2.2 Absorption losses

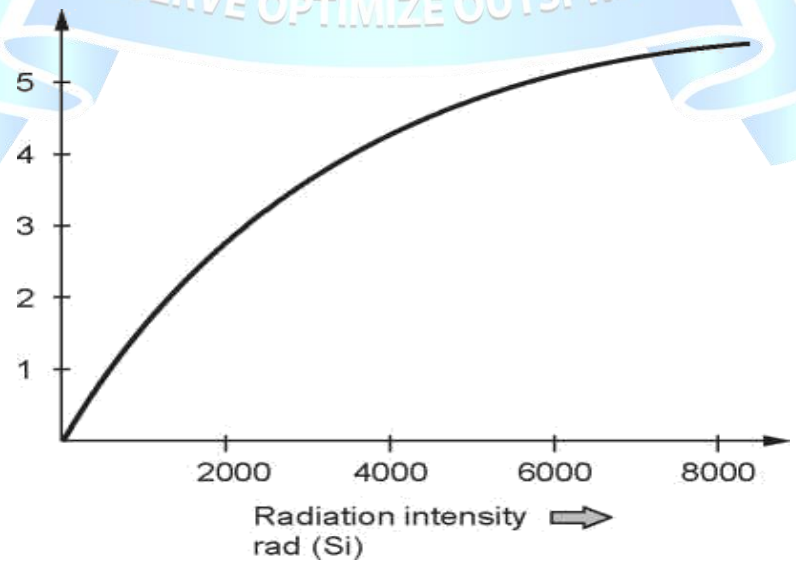
- Absorption loss is related to the material composition and fabrication process of fiber.
- Absorption loss results in dissipation of some optical power as heat in the fiber cable.
- Although glass fibers are extremely pure, some impurities still remain as residue after purification.
- The amount of absorption by these impurities depends on their concentration and light wavelength.

Absorption is caused by three different mechanisms.

1. Absorption by atomic defects in glass composition.
2. Extrinsic absorption by impurity atoms in glass matts.
3. Intrinsic absorption by basic constituent atom of fiber.

Absorption by Atomic Defects

- Atomic defects are imperfections in the atomic structure of the fiber materials such as missing molecules, high density clusters of atom groups. These absorption losses are negligible compared with intrinsic and extrinsic losses.
- The absorption effect is most significant when fiber is exposed to ionizing radiation in nuclear reactor, medical therapies, space missions etc. The radiation damages the internal structure of fiber.
- The damages are proportional to the intensity of ionizing particles. This results in increasing attenuation due to atomic defects and absorbing optical energy.
- The total dose a material receives is expressed in rad (Si), this is the unit for measuring radiation absorbed in bulk silicon.
- 1 rad (Si) = 0.01 J/kg
- The higher the radiation intensity more the attenuation as shown in Fig.



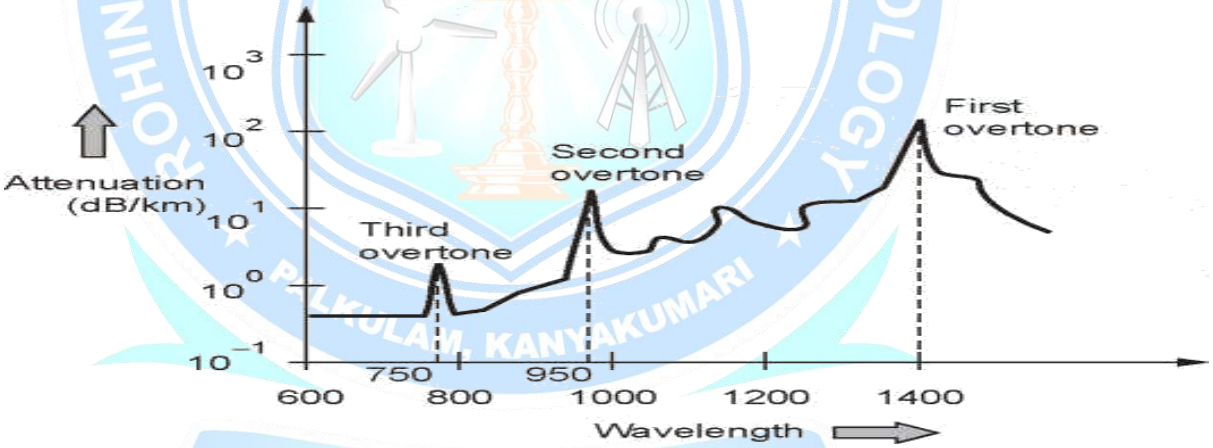
Extrinsic Absorption

- The extrinsic absorption is due to impurities present in fiber material such as :

  Transition metal impurities.

  OH ions

- Extrinsic absorption occurs due to electronic transitions between the energy levels and because of charge transitions from one ion to another.
- A major source of attenuation is from transition of metal impurity ions such as iron, chromium, cobalt and copper. These losses can be upto 1 to 10 dB/km. The effect of metallic impurities can be reduced by glass refining techniques.
- Another major extrinsic loss is caused by absorption due to OH (Hydroxil) ions impurities dissolved in glass. Vibrations occur at wavelengths between 2.7 and 4.2 pm. The absorption peaks occurs at 1400, 950 and 750 nm. These are first, second and third overtones respectively.
- Figure shows absorption spectrum for OH group in silica. Between these absorption peaks there are regions of low attenuation.



-

Intrinsic Absorption

- **Intrinsic absorption** occurs when material is in absolutely pure state, no density variation and inhomogenities. Intrinsic absorption sets the fundamental lower limit on absorption for any particular material.
- Intrinsic absorption results from electronic absorption bands in UV region and from atomic vibration bands in the near infrared region.
- The electronic absorption bands are associated with the band gaps of amorphous glass materials. Absorption occurs when a photon interacts with an electron in the valence band and excites it to a higher energy level. UV absorption decays exponentially with increasing wavelength (X).

- In the IR (infrared) region above 1.2 pm the optical waveguide loss is determined by presence of the OH ions and inherent IR absorption of the constituent materials.
- The inherent IR absorption is due to interaction between the vibrating band and the electromagnetic field of optical signal this results in transfer of energy from field to the band, thereby giving rise to absorption, this absorption is strong because of many bonds present in the fiber.
- Attenuation spectra for the intrinsic loss mechanism in pure Ge is shown in
- The ultraviolet loss at any wavelength

$$\alpha_{uv} = \frac{154.2x}{46.6x + 60} X\, 10^{-2} X\, e^{\frac{4.63}{\lambda}}$$

X is mole fraction of GeO_2

λ is operating wavelength.

α_{uv} is in dB

The loss in infrared (IR) region (above 1.2 μm) is given by

$$\alpha_{IR} = 7.81\, X\, 10^{11} X\, e^{\frac{-48.48}{\lambda}}$$