Photonics in Semiconductors, Spring 2017

Exercise 7, 16.3.2017

1. Dispersion and bitrate

a) The dispersion of a short light pulse propagating in a fiber is characterized by the broadened pulse width $\Delta\tau_{1/2}$. Estimate the maximum bitrate corresponding to $\Delta\tau_{1/2}$. Compute the bitrate limited by material dispersion in silica fiber. Use the result from exercise 4, problem 3.
b) If the light pulse has a Gaussian shape, show that the spread parameter is related to the bitrate by:

$$B \approx \frac{0.25}{\sigma}$$

2. Multimode fiber

Consider a multimode fiber with a core diameter of 100 µm, core refractive index of 1.4750, and a cladding refractive index of 1.4550 both at 850 nm. Consider operating this fiber at $\lambda = 850$ nm. (a) Calculate the V-number for the fiber and estimate the number of modes. (b) Calculate the wavelength beyond which the fiber becomes single mode. (c) Calculate the numerical aperture. (d) Calculate the maximum acceptance angle. (e) Calculate the modal dispersion $\Delta\tau$ and hence the bit rate $\times$ distance product.

3. Single mode fiber

Consider a fiber with a 86.5% SiO_2 - 13.5% GeO_2 core of diameter of 8 µm and refractive index of 1.468 and a cladding refractive index of 1.464 both refractive indices at 1300 nm where the fiber is to be operated using a laser source with a half maximum width of 2 nm. (a) Calculate the V-number for the fiber. Is this a single mode fiber? (b) Calculate the wavelength below which the fiber becomes multimode. (c) Calculate the numerical aperture. (d) Calculate the maximum acceptance angle. (e) Obtain the material dispersion and waveguide dispersion and hence estimate the bit rate $\times$ distance product (B $\times$ L) of the fiber. (D_m = -7.5 ps km^{-1}nm^{-1}, D_w = -5 ps km^{-1}nm^{-1}).

4. Graded index fiber

If a fiber has an axial index profile of

$$\begin{aligned} n &= n_1\left[1 - 2\Delta\,(r/a)^{\gamma}\right] && r < a \\ n &= n_2 && r \geq a \end{aligned}$$

where $\gamma = 2\,(1-\Delta)$, the dispersion per unit length is given by:

$$\frac{\sigma}{L} \approx \frac{n_1}{20\sqrt{3}c}\Delta^2$$

Consider a graded index fiber, with $n_1 = 1.480$, $n_2 = 1.460$, $\lambda = 1.3\ \mu m$, $a = 25\ \mu m$. Compute the bitrate-length-product. Compare to a value for multimode step index fiber.