INTRODUCTION TO OPTICAL MATERIALS

Definition

The materials which are sensitive to light are known as optical material. Their main function is to alter or control EM radiation in the UV, visible or IR spectral regions.

* They are fabricated into, lenses, mirrors, windows, prisms, polarizers, detectors & modulators.

* They can be used to refract, reflect, transmit, disperse, polarize, detect and transform light.

* At the microscopic level, atoms and their electronic ~~configuratusations~~ configurations in the material interact with the EM radiation to determine its macroscopic optical properties such as transmission and refraction.

* The optical properties are functions of :
    i) Wavelength of incident light.
    ii) Temperature of the material.

(iii) Applied pressure on the material

(iv) External electric & magnetic field applied to the material.

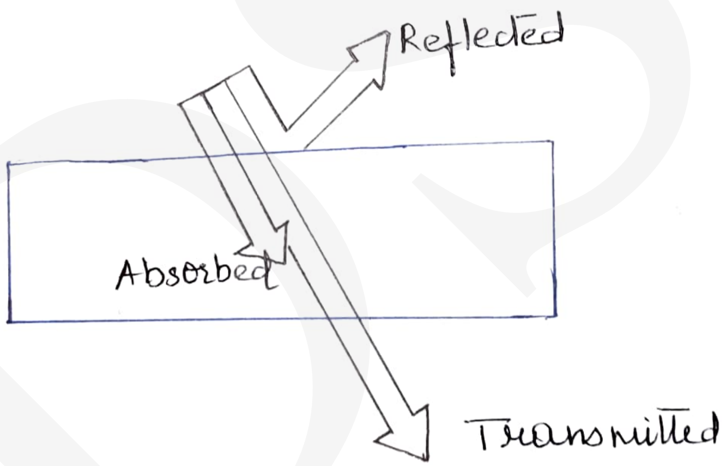
CLASSIFICATION OF OPTICAL MATERIALS BASED ON THE NATURE OF PROPAGATION OF LIGHT

Optical materials are classified into three types –

(i) Transparent

(ii) Translucent

(iii) Opaque



(i) Transparent

The materials which allow light to pass through them with no to very little absorption / reflection are transparent material.

One can clearly view the object through them.

Light scatters very less while passing through them.

Transparent materials are used for lenses, spectacles, electrical insulators & semi conductors (few).

Translucent

A substance is called translucent if it allows partial transmission. The light rays get scattered in the interior of such objects and hence, the diffused light is transmitted to the other side of the material. One can't view objects clearly on the other side of these materials.

Translucency can occur due to –

Non uniform Density – Non uniform distribution of matter.

Crystallographic defects – defects in a crystal structure

Boundaries – Grain boundaries & cell boundaries can behave as scattering centers.

Eg: Frosted glass, butter paper, etc.

Opaque

Opaque substance do not allow transmission of light. Any incident light gets reflected, absorbed, or scattered.

Eg: Wood, metal, stone etc.

INTERACTION OF LIGHT WITH SOLIDS

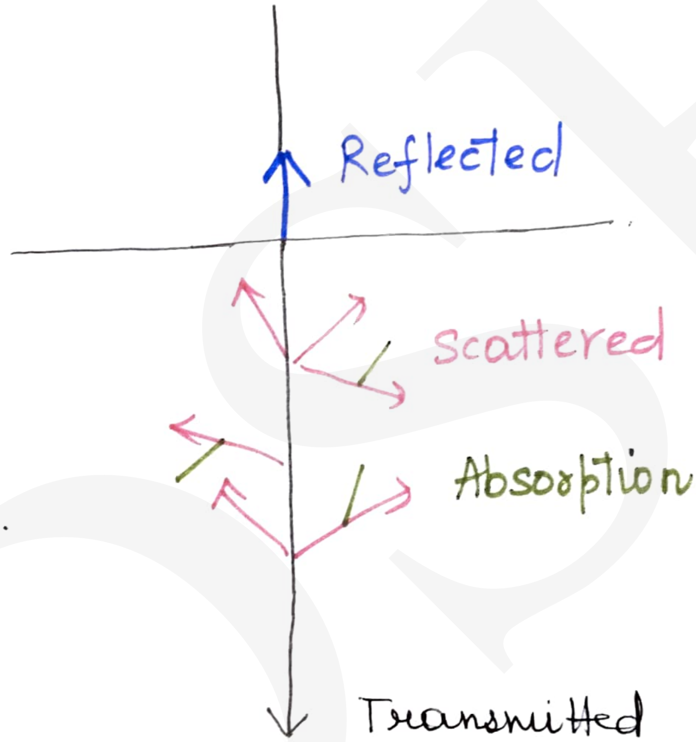
Incident light on a solid can be –

Reflected off the sample

Absorbed by the sample

Scattered by the sample at different points

Transmitted through the sample



Let ϕ_e be the radiant flux.

$\phi_e = \frac{dQ_e}{dt}$ [This is energy per unit time]

Intensity $I_e^i = \frac{\phi_e}{\text{unit area}}$ ie $\frac{\text{radiant flux}}{\text{unit area}}$

I_e^i signifies total incident flux per unit area ie. radient flux received by the surface.

$$\boxed{I_e^i = I_T + I_R + I_A} \quad \text{--- (1)}$$

where I_T = transmitted light intensity.

I_R = Reflected light intensity.

I_A = Absorbed light intensity.

Reflectance, transmittance and absorptance

Reflectance R is the ratio of the amount of flux reflected by the surface to the amount of flux incident on it.

$$\boxed{R = \frac{\phi_e^r}{\phi_e^i}}$$

where ϕ_e^r is radiant flux reflected by the surface

ϕ_e^i is incident flux or radiant flux received by the surface

Transmittance T is the ratio of the amount of flux transmitted by a surface to the amount of flux incident on it.

$$\boxed{T = \frac{\phi_e^t}{\phi_e^i}}$$

where ϕ_e^t is the radiant flux transmitted.

Absorptance A is ratio of the amount of flux absorbed by the surface to the amount of flux received by the surface (incident on it).

$$\boxed{A = \frac{\phi_e^a}{\phi_e^i}}$$

where ϕ_e^a is the radiant flux absorbed by the surface.

$$\boxed{T + R + A = 1}$$

SCATTERING OF LIGHT

Scattering of light is a phenomenon in which light rays get deviated from its straight path on striking an obstacle like dust | gas molecule etc.

* During scattering the intensity of the wave attenuates as it travels through a medium.

{Electromagnetic wave. Scattering

- Elastic scattering
  eg: Rayleigh
  Mie
- Inelastic scattering
  eg: Raman
  Compton

Rayleigh scattering

* Rayleigh scattering is elastic scattering of light where the frequency/ wavelength of the scattered light is same as that of incident light.

* In Rayleigh scattering, scattering particles have a radius less than approximately $1/10^{th}$ of the

wavelength of the radiation.

* The intensity of the scattered light is inversely proportional to the fourth power of the wavelength ($\propto \frac{1}{\lambda^4}$). Therefore shorter wavelengths are scattered more than the longer wavelength.

Raman Scattering

* Raman Scattering is inelastic scattering of light where wavelength / frequency of the scattered light is different i.e either larger or shorter than the incident radiation.

* Probability of Raman scattering to occur is 0.001% of the Rayleigh scattering.

* If scattered photon has higher frequency it's called anti-stokes and if scattered photon has lower frequency than incident photon it's called Stokes scattering.

$h\nu_0$	Elastic
$h\nu_0 + h\Delta\nu$	Anti Stokes
$h\nu_0 - h\Delta\nu$	Stokes

Compton Scattering

Scattering of highly energetic radiation such as x rays off the free $\bar{e}$ or charged particles.

* The wavelength of the scattered x rays increases by an amount $\Delta\lambda$, called the wavelength shift, & that $\Delta\lambda$ depends not on the intensity of incident radiation but only on the scattering angle.