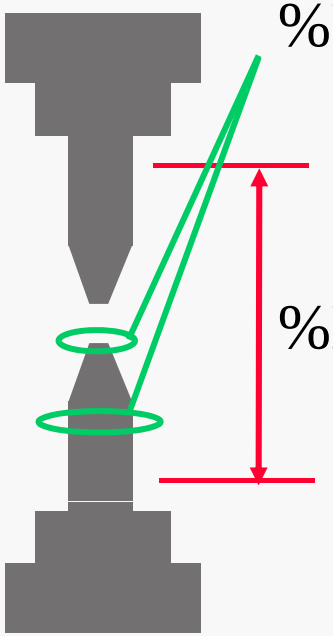
Rockwell Hardness Testing (HRC)

scale

indenter
(120° diamond pyramid)

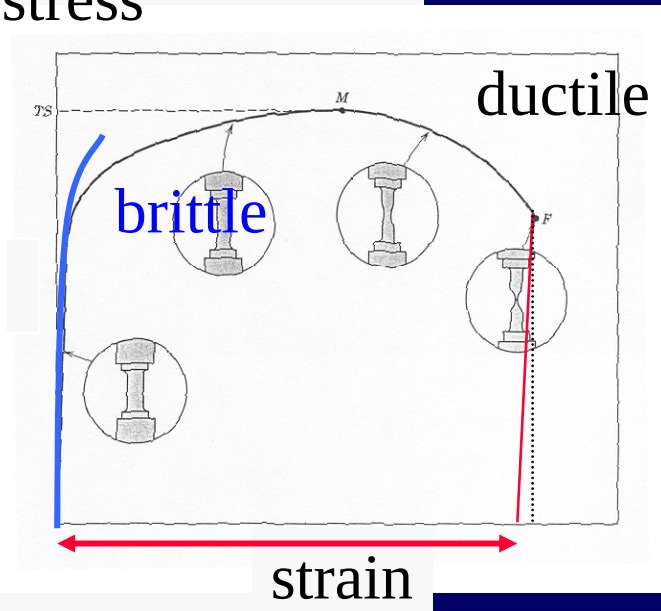
specimen

Ductility



%RA, percent reduction in area

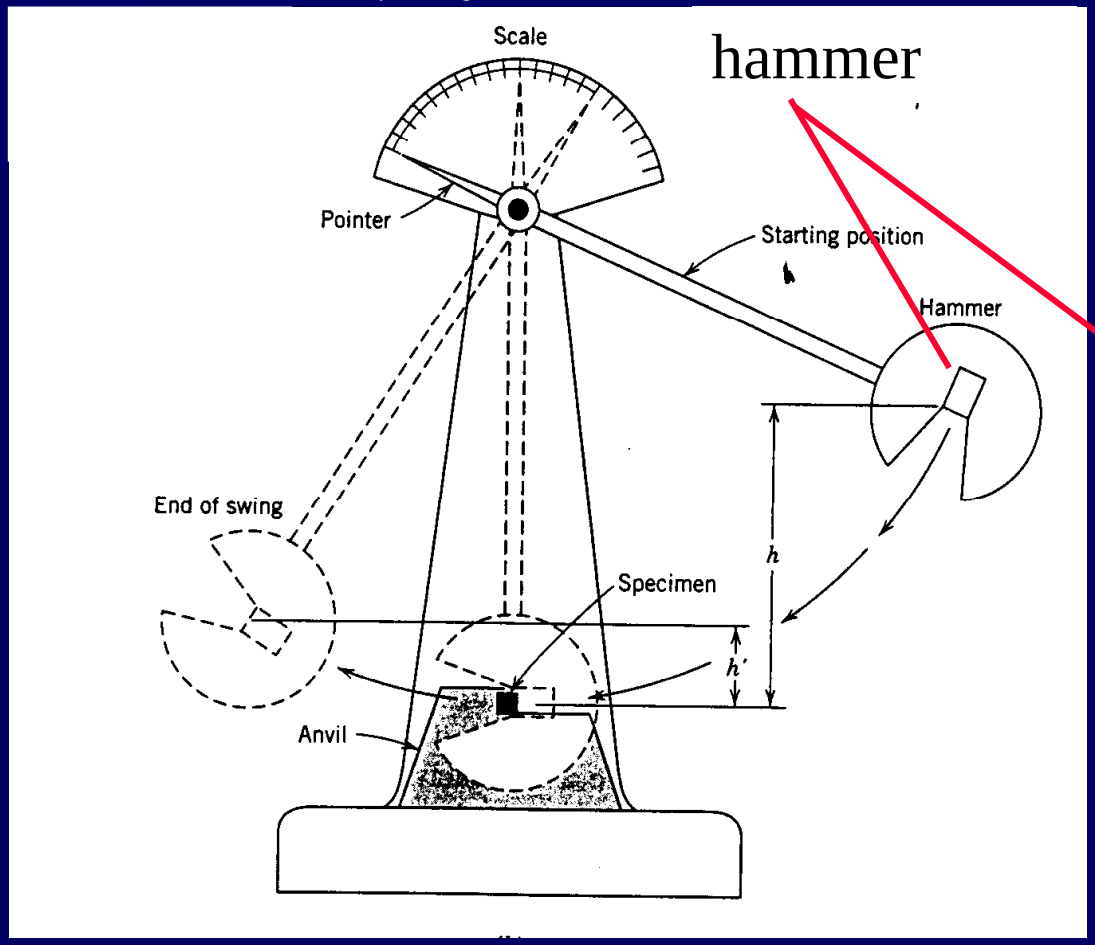
%EL, percent elongation



Charpy Impact Testing

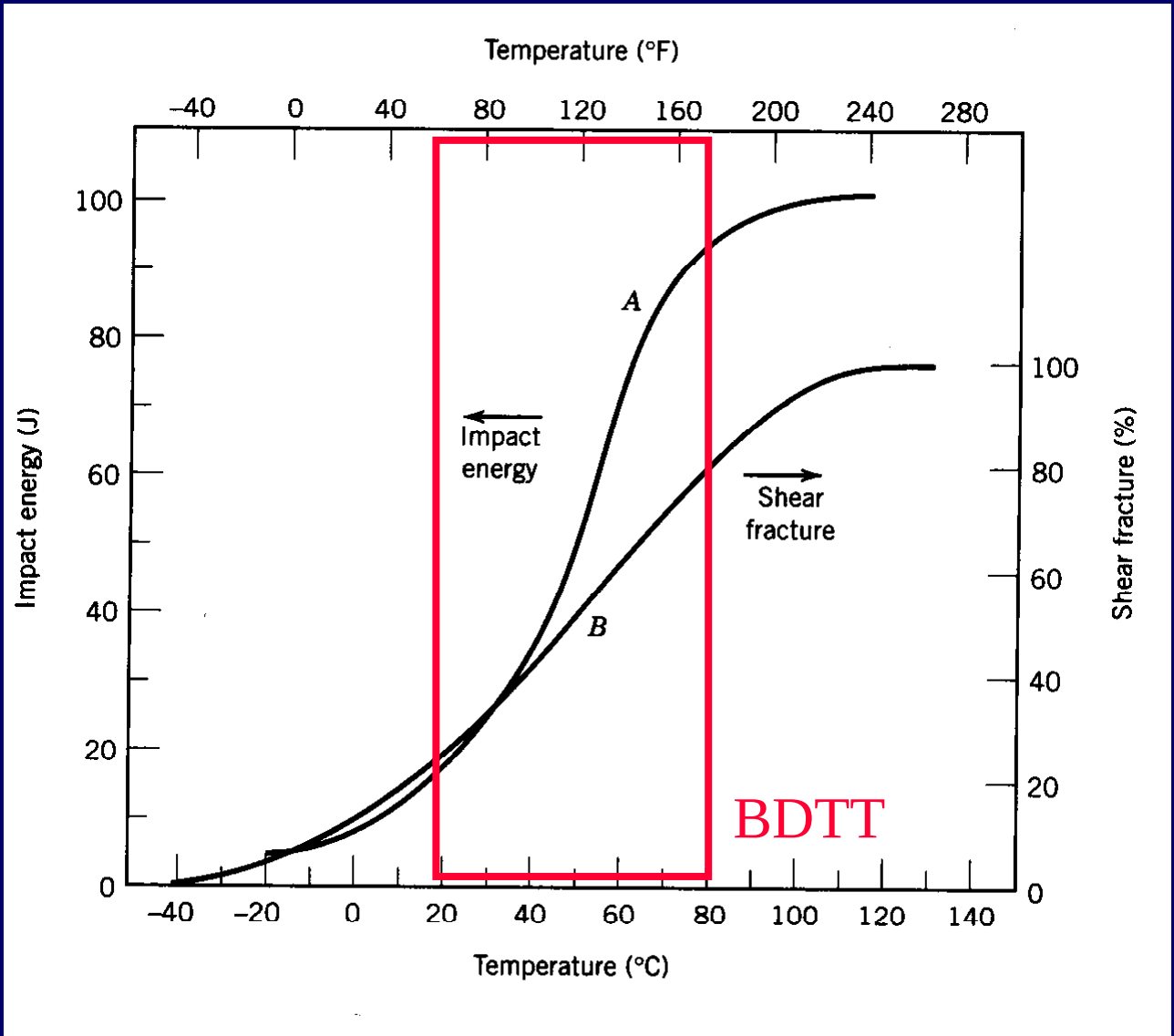
impact energy $A_v = mg(h-h')$

specific $a_k = A_v / A_0$

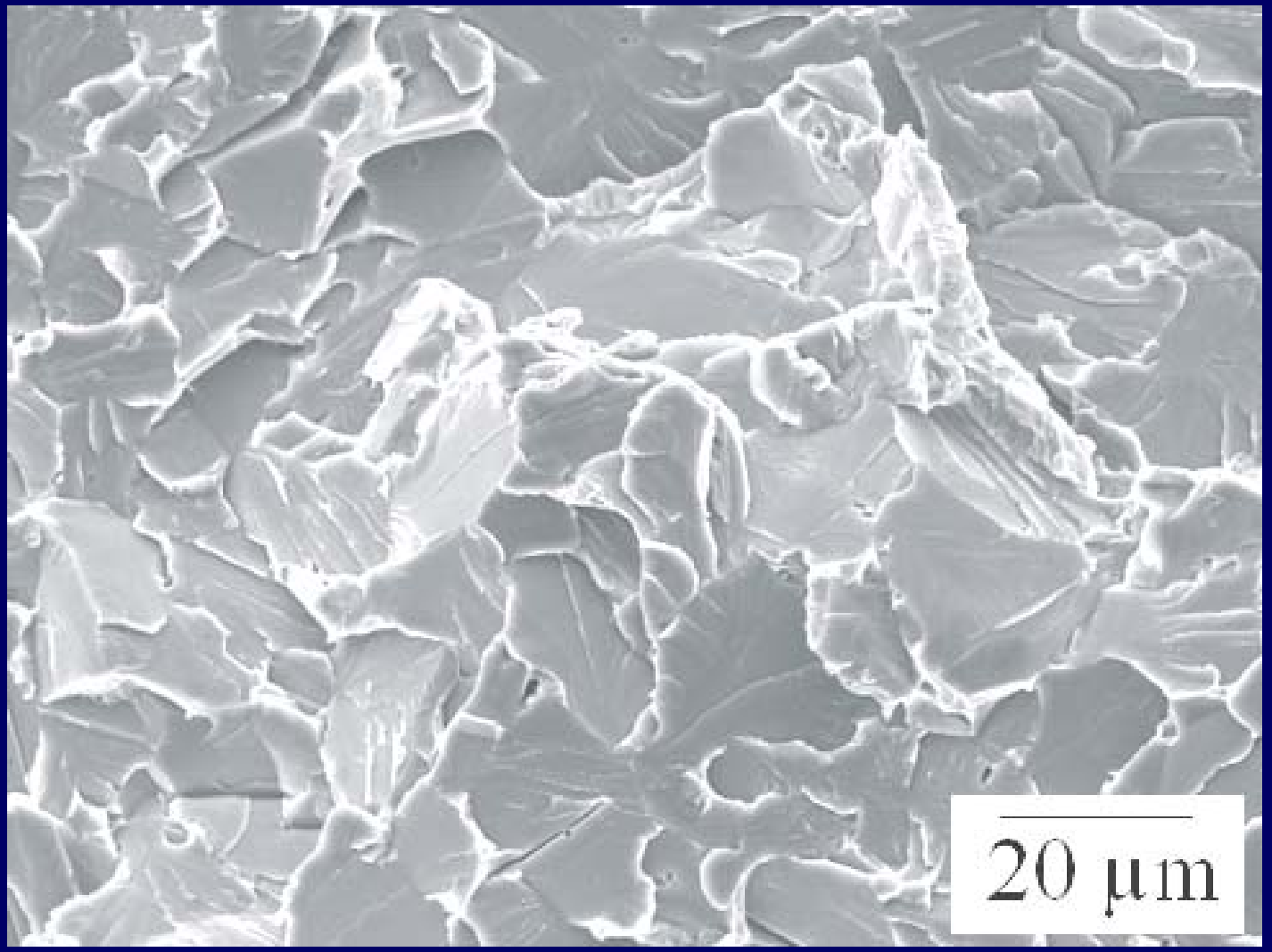


(DIN 50115)

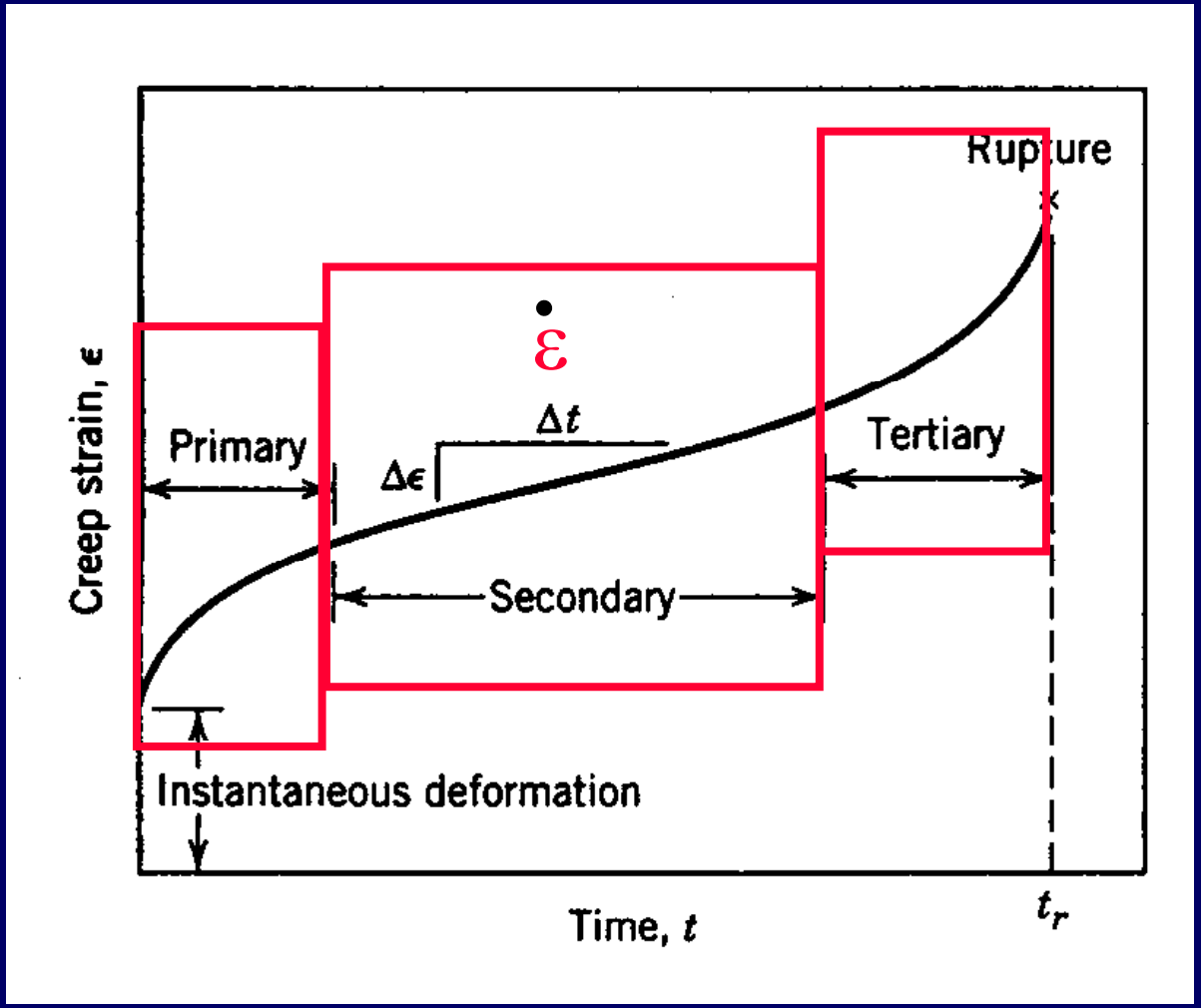
T-Dependence of *Av*



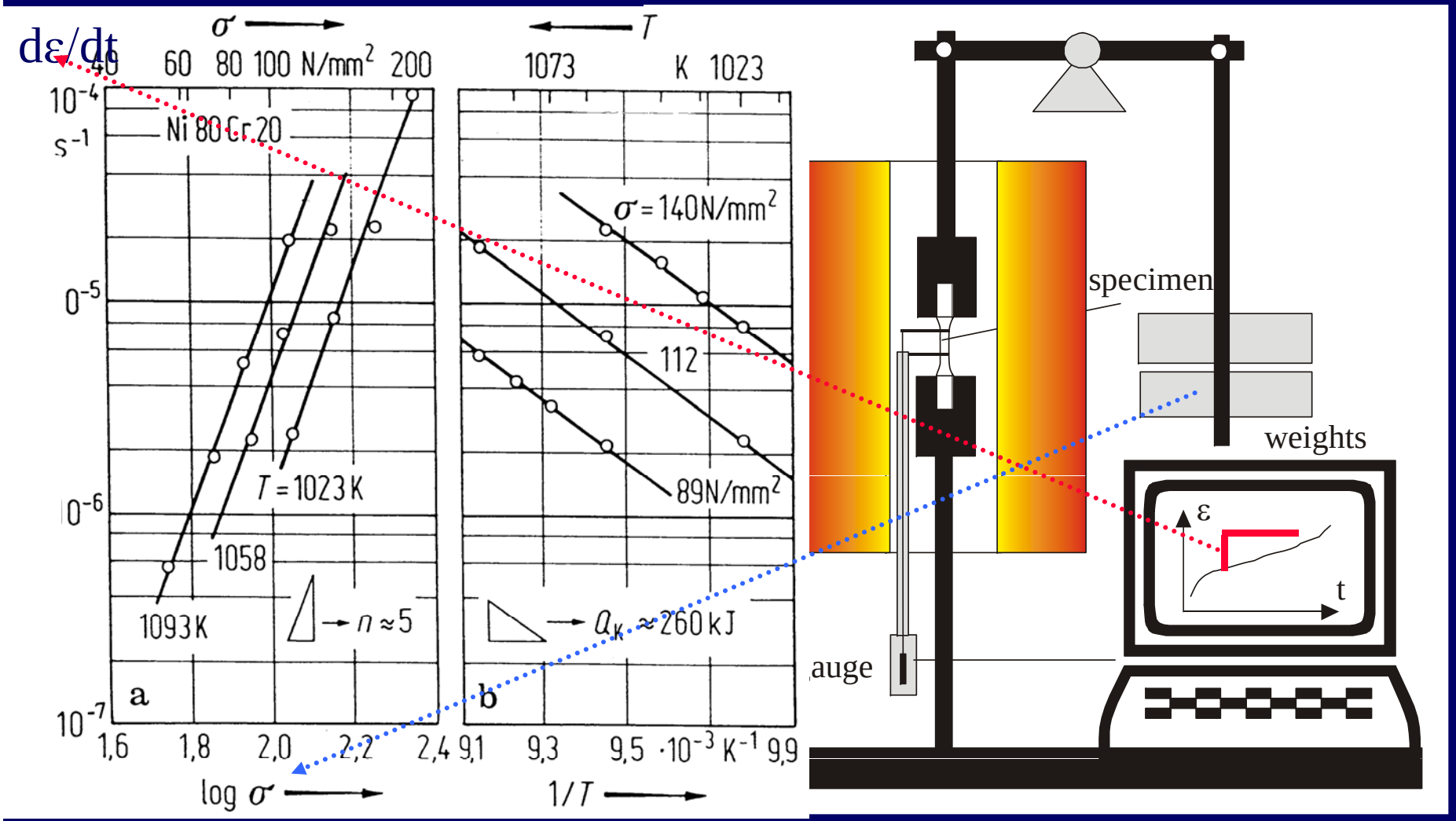
Cleavage Fracture at Low Temperatures



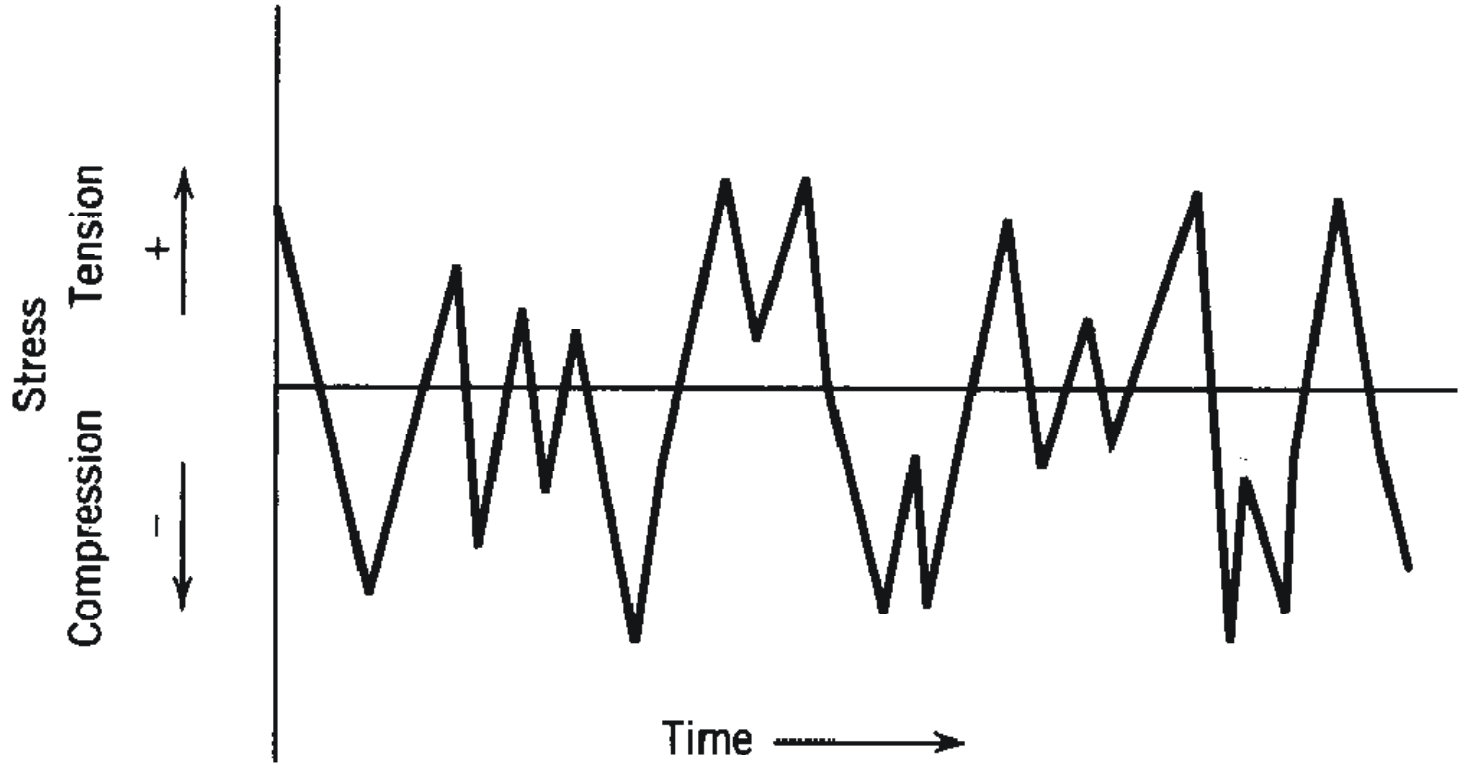
Deformation at Elevated Temperatures: Creep



Creep Testing

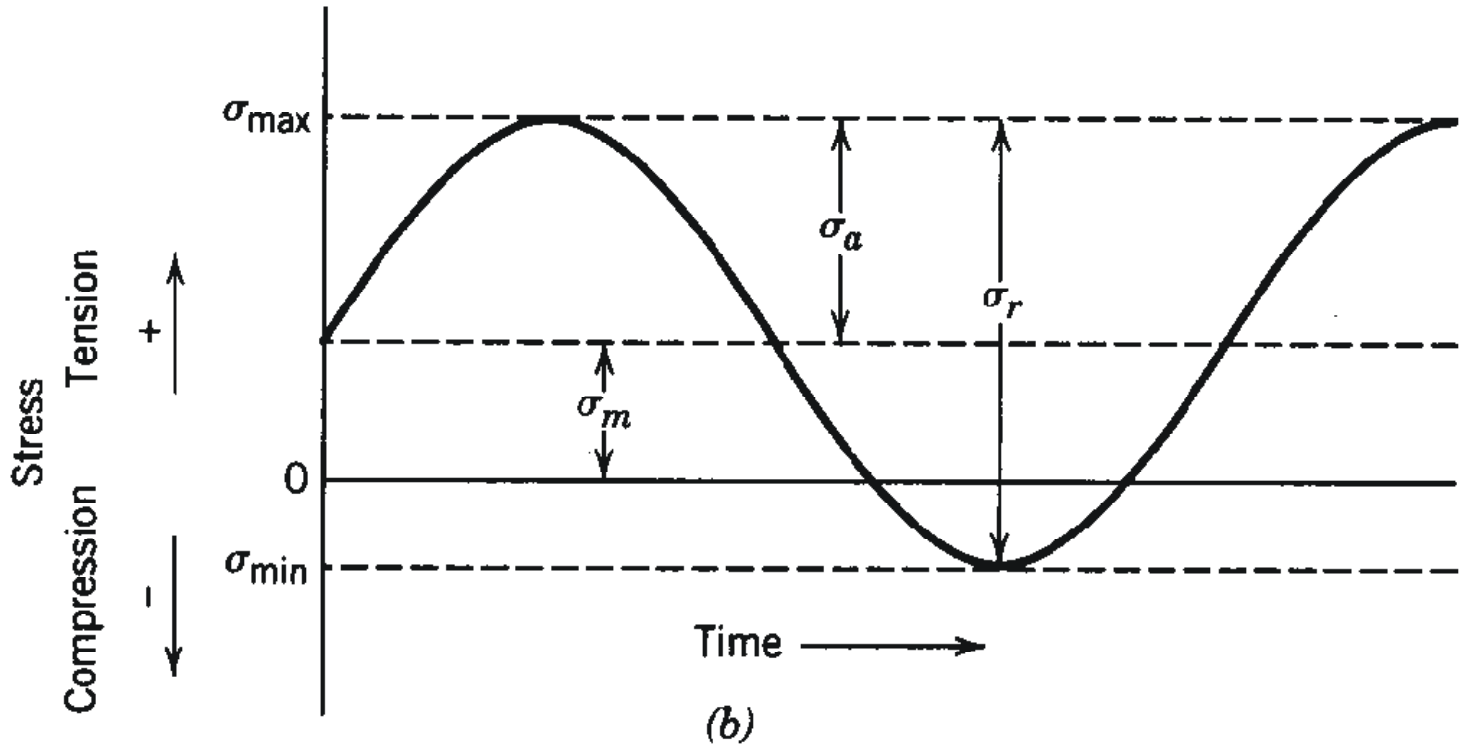


Fatigue Loading during Service



(c)

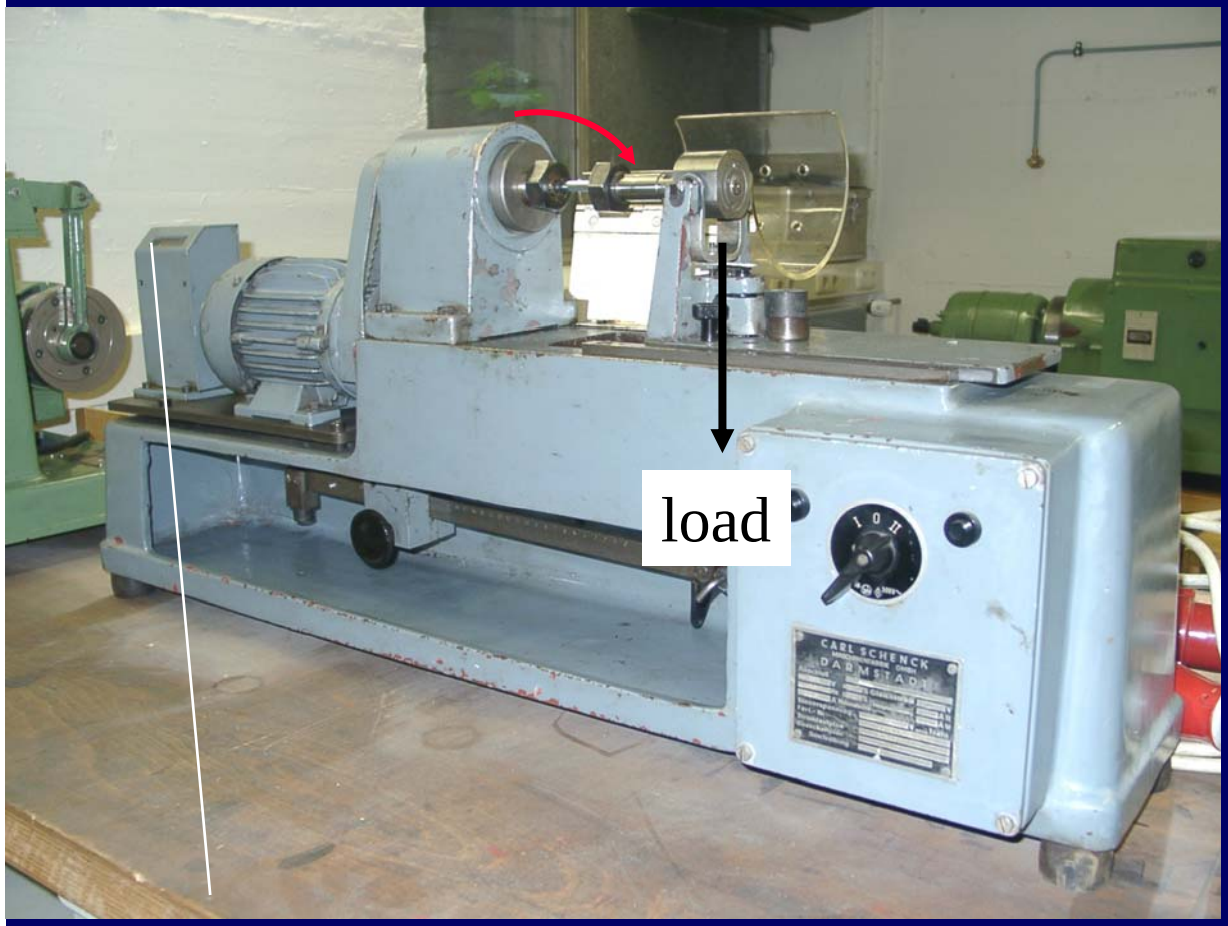
Fatigue Testing



Fatigue Testing

rotating-bending

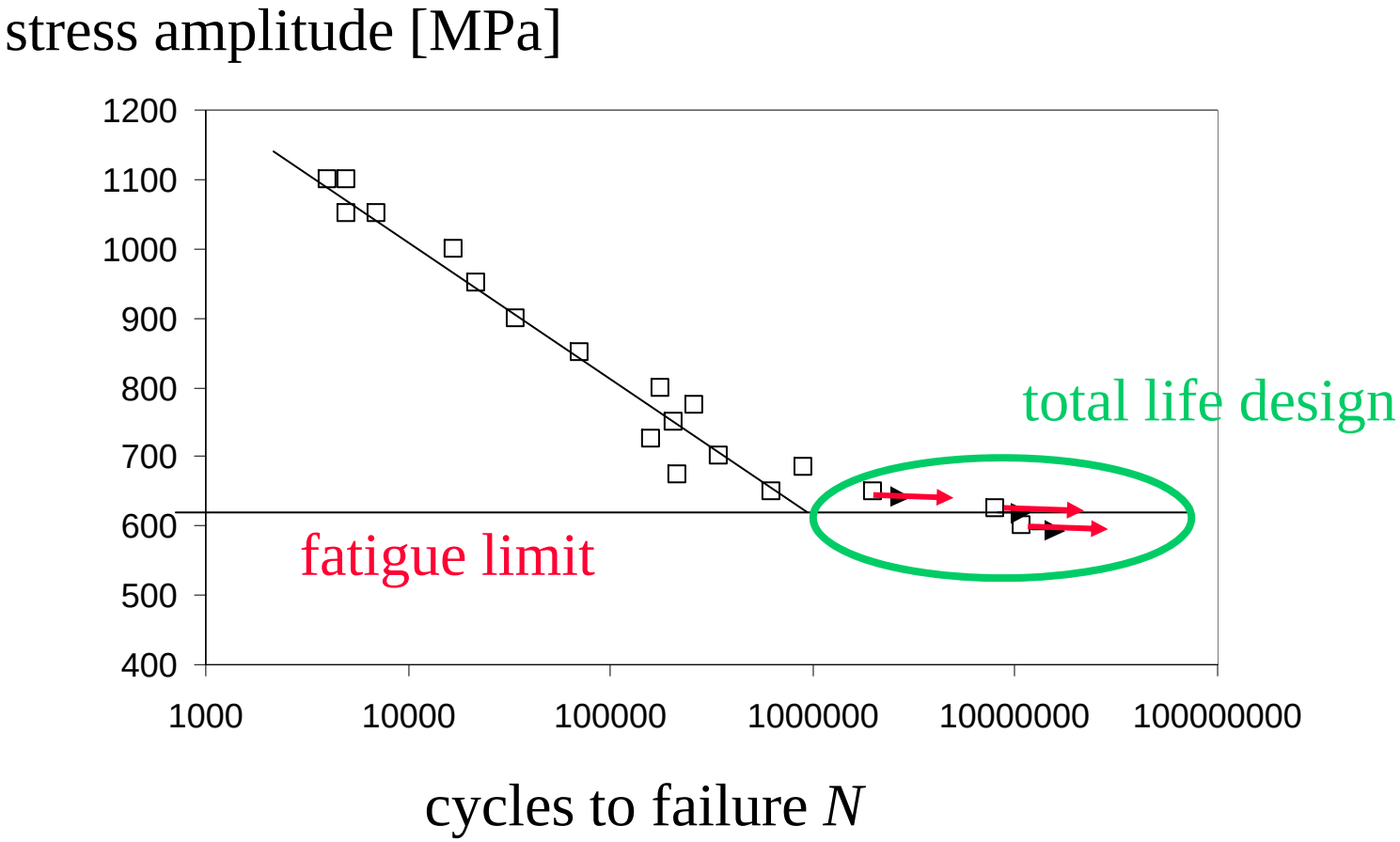
push-pull



counter

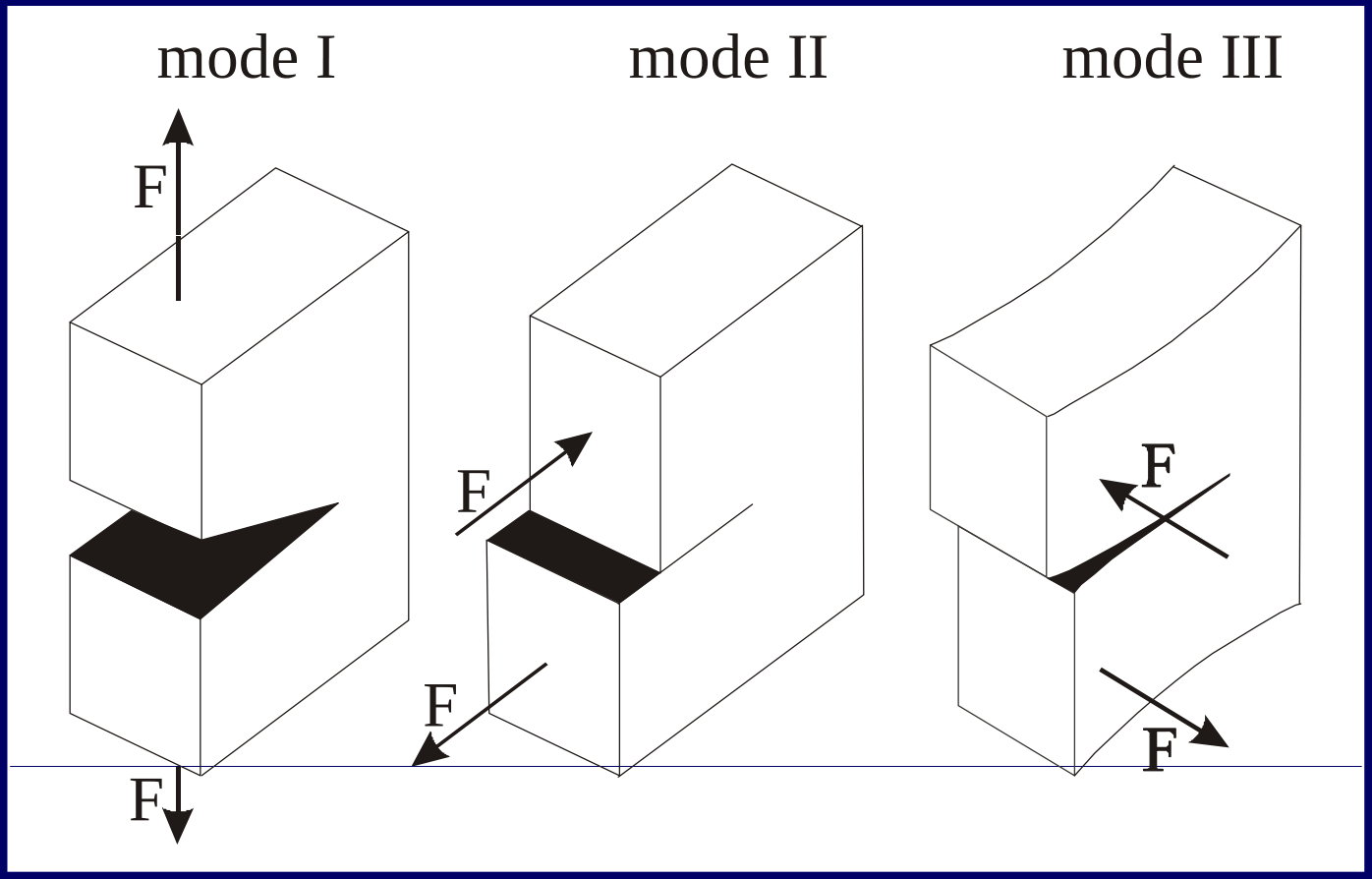
servohydraulic actuator

Fatigue-Testing: The S/N Diagram



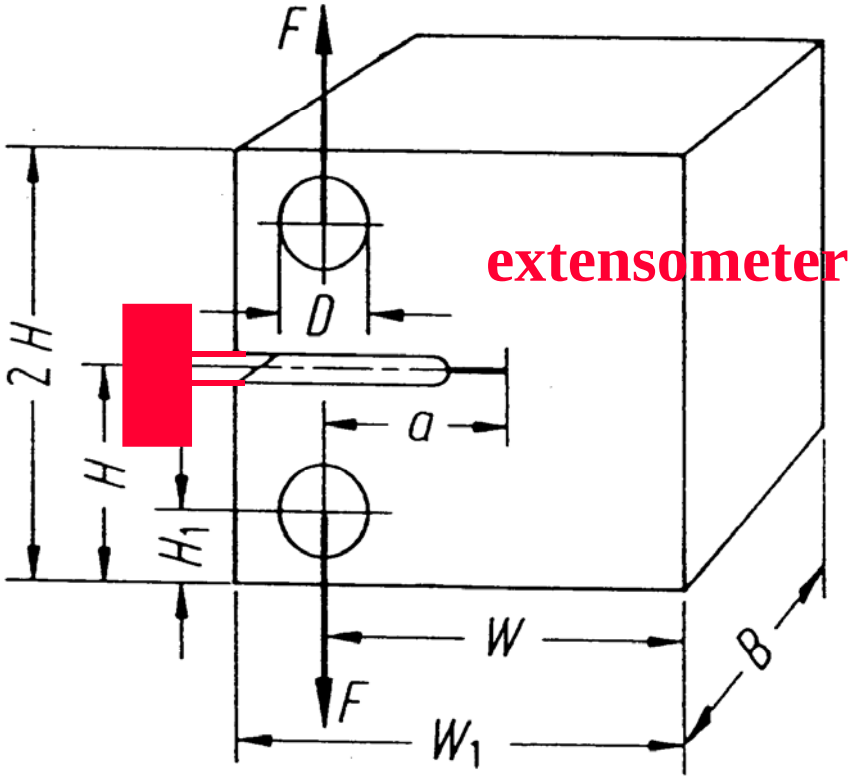
Fracture Mechanics

K_{Ic} represents resistance to brittle fracture [MPam$^{0.5}$]

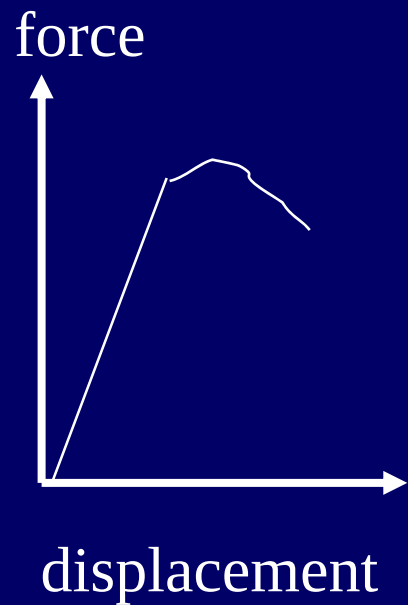


Determination of K_{Ic} using Compact Tension (CT specimens)

$a = W/2$
$W = 2{,}0\ B$
$H = 1{,}2\ B$
$D = 0{,}5\ B$
$W_1 = 2{,}5\ B$
$H_1 = 0{,}65\ B$



extensometer



$B \geq 2{,}5\ (\frac{K_{Ic}}{R_p})^2$

$a \geq 2{,}5\ (\frac{K_{Ic}}{R_p})^2$