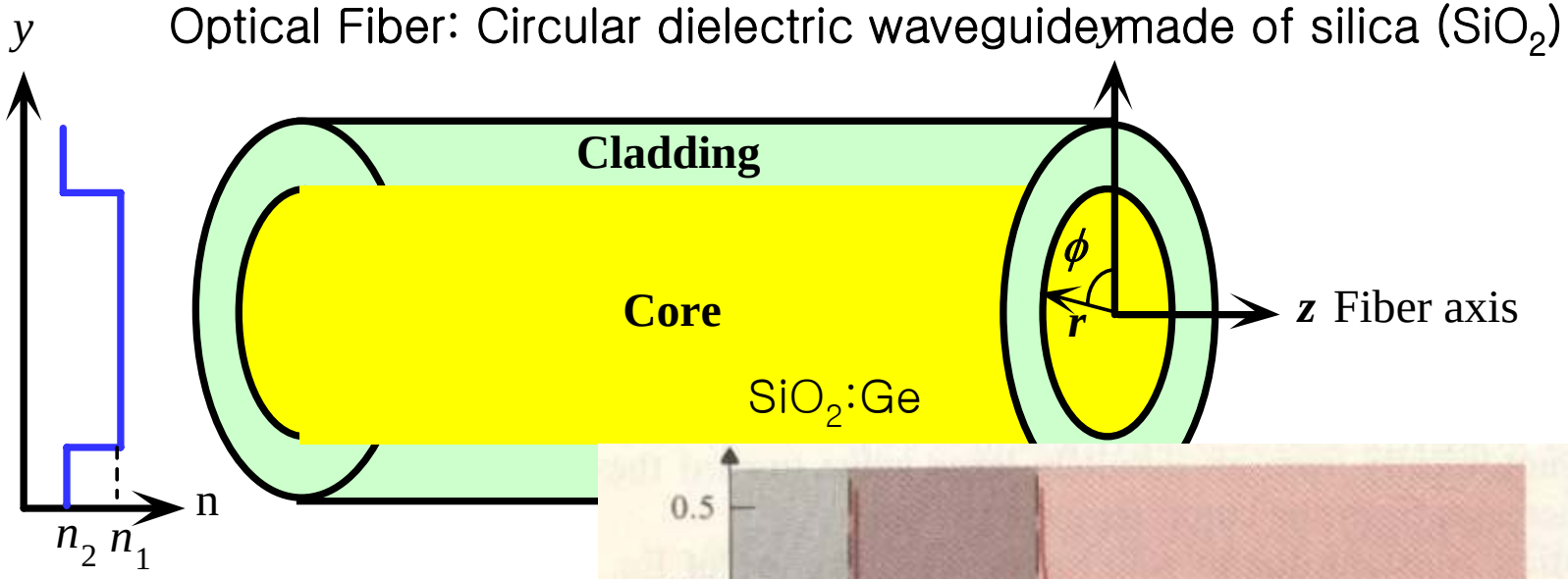
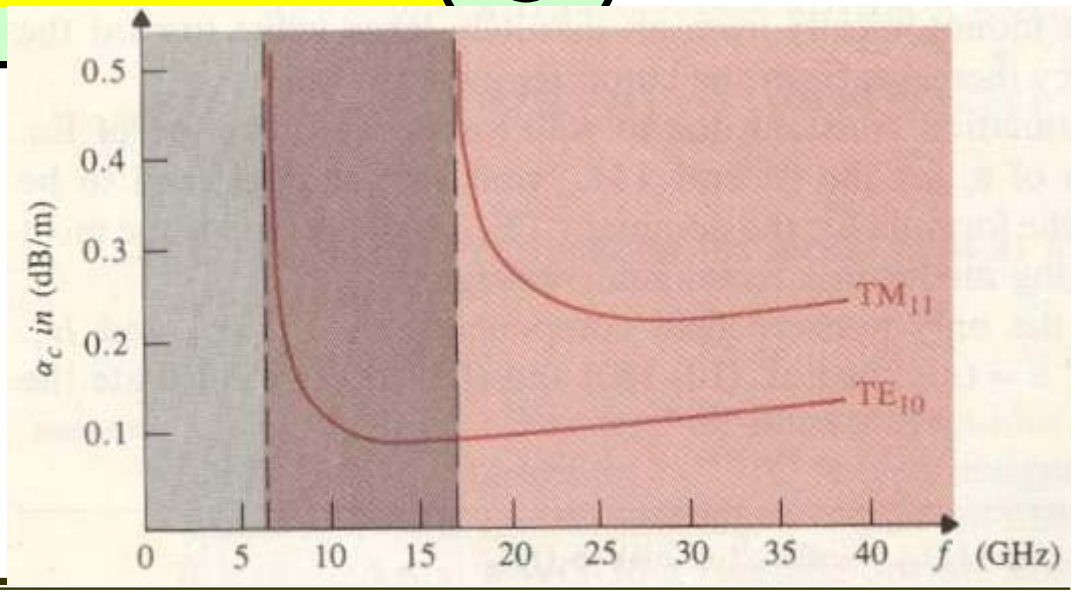
Lect. 13: Optical Fiber

Optical Fiber: Circular dielectric waveguide made of silica (SiO_2)



What is special about fiber?
- Extremely low loss: 0.2dB/km
- Can be very long: 100's of km



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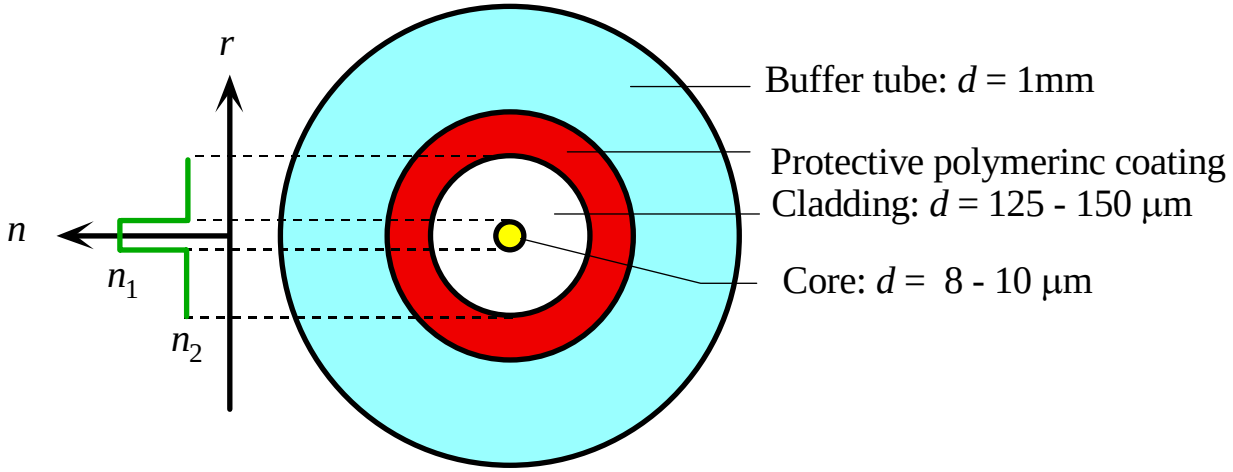

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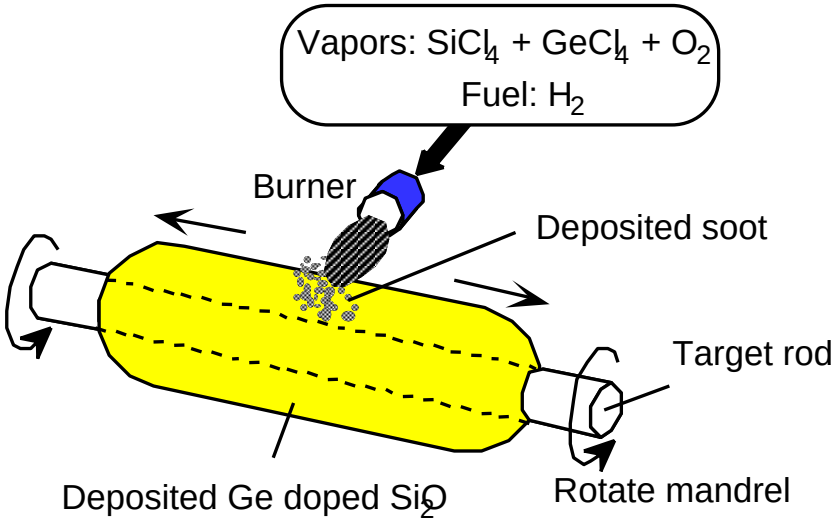
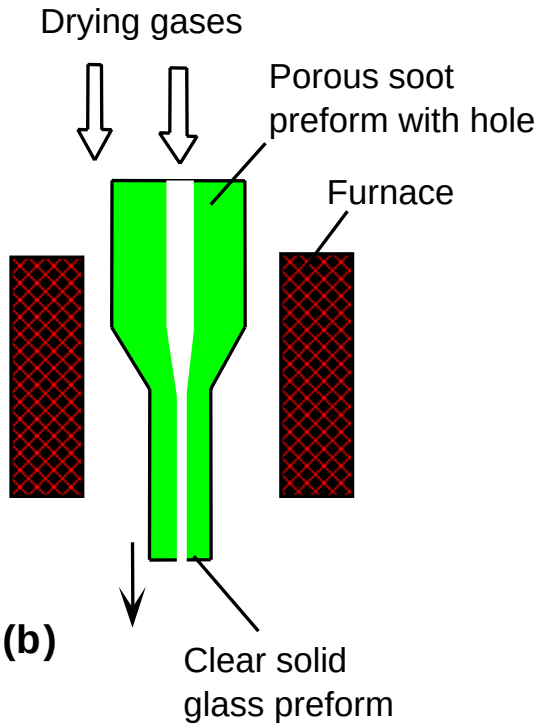


(a)



(b)

$SiCl_4 + O_2 \rightarrow SiO_2 + 2Cl_2$

$GeCl_4 + O_2 \rightarrow GeO_2 + 2Cl_2$

Sintering at 1400–1600 deg C

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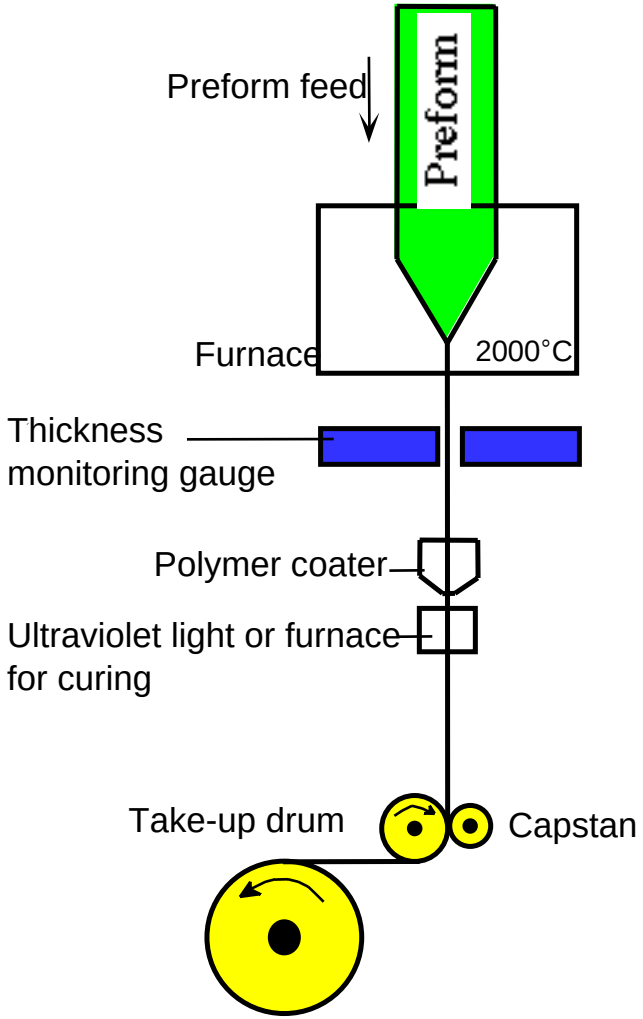

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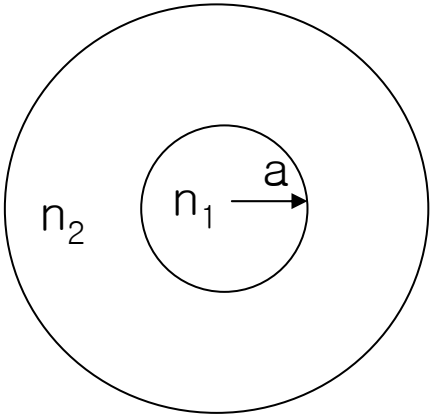
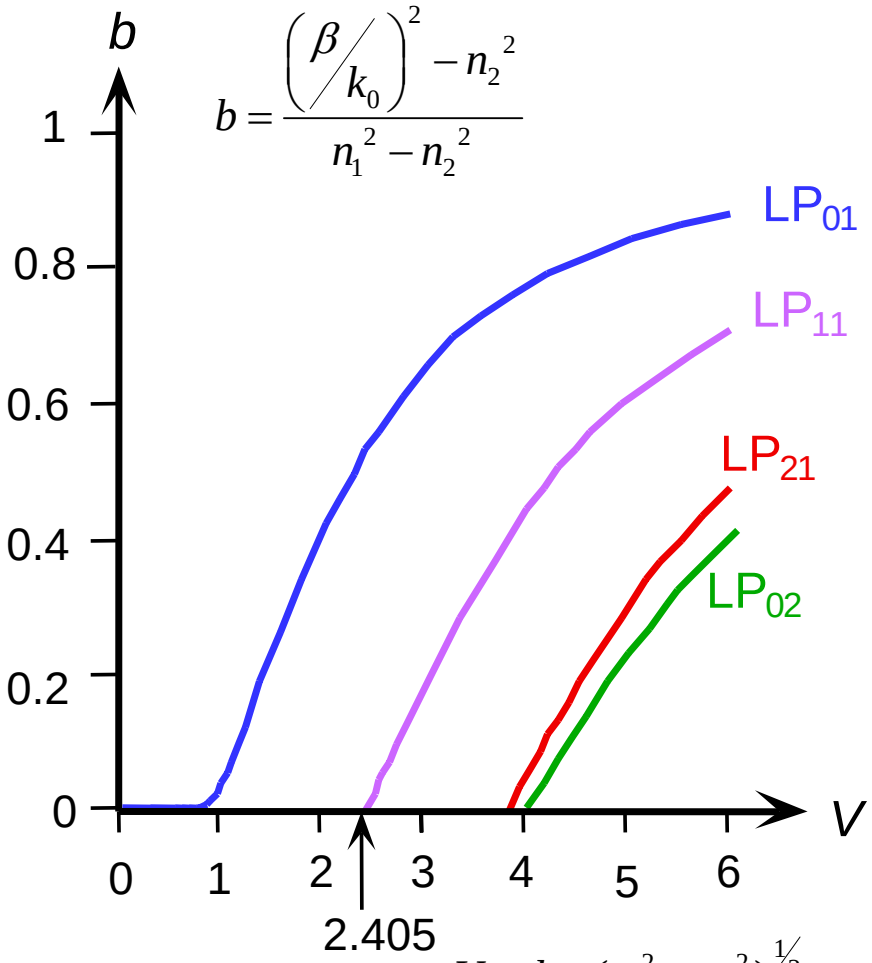


Solving for guided modes for circular dielectric waveguide problem in (r, f, z) coordinate is very complicated.

It can be shown that with a little approximation, LP (linearly polarized) mode solutions are obtained.

$$E_{LP} = E_{lm}(r,\phi)\,\mathrm{e}^{-j\beta_{lm}z}$$



$V = k_0 a (n_1^2 - n_2^2)^{1/2}$

(a : fiber core radius)

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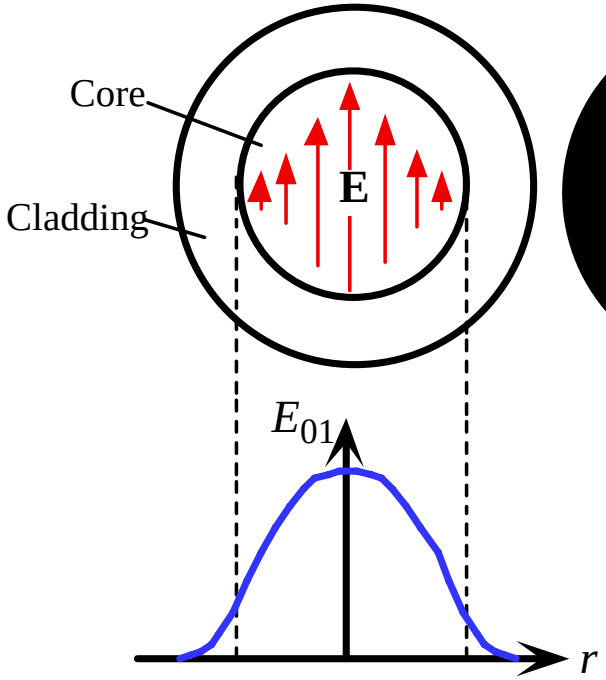
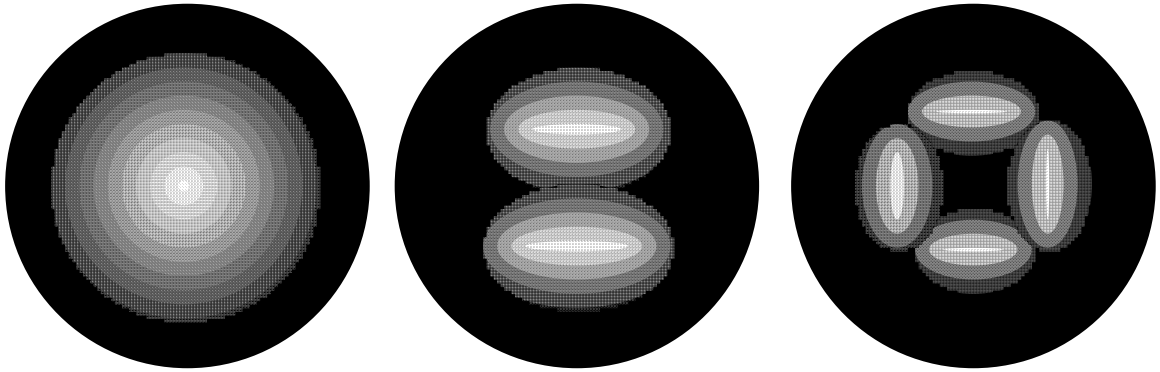
(a) The electric field of the fundamental mode

(b) The intensity in the fundamental mode LP_{01}

(c) The intensity in LP_{11}

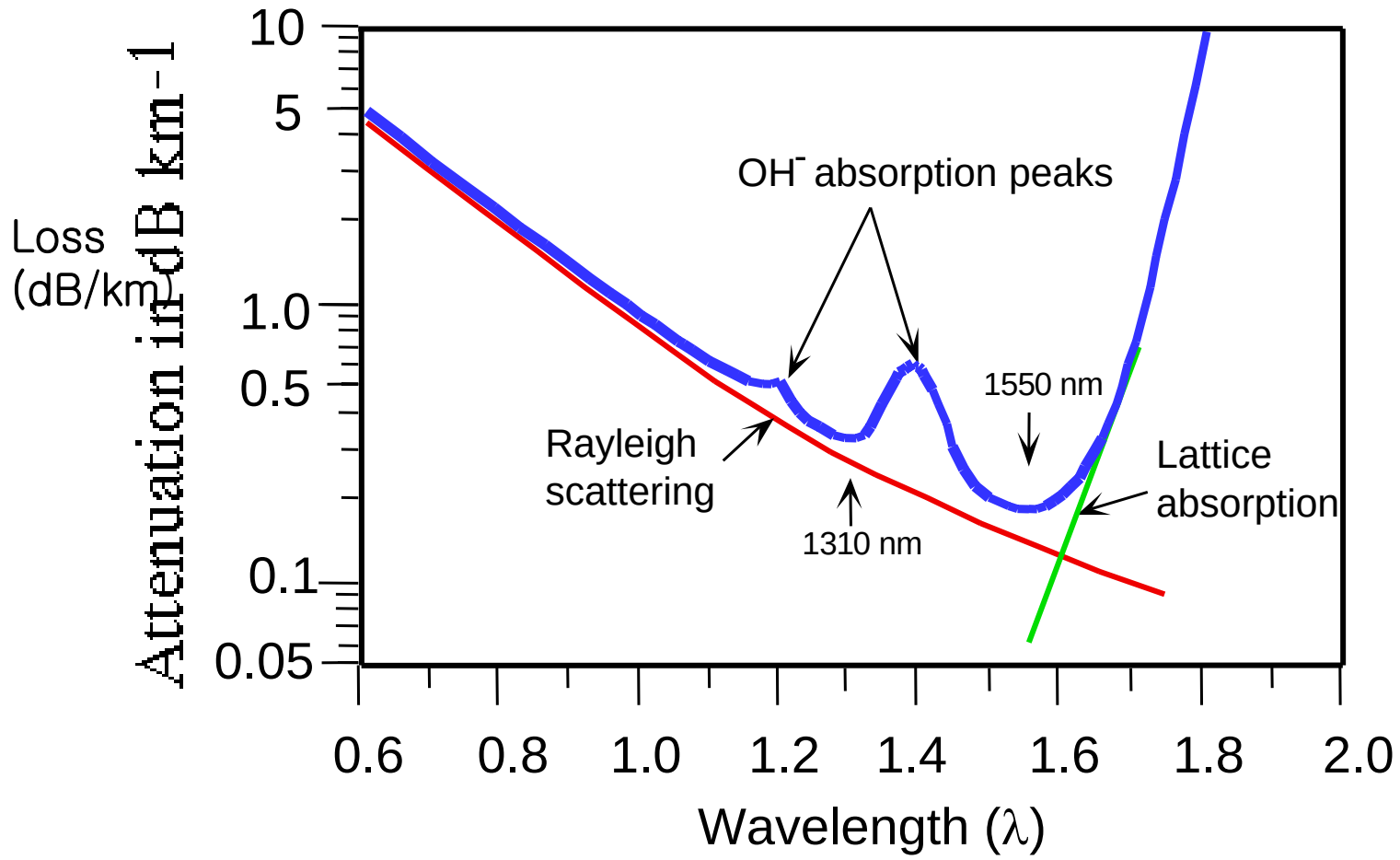
(d) The intensity in LP_{21}





For LP_{lm} mode,
m maxima along r,
2l maxima along ϕ

Loss in fiber



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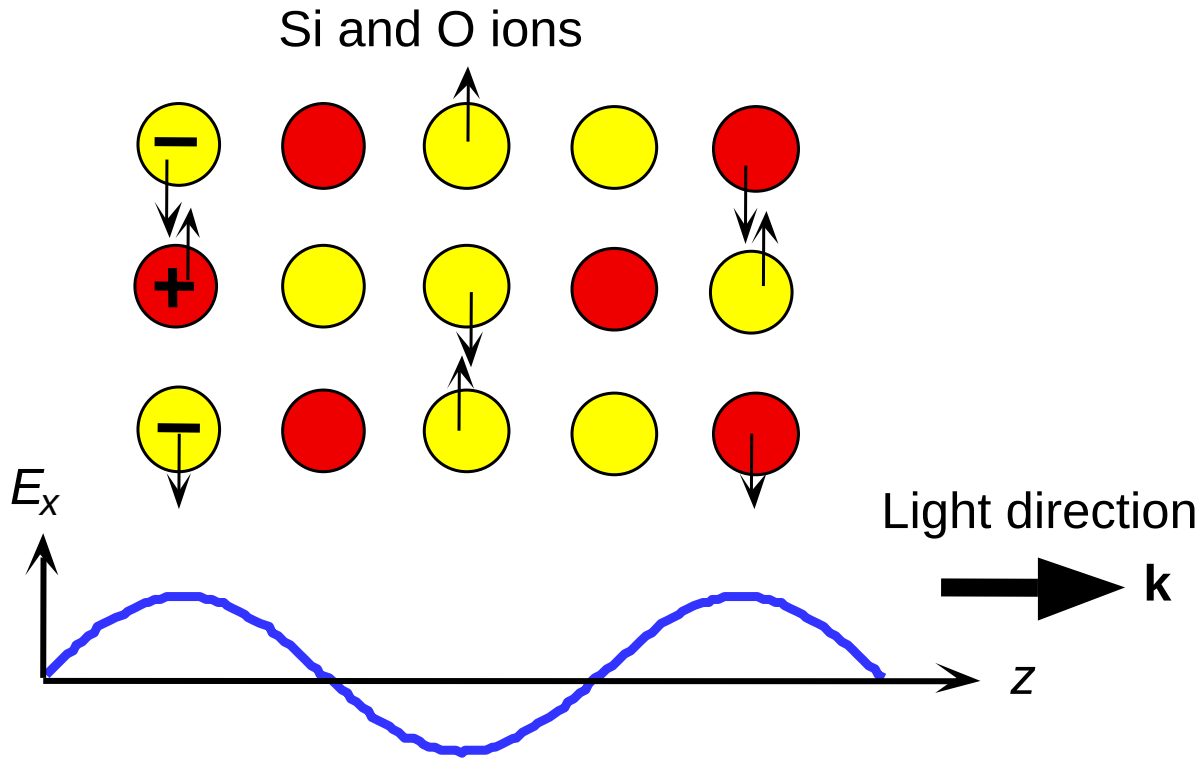
Lattice Absorption:
EM waves cause vibration of ions inside fiber.
Peak absorption occurs at around λ= 9 μm in Silica fiber.



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Rayleigh scattering
A small portion of EM waves get directed away from small dielectric particles that are due local fluctuation of fiber refractive index.
More scattering with smaller wavelength (inversely proportional to λ^3).