

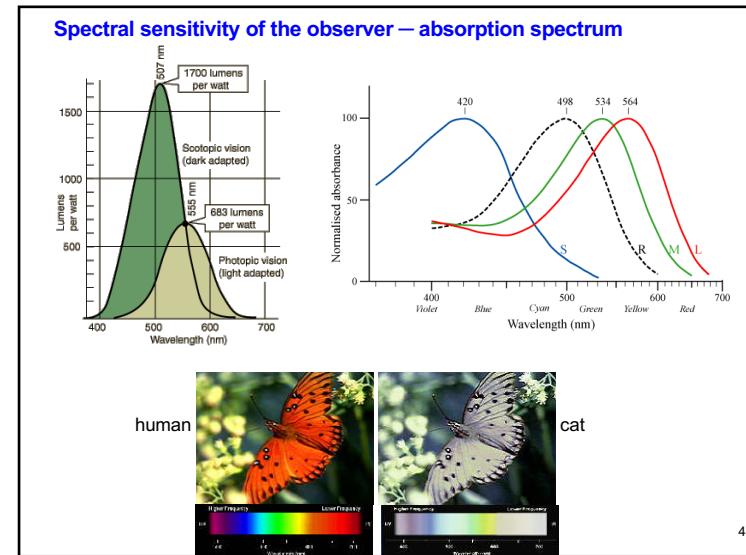
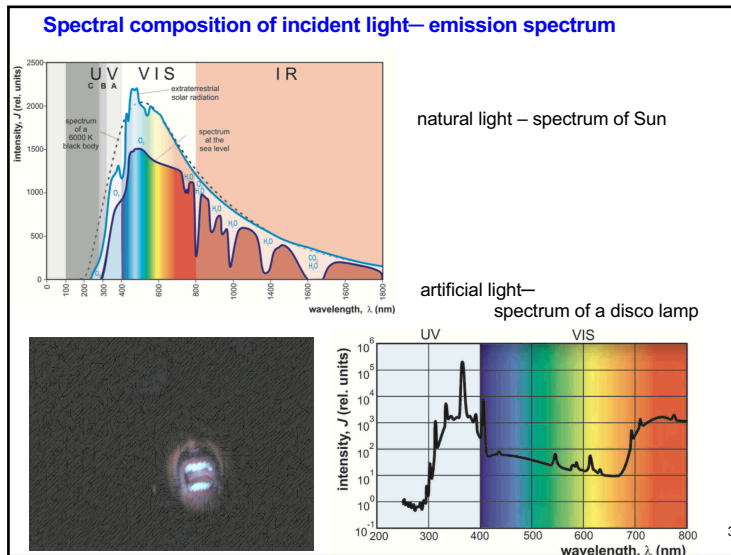
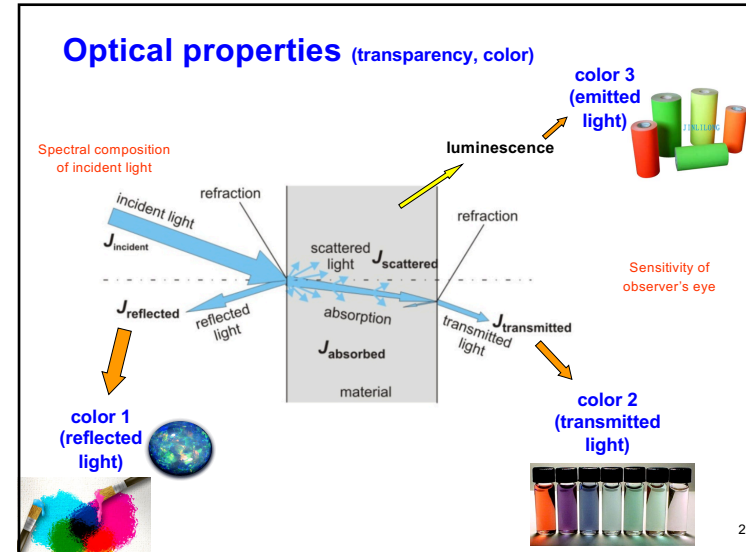
Physical Foundatiouns of dental materials science

12. Optical properties.

Comparative summary.

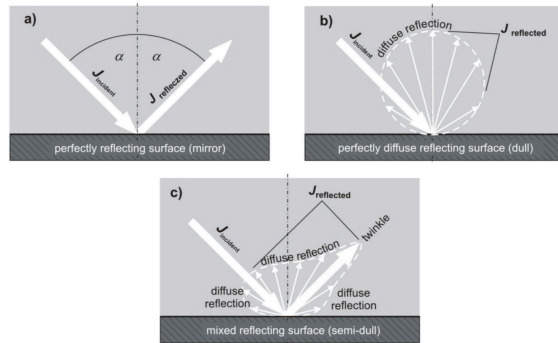
e-book chapters: 20, 21

1



Interaction of light with matter \Rightarrow color

1. Reflection:



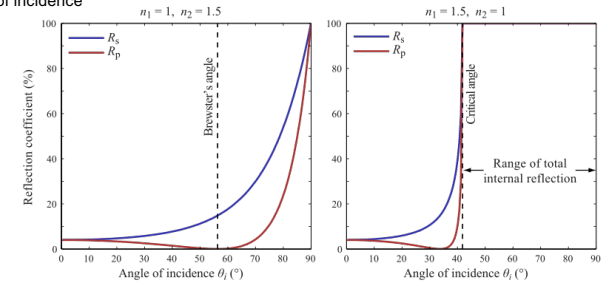
Spectral reflectance $\rho(\lambda)$:

$$\rho_\lambda = \frac{J_{\text{reflected}}}{J_{\text{incident}}}$$

5

ρ depends on:

1. angle of incidence



2. type of materials (refractive indices)

when angle of incidence is zero:



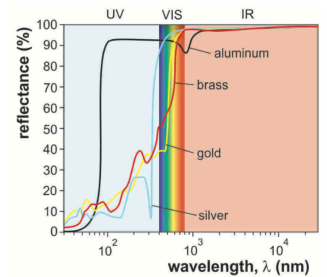
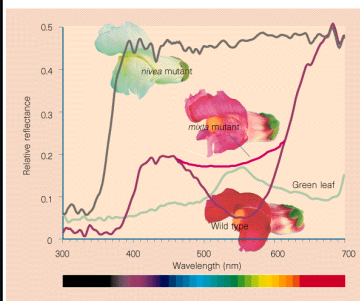
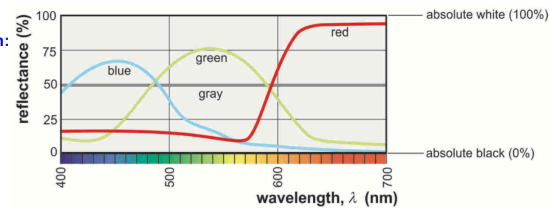
$$\rho = \left(\frac{n_1 - n_2}{n_1 + n_2} \right)^2$$

6

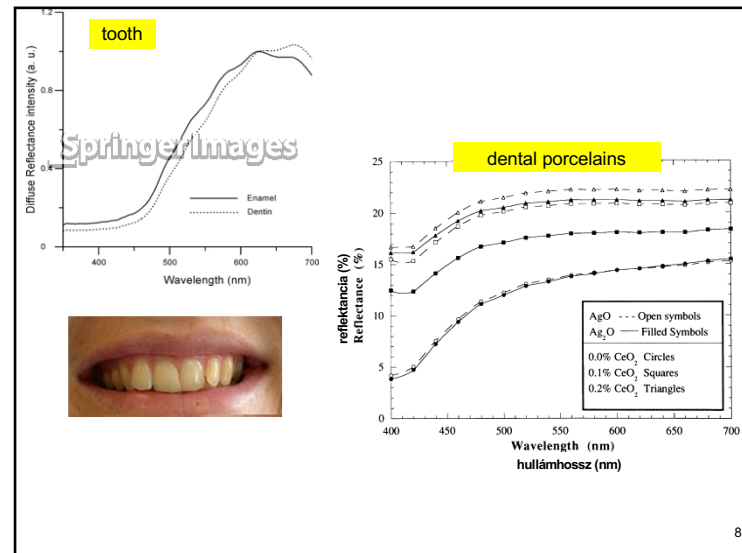
3. wavelength

Reflection spectrum:

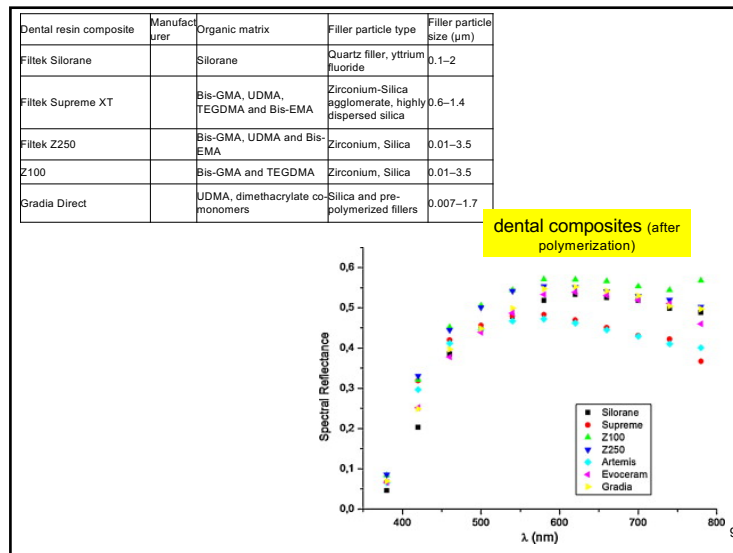
color 1
(reflected light)



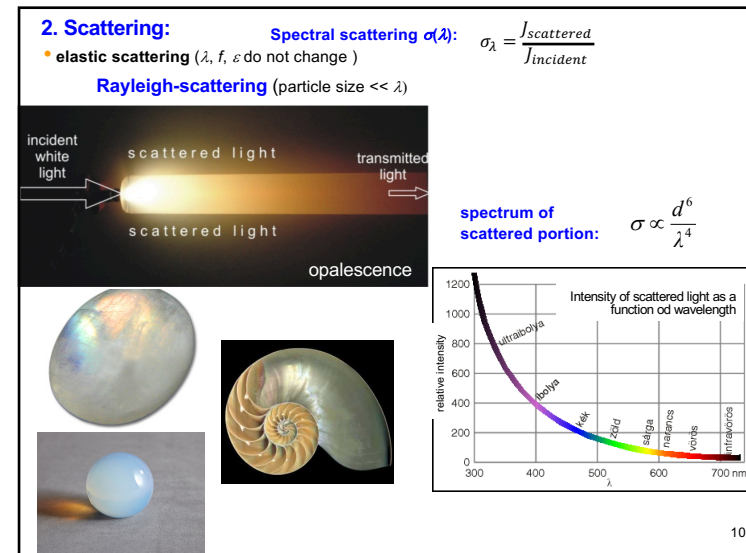
7



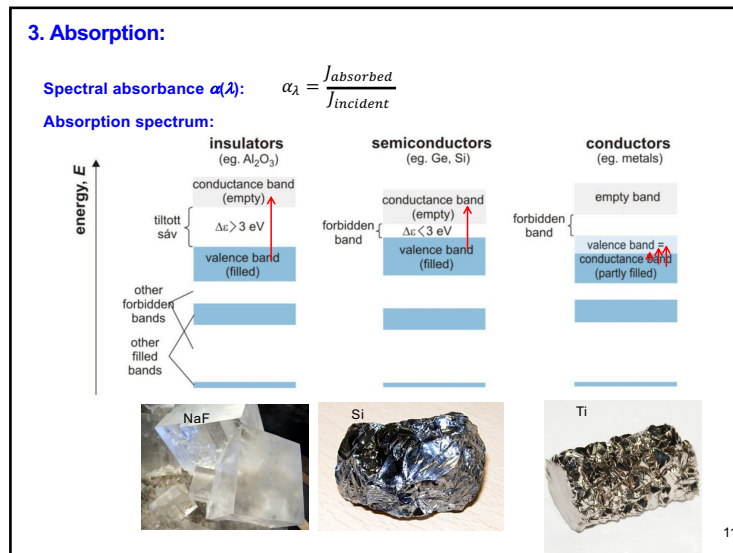
8



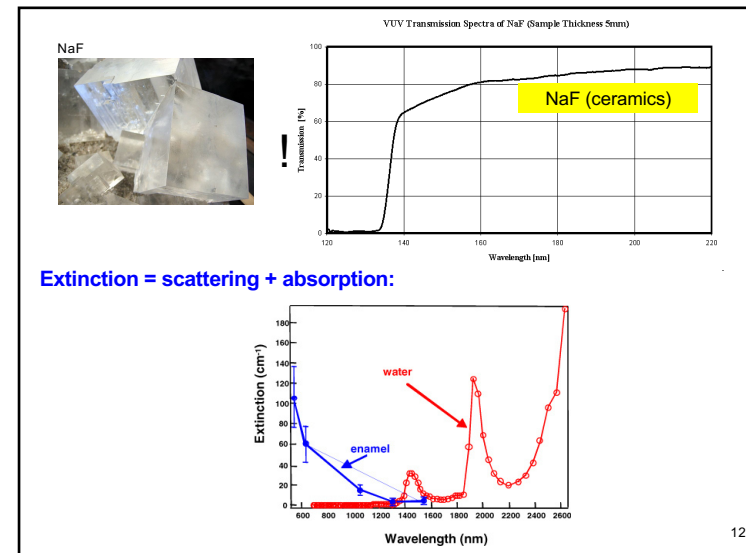
9



10



11

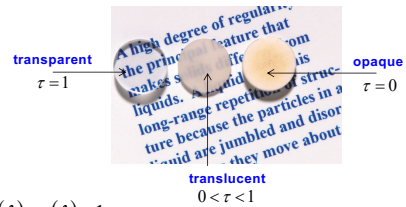


12

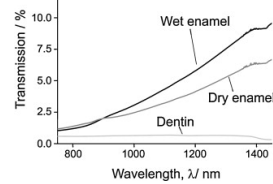
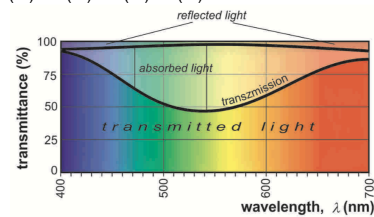
4. Transmission:

Spectral transmittance $\tau(\lambda)$:

$$\tau_{\lambda} = \frac{I_{\text{transmitted}}}{I_{\text{incident}}}$$

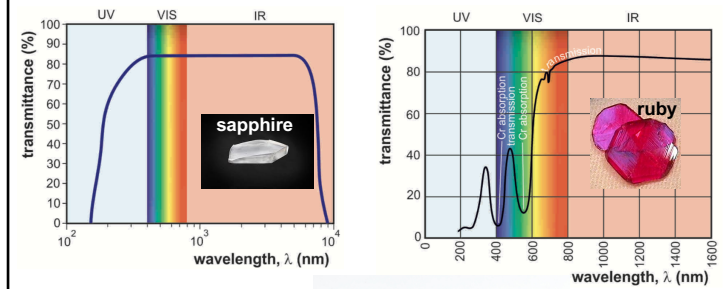


$$\rho(\lambda) + \sigma(\lambda) + \alpha(\lambda) + \tau(\lambda) = 1$$



13

Transmission spectrum:

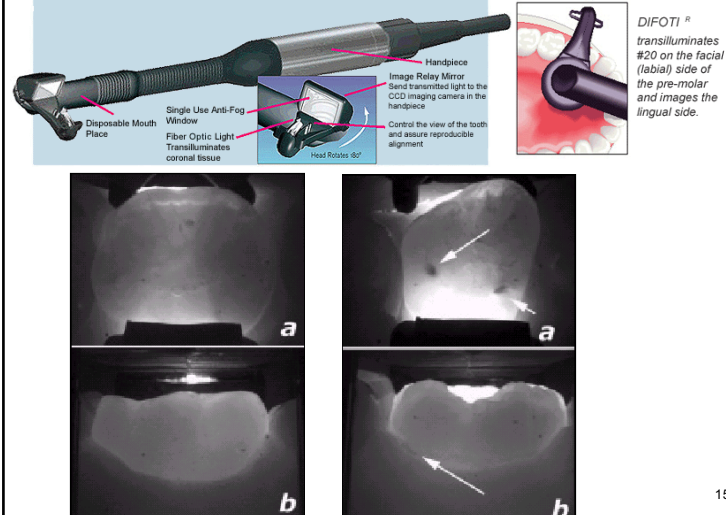


color 2
(transmitted light)



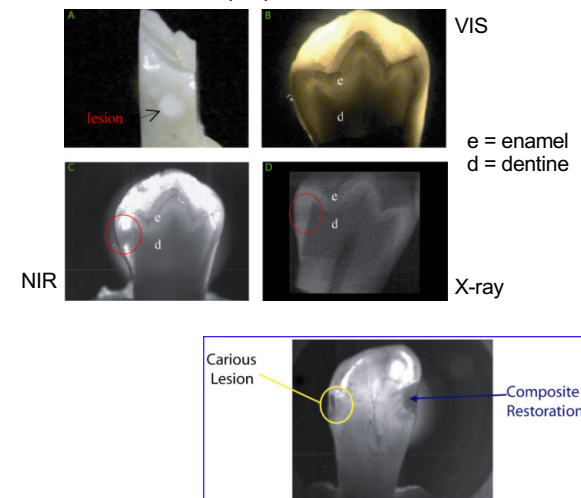
14

DIFOTI® (Digital Imaging Fiber-Optic Trans-Illumination)



15

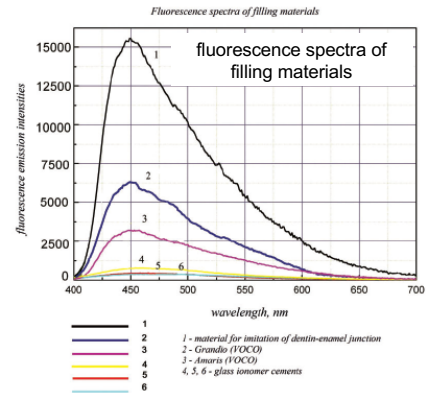
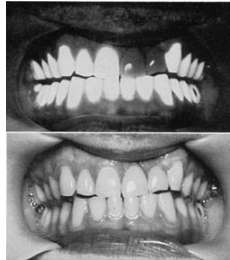
Trans-illumination in near infrared (NIR)



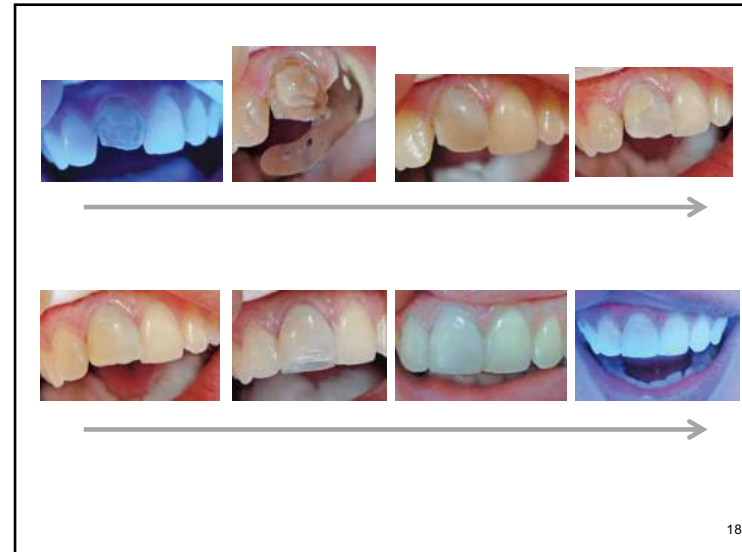
16

5. Fluorescence

fluorescence of enamel

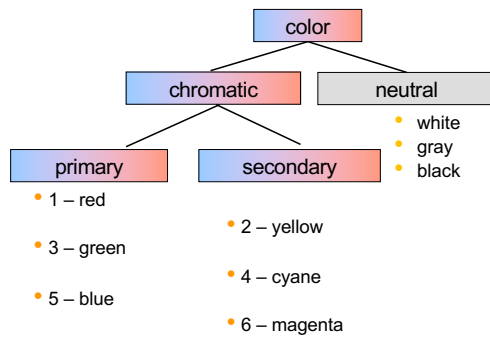


17



18

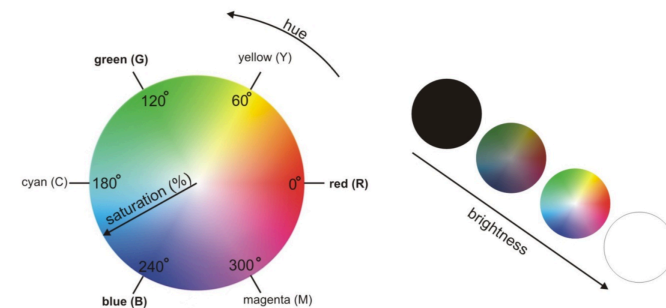
Color



19

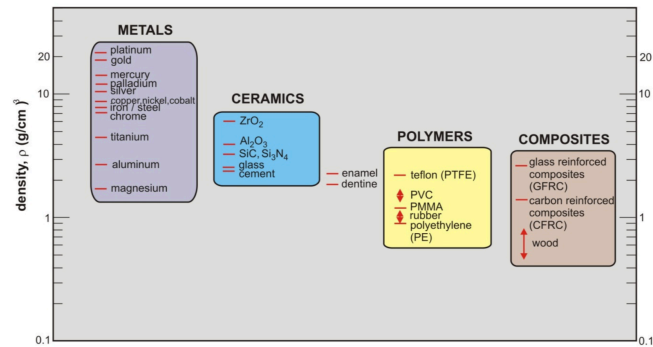
color coordinates

- hue
- saturation
- brightness



20

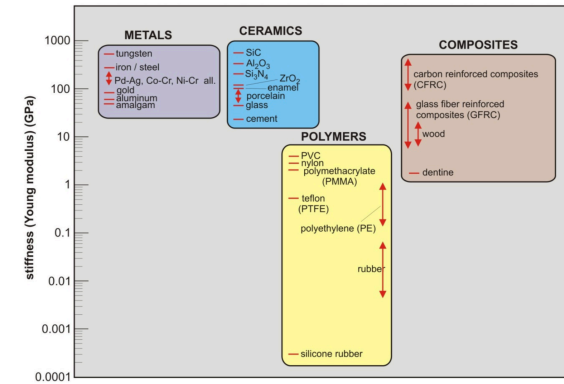
Comparison of dental materials



Density: polymers, composites < ceramics < metals

Depends on atomic mass, packing ratio

21

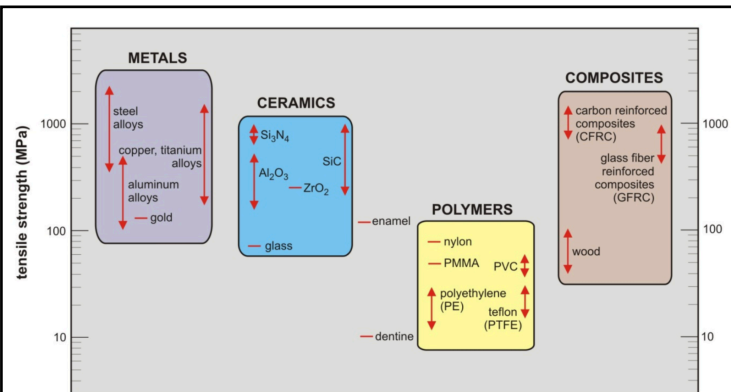


Stiffness: polymers < composites < metal, ceramics Depends on: bond energy

Resilience: ceramics < metals < composites < polymers

Ductility: ceramics < metals, composites, polymers

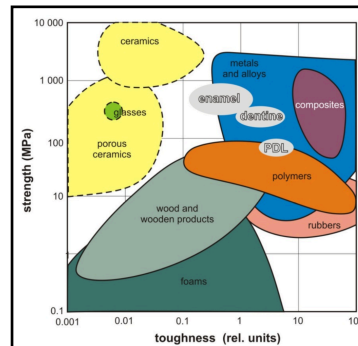
22



tensile strength: polymers < composites, ceramics < metals
Depends on: bond energy, crack resistance (ductility, brittleness)

compressive strength: Crack formation is less dominant, so ceramics have higher value

23



compressive strength:
polymers < composites, caremics, metals

Toughness:
ceramics < polymers, composites, metals
(strength, elastic strain recovery, plasticity)

Hardness:
polymers < composites < metals < ceramics
(stiffness and plasticity!)

24

Electric conductance: ceramics, composites, polymers < metals

Thermal conductance: ceramics, composites, polymers < metals
(correlates with electric conductance)

Melting point: polymers < composites < metals < ceramics
depends on bond energy

thermal expansion coefficient: ceramics < metals < composites < polymers
(inversely proportional to bond energy!)

Reflectance: ceramics, composites, polymers < metals
(in the VIS range, wavelength dependent!)

Transmittance: metals < composites < polymers, ceramics
(in the VIS range, wavelength dependent!)

25

25

metals

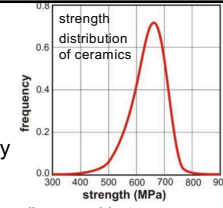
In general:

- solid
- large density
- stiff
- strong
- ductile (malleable)
- tough (ductile fracture)
- hard
- low specific heat
- good heat conduction
- good heat shock resistance
- good electric conduction
- opaque, high reflectance
- poor corrosion resistance

ceramics

In general:

- solid
- medium density
- stiff
- strong (medium tensile strength)
- not ductile
- brittle (brittle fracture)
- „crack sensitive“
- very hard
- medium specific heat
- thermal insulator
- low heat shock resistance
- electric insulator
- diverse optical properties
- good corrosion resistance



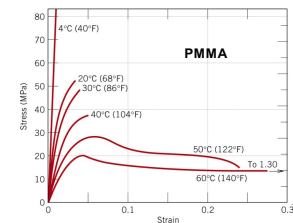
26

26

polymers

In general:

- liquid or solid
- low density
- low stiffness - elastic
- medium or weak strength
- ductile
- medium toughness
- medium hardness - soft
- viscoelastic
- medium specific heat
- thermal insulator
- medium heat shock resistance
- electric insulator
- diverse optical properties
- medium corrosion resistance



Important:

- temperature
- molecular mass
- degree of crystallinity

27

27

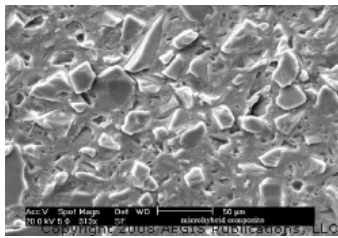
composites (dental)

In general:

- solid
- low – medium density
- medium stiffness - elastic
- strong
- ductile
- tough
- hard – medium hard
- viscoelastic
- medium specific heat
- thermal insulator
- medium heat shock resistance
- electric insulator
- diverse optical properties
- good corrosion resistance

Important:

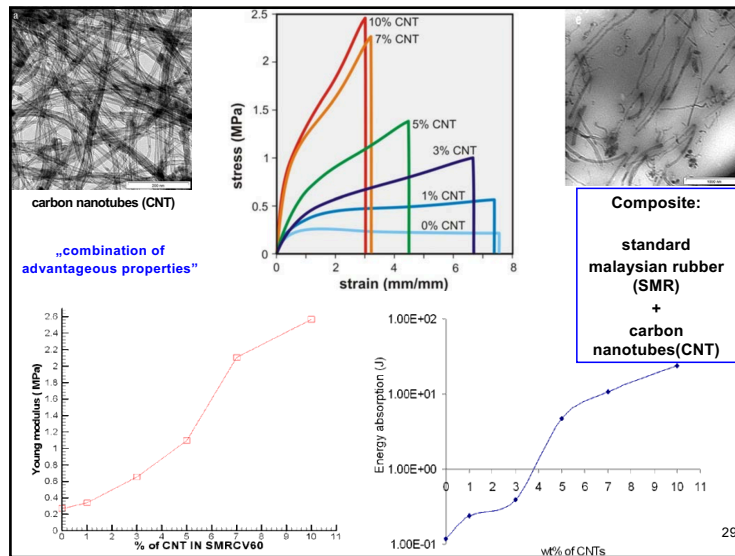
- composition
- particle size of dispersion phase



→ microhybrid → nanohybrid composites

28

28



29