



Physical Foundations of Dental Materials Science

8.

Mechanical properties of materials 2.

Plasticity

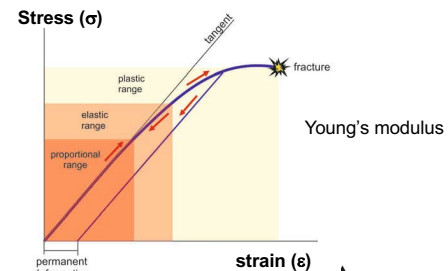
Kiemelt témák:

- ❖ *Strength*, plasticity and toughness
- ❖ Mechanism of plastic deformation in crystals
- ❖ Fractures
- ❖ Hardness

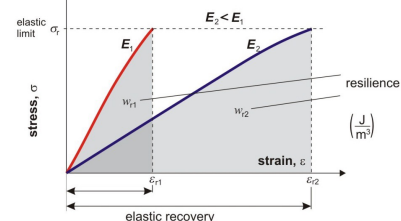
E-book
chapter 16, 17.

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

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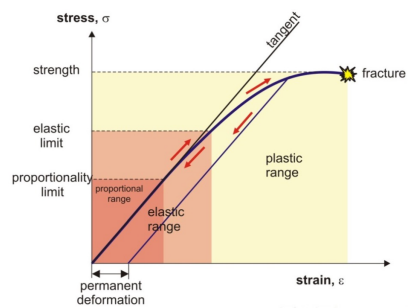


Resilience

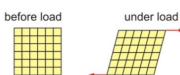


2

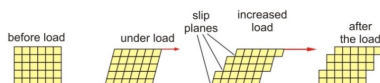
Stress - strain diagram



ELASTIC DEFORMATION



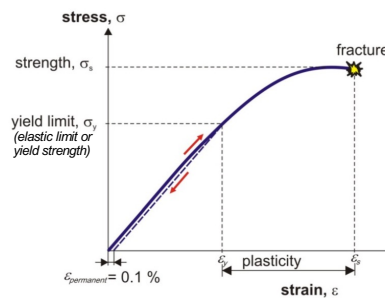
PLASTIC DEFORMATION



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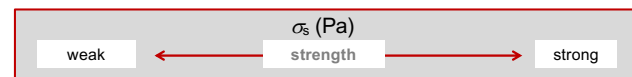
Plastic behavior



yield limit, σ_y (Pa)

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

plasticity, $\epsilon_s - \epsilon_y$ (%)

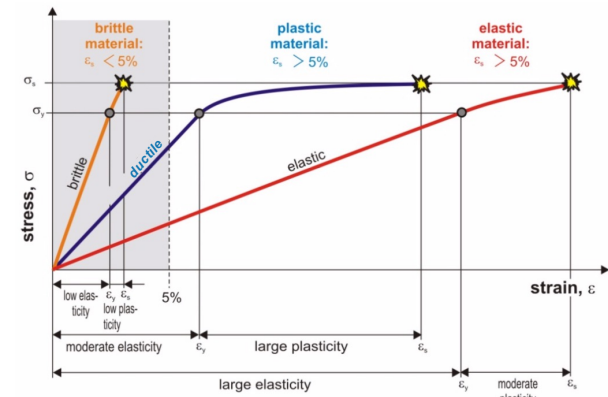


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Strength of some dental materials

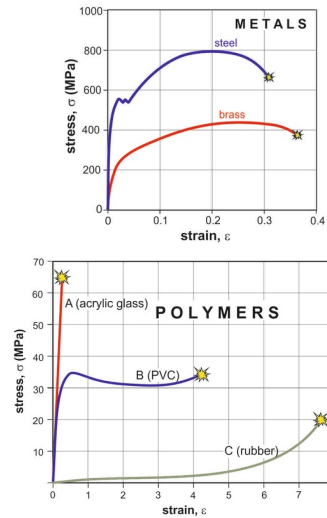
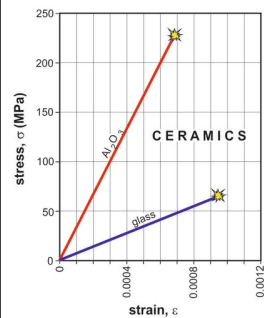
material	σ_{tensile} (MPa)	$\sigma_{\text{comp.}}$ (MPa)
enamel	≈ 10	≈ 400
dentine	≈ 110	≈ 300
ceramics	5-400	20-5000
porcelain	≈ 25	≈ 300
polyethylene (high density)	≈ 30	
amalgam	30-55	200-450
PMMA	≈ 50	≈ 80
glass	$\approx 50-70$	≈ 700
gold	108	
aluminum oxide	≈ 170	≈ 2100
zirconium dioxide	≈ 250	≈ 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	

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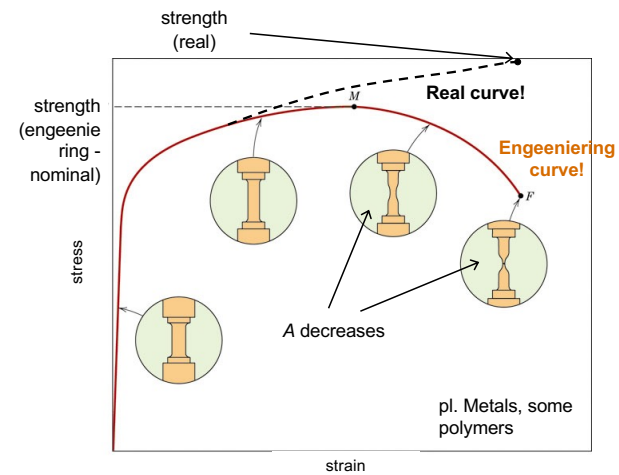
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Examples:

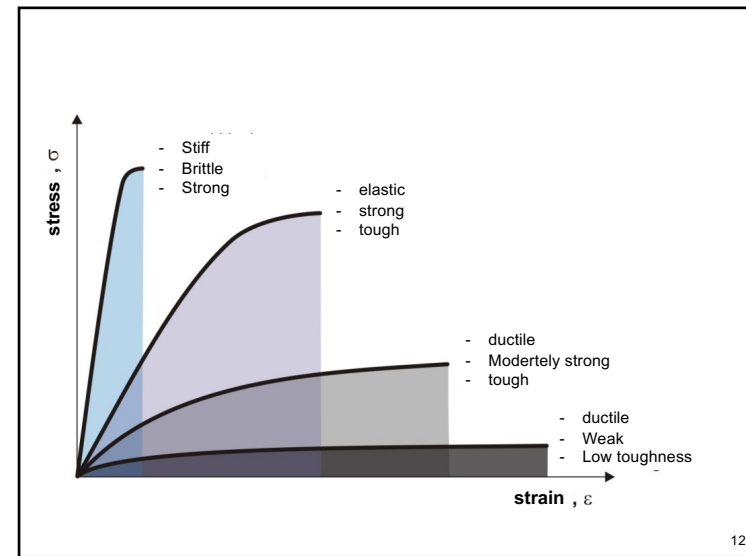
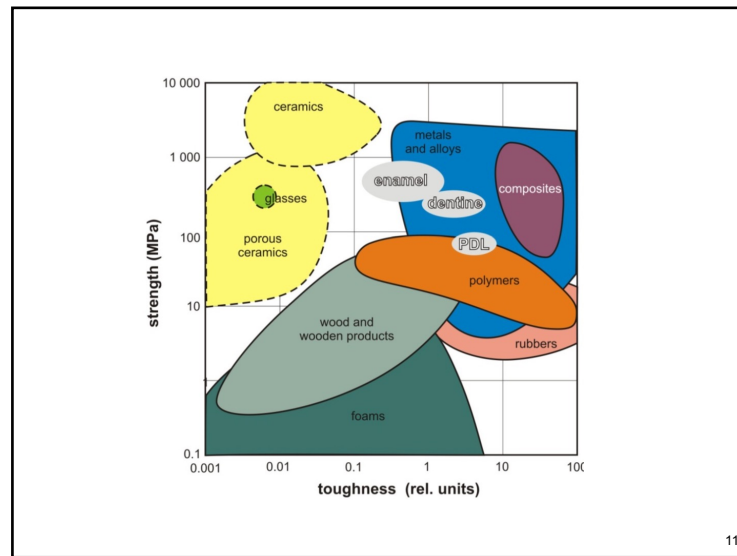
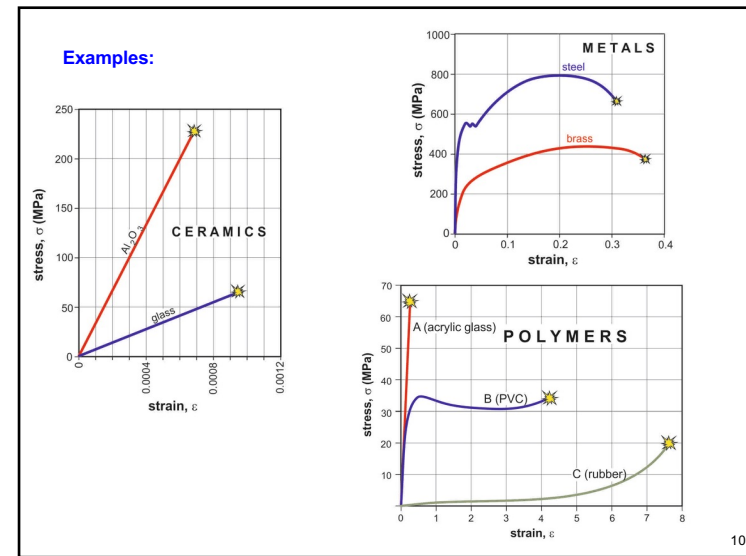
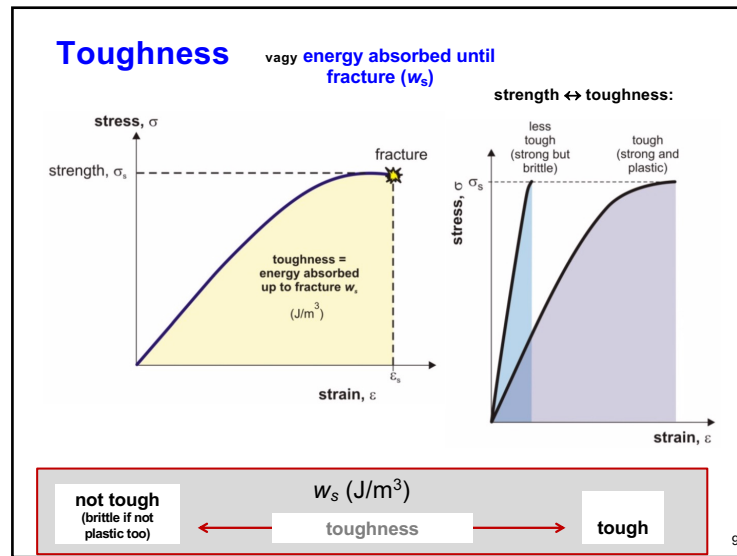


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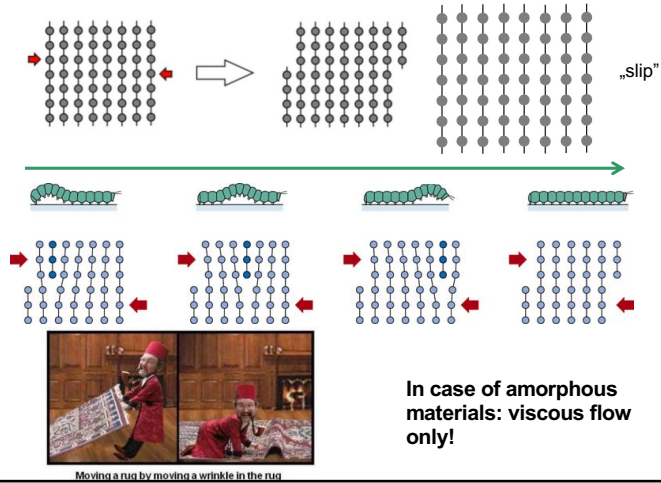
Engineering vs. „real” system



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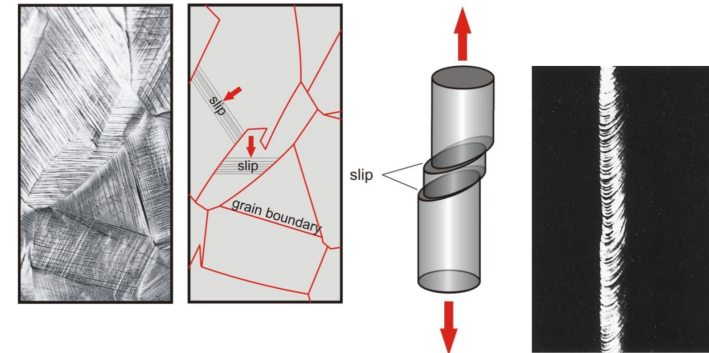


Mechanism of plastic deformation in crystals:

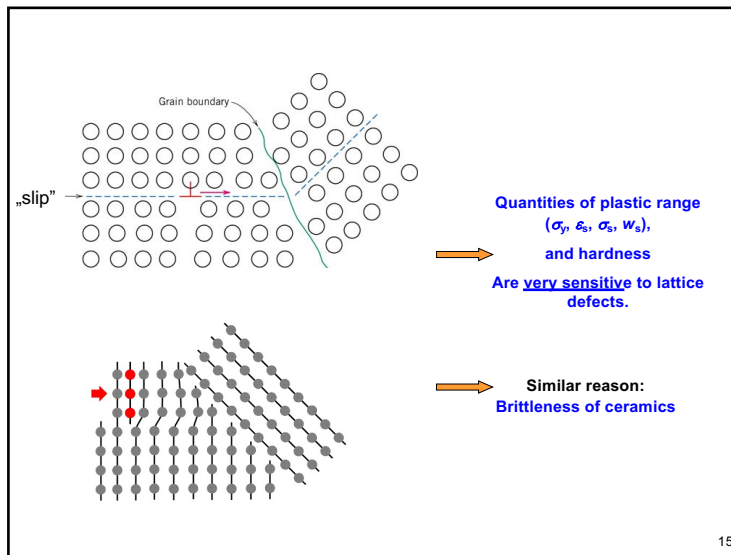


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Movement of dislocations

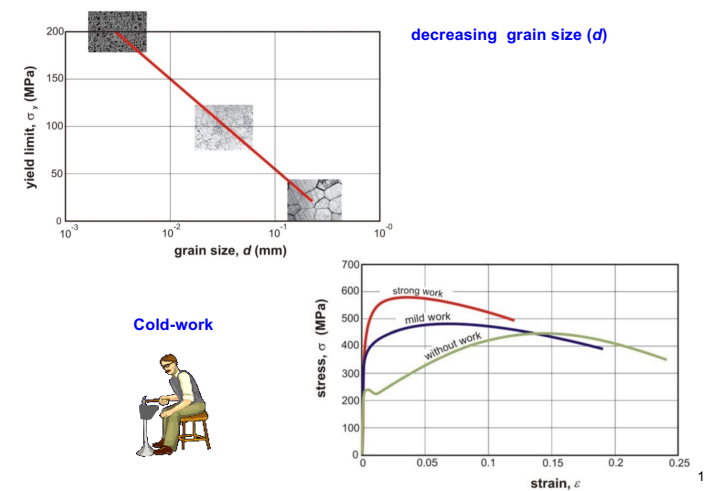


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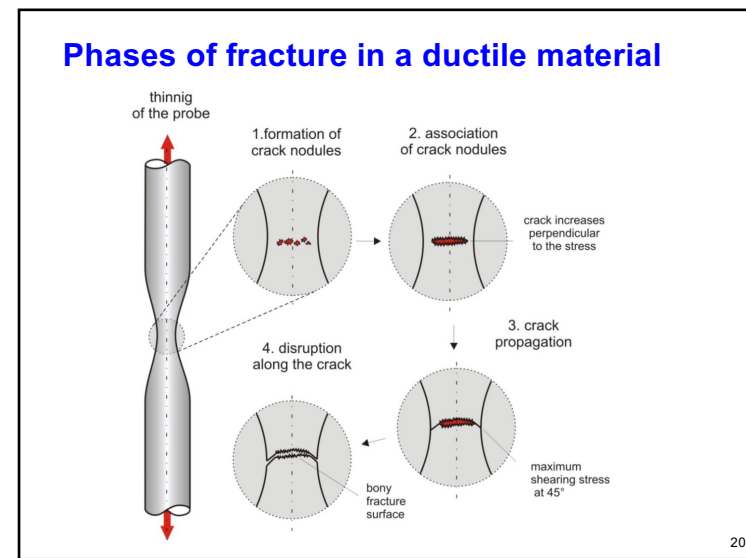
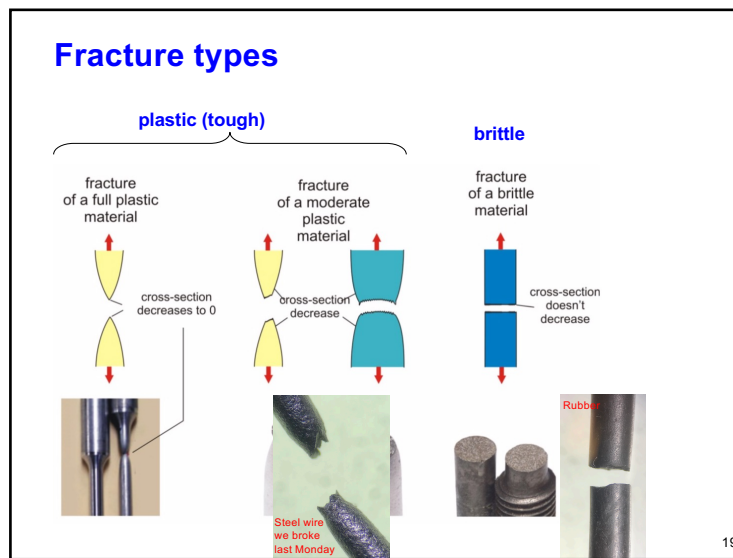
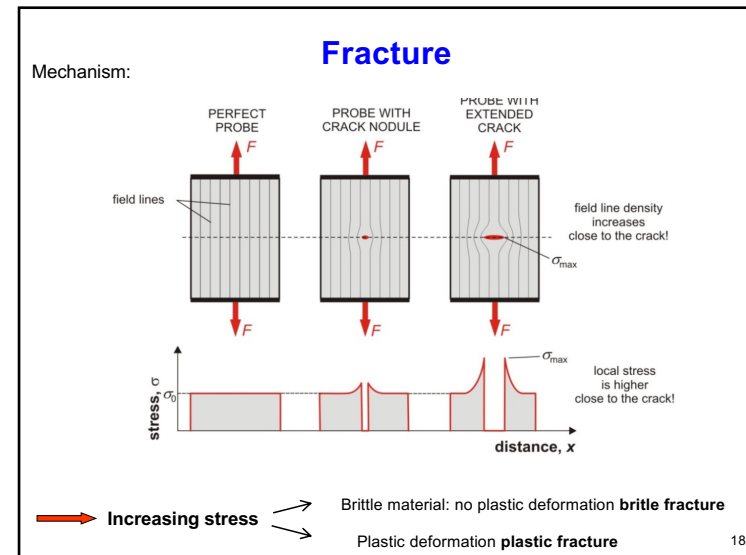
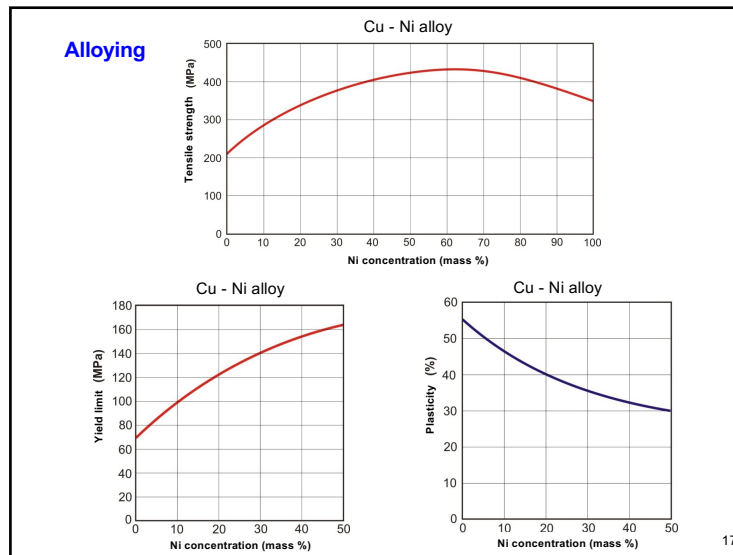


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Changing the strength and plastic properties of metals



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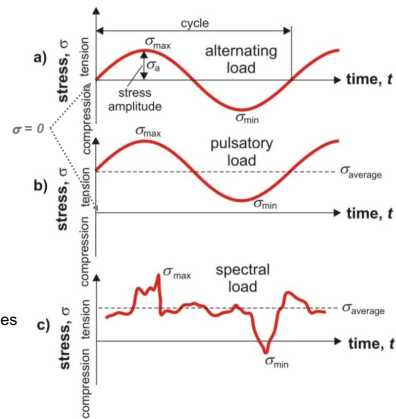
Fatigue, fatigue fracture



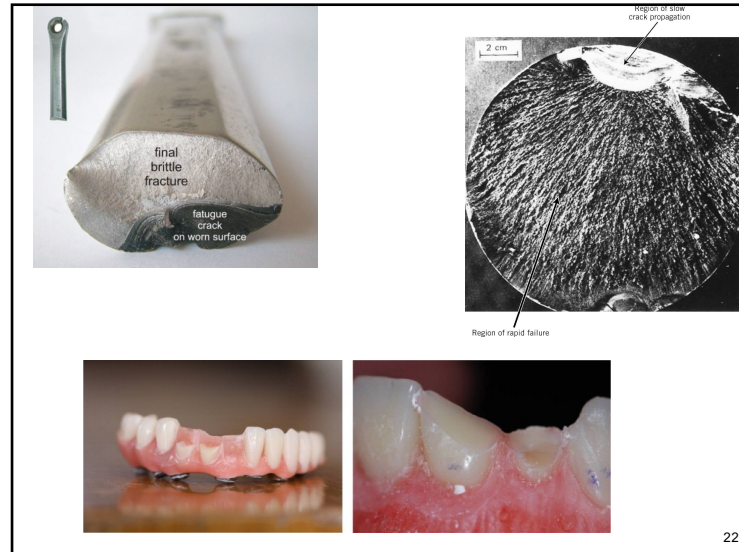
Persistent, repetitive load (stress)
→ structural changes
→ strength decreases

Crack formation!

Types of loads:

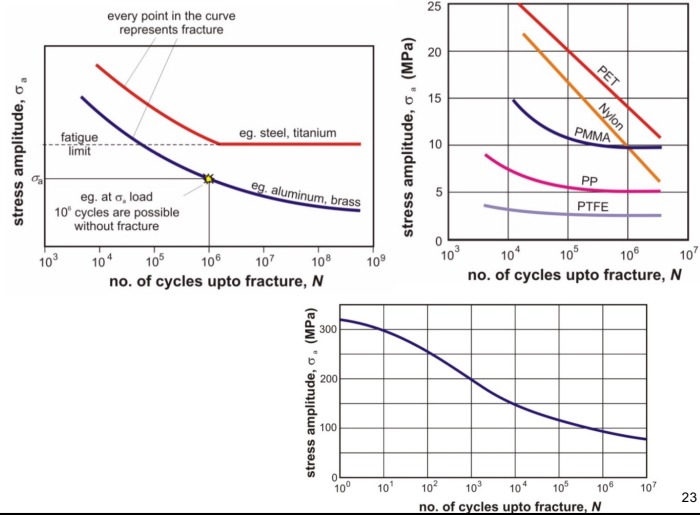


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Fatigue curve:



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Hardness

Resistance against plastic deformation



Mohs-scale:



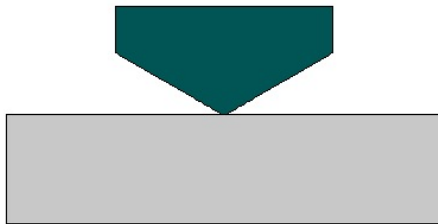
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Hardness measurement

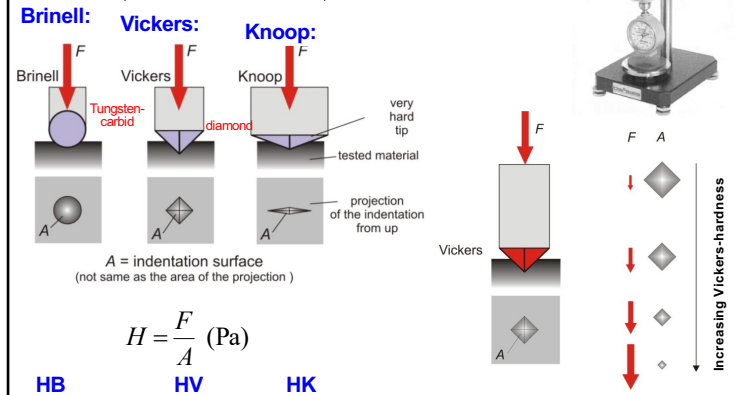
Rockwell C Test 4940 Sy=193 ksi u=.2
time= 0.0000E+00
dst= 0.10000E+01



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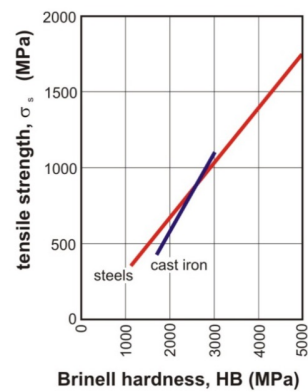
Hardness measurement

Methods of microhardness measurement



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Connections with strength:

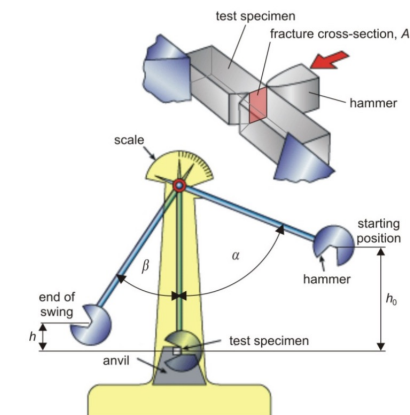


Hardness of dental materials:

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

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Charpy test



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

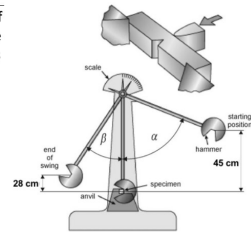
Specific impact energy = impact energy / cross sectional area of test specimen (J/m²)

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5. A piece of zirconia with a fracture cross-sectional area of 1 cm^2 is tested in a Charpy. The drawing shows the hammer's start and end positions. The hammer has a mass of 2 kg. Calculate the specific impact energy of zirconia!



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