

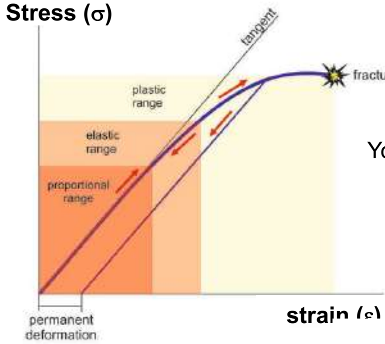

Physical Bases of Dental Material Science 8.

Mechanical properties of materials 2.
Plasticity

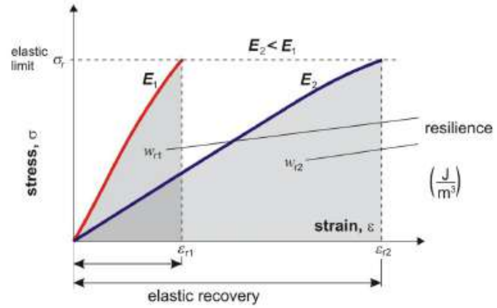
Kiemelt témák:
- *Strength*, plasticity and tougness
- Mechanism of plastic deformation in crystals
- Fractures
- Hardness

E-book chapter 16, 17.

Problems: Chapter 4.: 26, 27, 29, 30, 32, 33, 34, 36

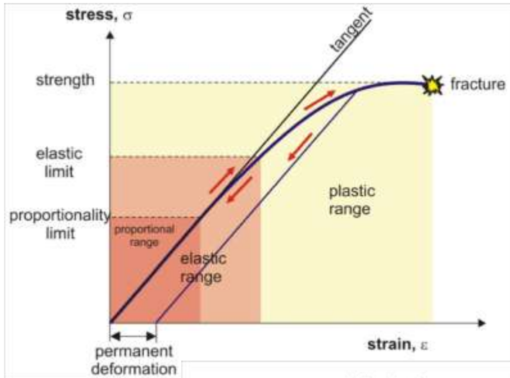


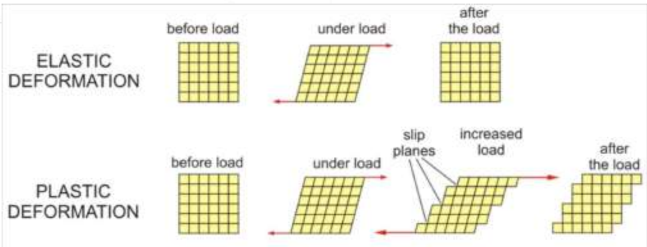
Young's modulus



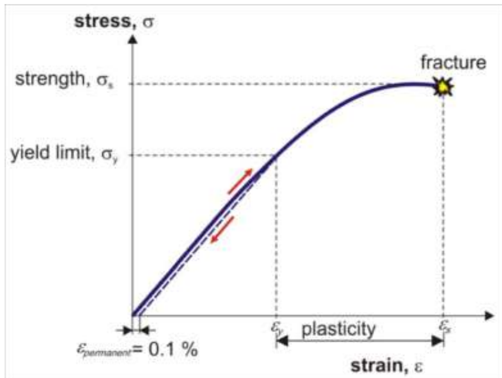
Resilience

Stress - strain diagram





Plastic behavior



yield limit, σ_y (Pa)

strength, σ_s (Pa)
- tensile,
- compressive,
- bending,
- shear,
- torsional

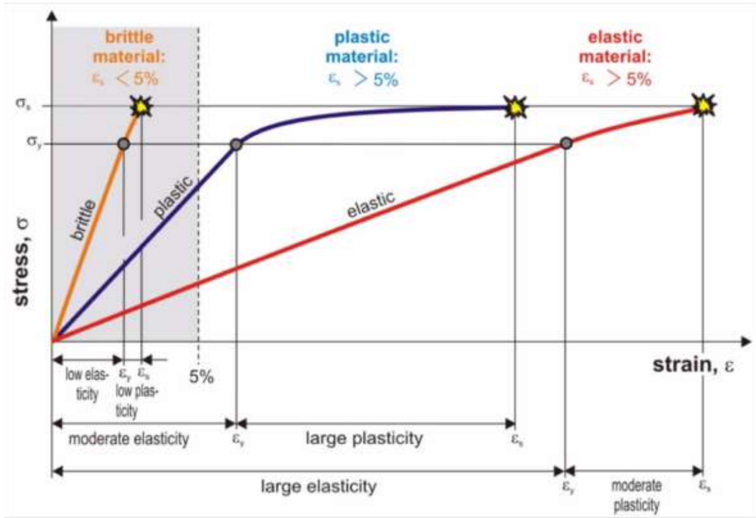
plasticity, ε_s - ε_y (%)

σ_s (Pa) F_s (N)

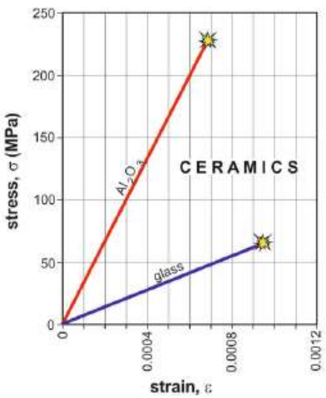
weak ← strength → strong

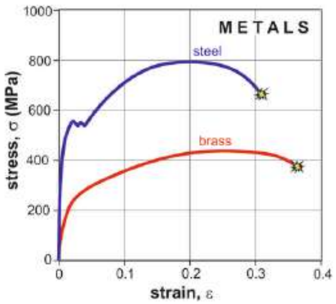
Strength of some dental materials

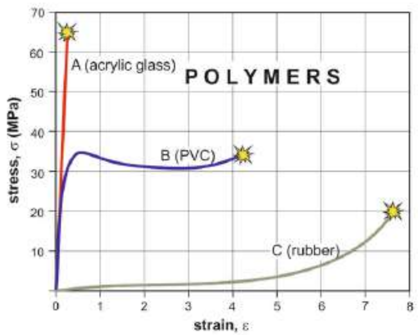
material	$\sigma_{tensile}$ (MPa)	$\sigma_{comp.}$ (MPa)
enamel	≈ 10	≈ 400
dentine	≈ 110	≈ 300
ceramics	5-400	20-5000
porcelain	≈ 25	≈ 300
polyethylene (high density)	≈ 30	
amalgam	30-55	200-450
PMMA	≈ 50	≈ 80
glass	≈ 50-70	≈ 700
gold	108	
aluminum oxide	≈ 170	≈ 2100
zirconium dioxide	≈ 250	≈ 2500
gold alloys	300-900	
Pd-Ag alloys	400-700	
Ni-Cr alloys	400-900	
Co-Cr alloys	600-800	
Ti alloys	900-1100	
carbon-fiber (61%) reinforced epoxy	≈ 1700	



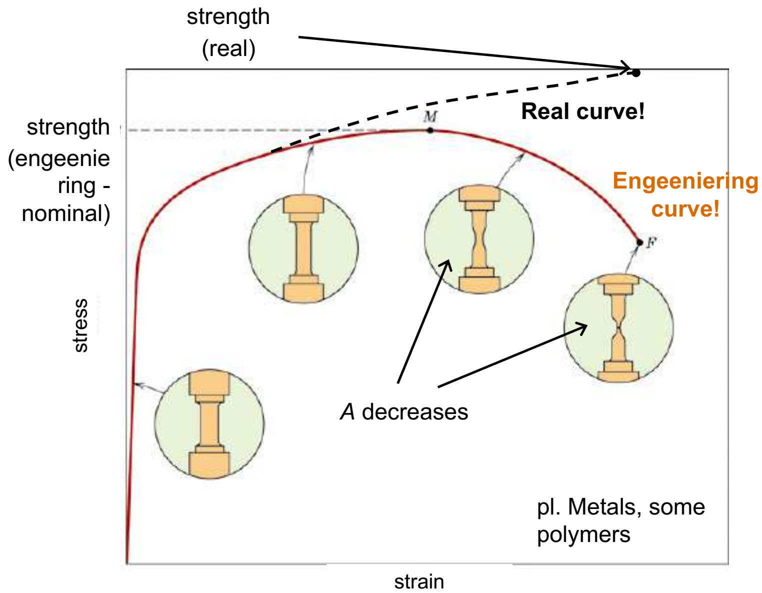
Examples:

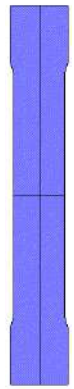






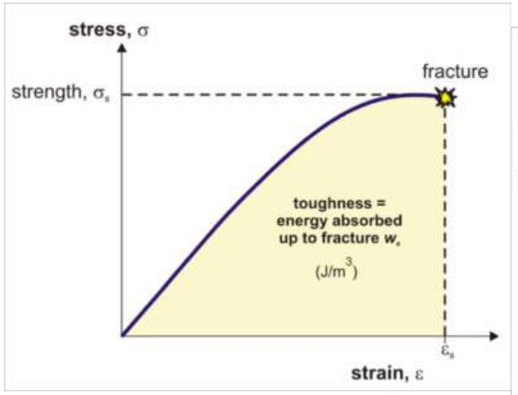
Engenieering vs. „real” system



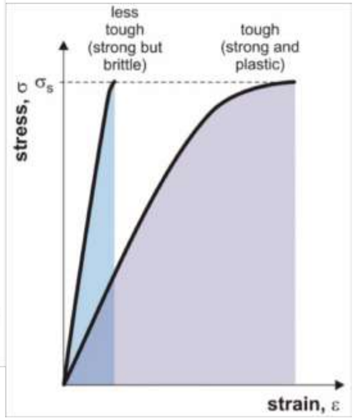


Toughness

vagy **energy absorbed until fracture (w_s)**



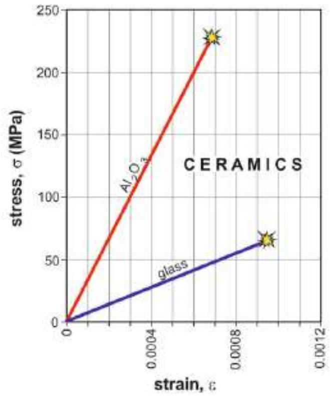
strength ↔ toughness:

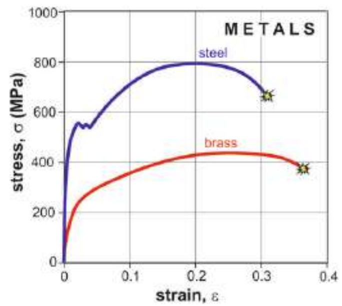


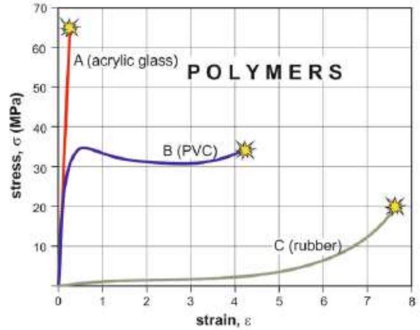
w_{sz} (J/m^3) W_{sz} (J)

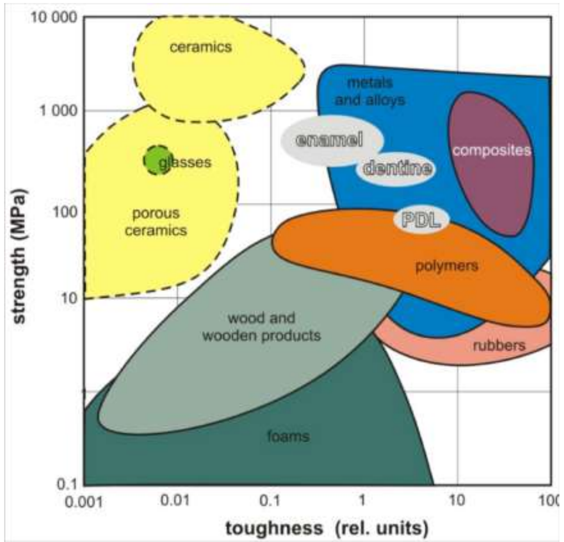
(brittle) Not tough ← toughness → **tough**

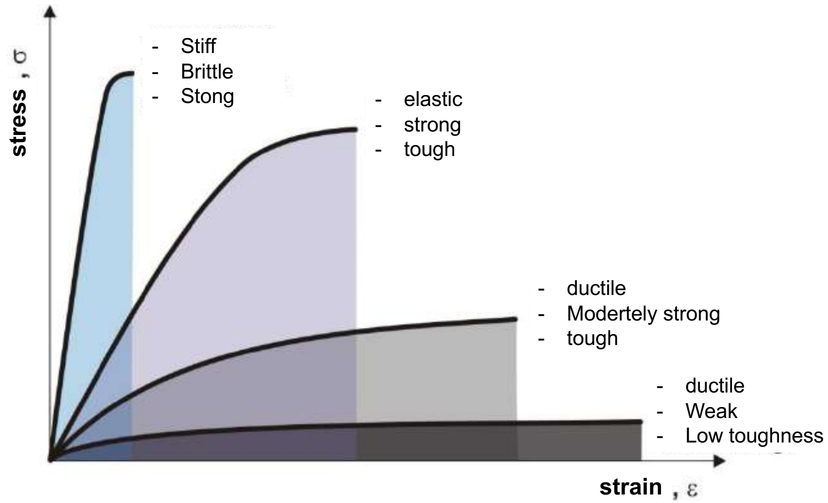
Examples:



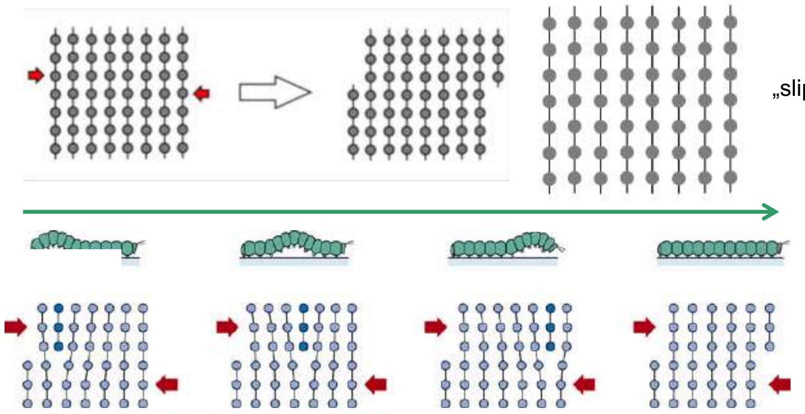








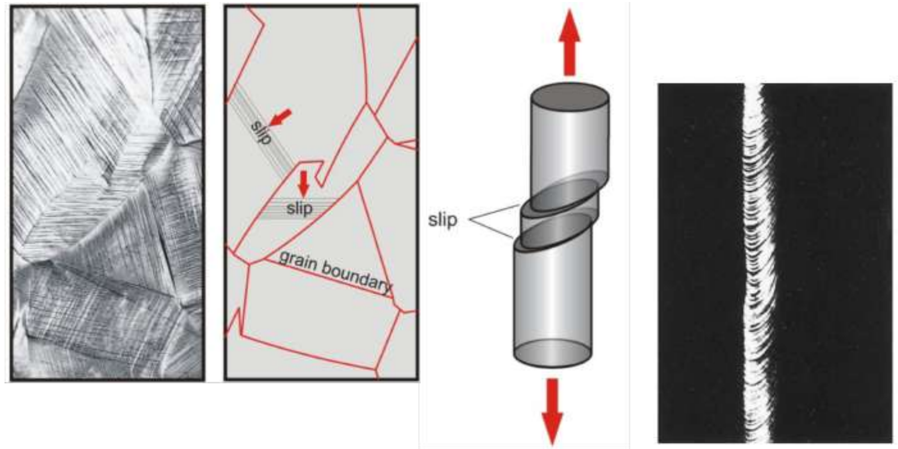
Mechanism of plastic deformation in crystals:

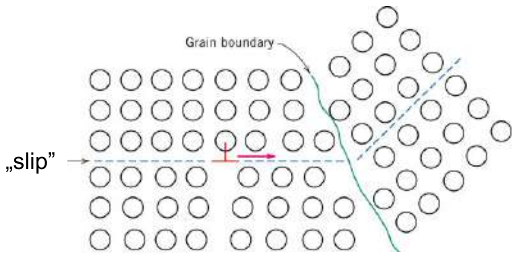


Moving a rug by moving a wrinkle in the rug

In case of amorphous materials: viscous flow only!

Movement of disclocations

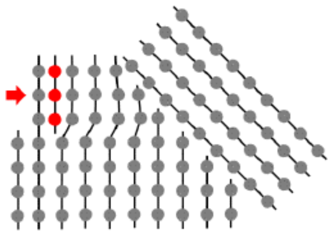




Quantities of plastic range (σ_y, ε_s, σ_s, w_s),

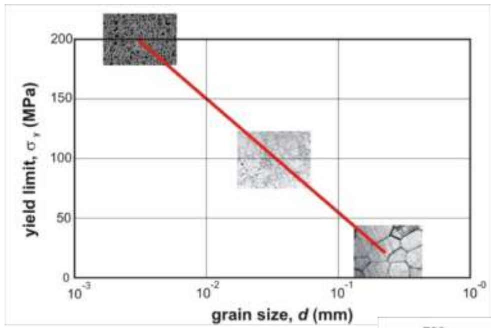
and hardness

Are very sensitive to lattice defects.



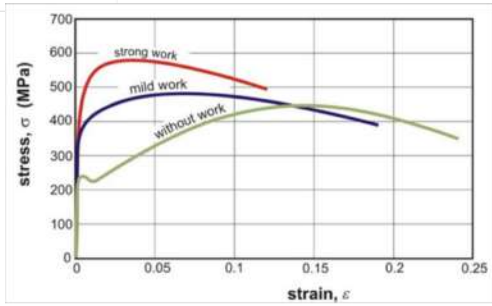
Similar reason:
Brittleness of ceramics

Changening the strength and plastic properties of metals

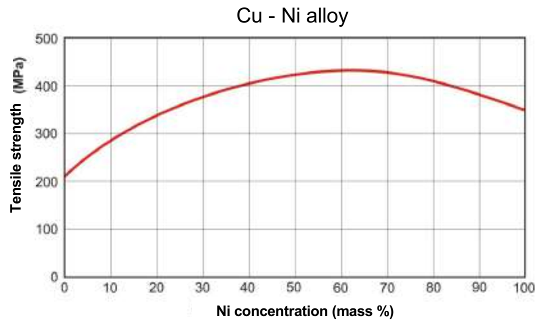


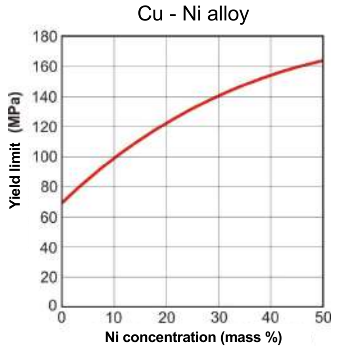
decreasing grain size (d)

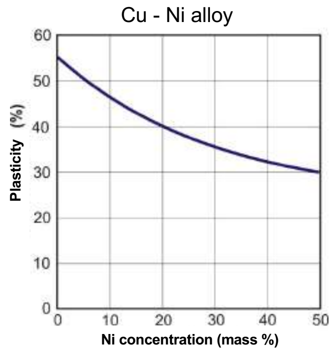
Cold-work



Alloying

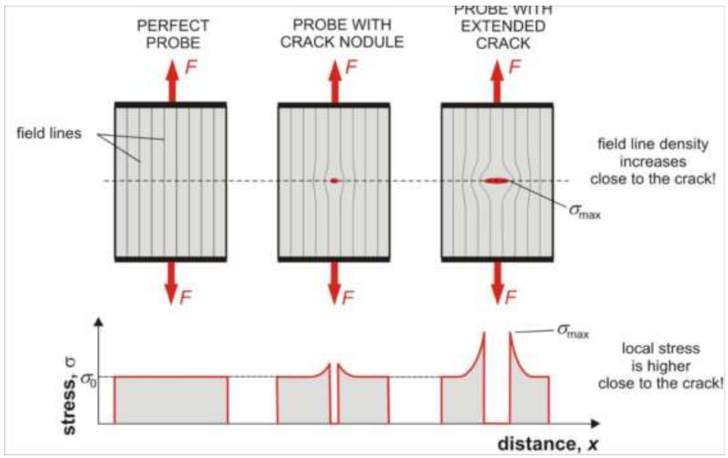






Fracture

Mechanism:

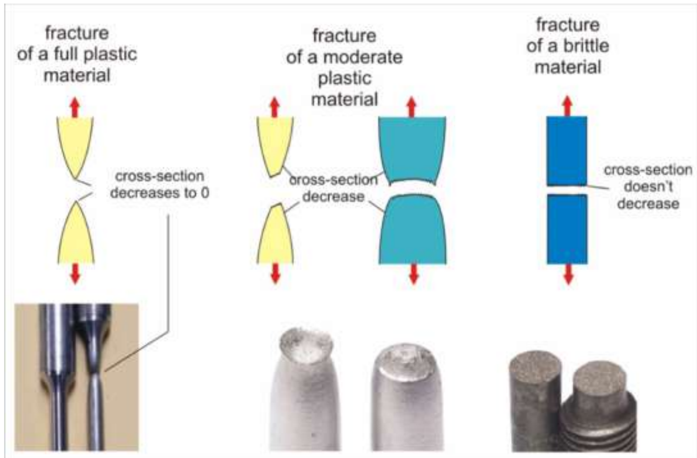


Increasing stress

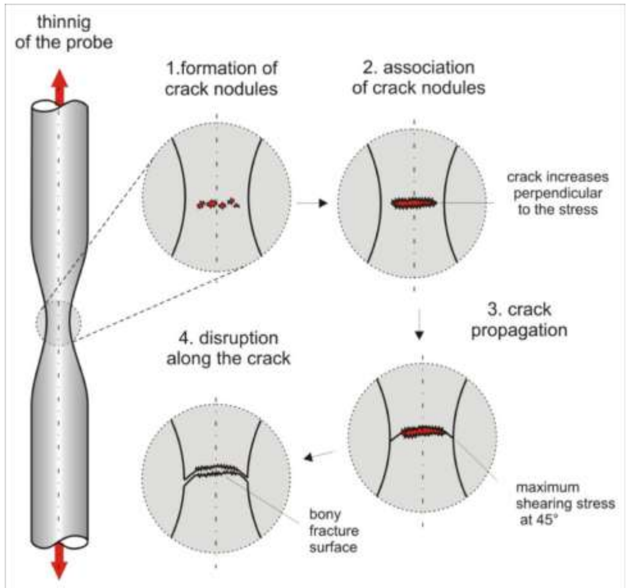
- Brittle material: no plastic defoemation **britle fracture**
- Plastic deformation **plastic fracture**

Fracture types

plastic (tough) | **brittle**



Phases of fracture in a ductile material



Fáatigue, fatigue fracture

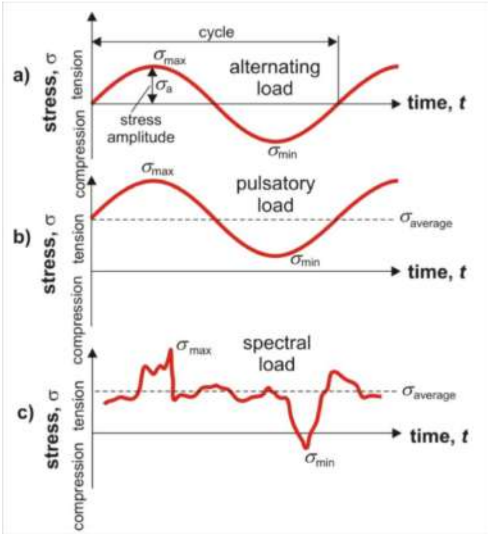
Persistant, repetitive load (stress)

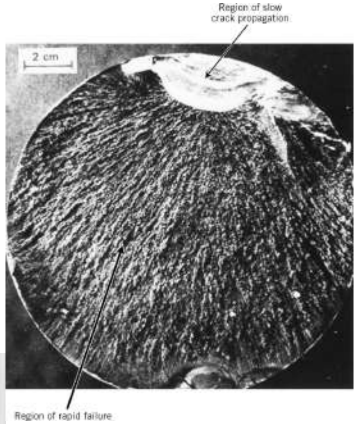
→ structursl changes

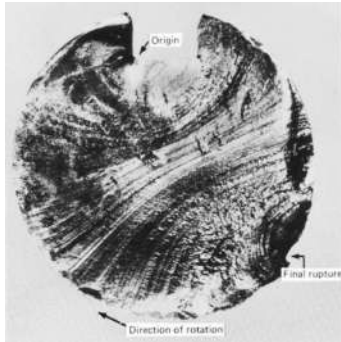
→ strength decreases

Crack formation!

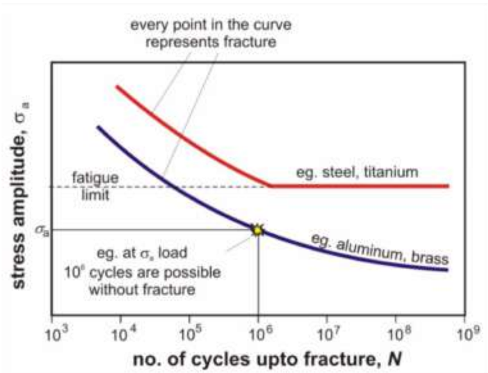
Types of loads:

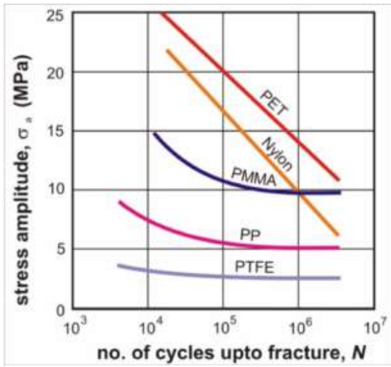


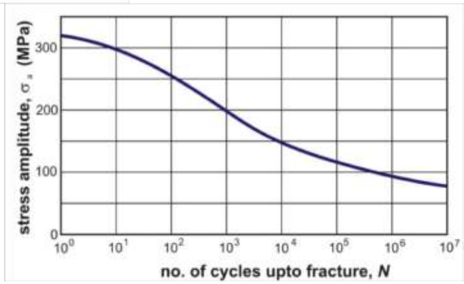




Fatigue curve:



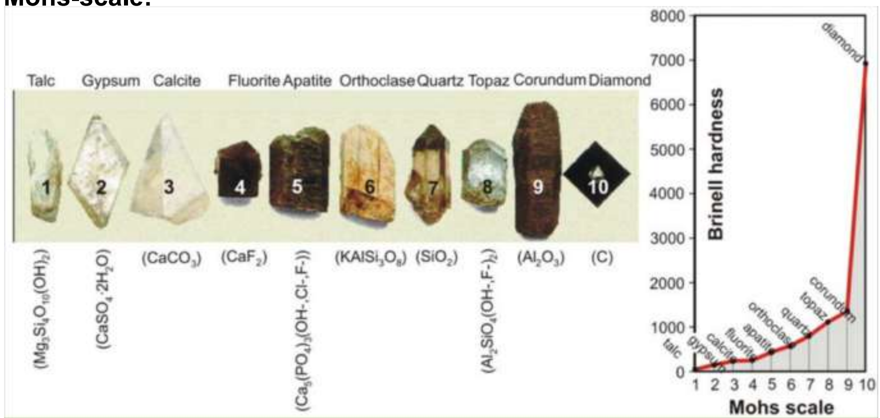




Hardness

Resistance against plastic deformation

Mohs-scale:

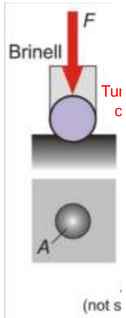


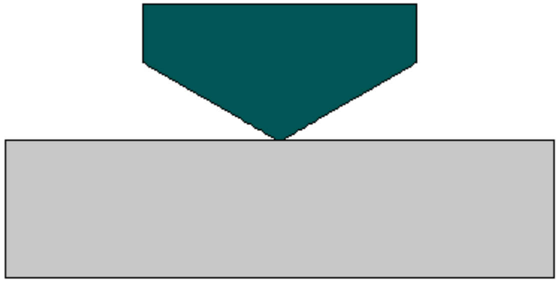
Hardness measurement

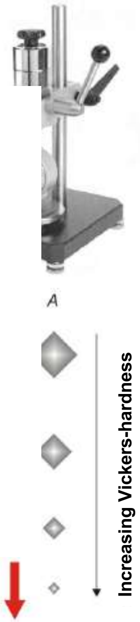
Methods of microhardness measurement

Rockwell C Test 4340 Sy=133 ksi u=.2
time= 0.0000E+00
dsf = 0.10000E+01

Brinell:

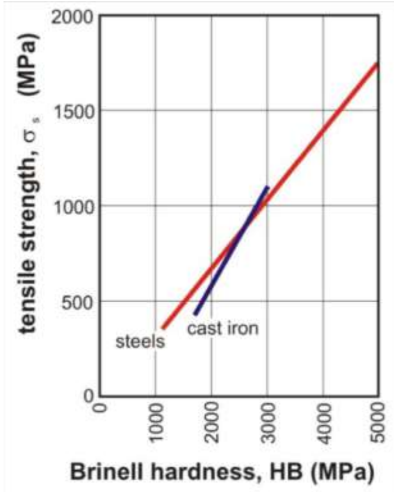






HB **HV** **HK**

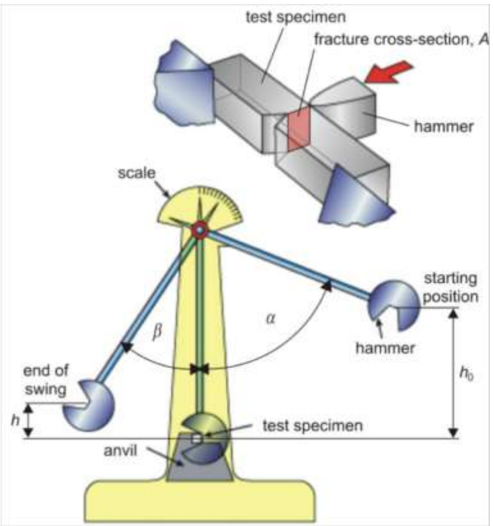
Connections with strength:



Hardness of dental materials:

material	HV (MPa)	HK (MPa)
dentine	≈ 600	≈ 700
enamel	≈ 3400	3400-4000
gold		60-70
acrylate	≈ 200	≈ 200
gold alloys	600-2500	≈ 2000
amalgam	≈ 1000	
Pd-Ag alloys	1400-1900	
Ni-Cr alloys	3000-4000	2000-3500
Co-Cr alloys	≈ 4000	3000-4500
glass		≈ 5000
porcelain	4500-7000	≈ 6000

Charpy test



Impact energy = The loss of the hammer's potential energy (J)

Specific impact energy= impact energy / cross sectional area of test specimen (J/m^2)

Effect of temperature:

plastic fracture– brittle fracture transition