Simulation: numerical modeling task

Name of course: Basic principles of optical fiber communication

Course number: 377.2.5060

One of the winning devices has been the single-mode fiber, having a step-index profile with a higher refractive index in the center core and a lower index in the outer cladding. Today's fibers have losses near the theoretical limit of 0.16 dB/km at 1.55 μm (near-infrared light). Numerical software plays an important role in the design of single-mode waveguides and fibers. For a fiber cross section, even the simplest shape is difficult and cumbersome to deal with analytically.

Consider a multimode step-index fiber made of silica glass with the inner core of radius a made of pure silica glass with refractive index $n_1 = 1.4457$, and the cladding is doped with a refractive index of $n_2 = 1.4378$ while the free-space wavelengths of 1.55 μm so $n_1 > n_2 \gg n_3$. The radius of the cladding is $\gg a$ so that the field of confined modes is zero at the exterior boundaries.

1. (20 points) Find an effective mode index of a confined guided mode and the propagation constant β for TM and TE (are they the same?). What would be the *V* number? Plot the dispersion maps and relate the guided modes m and V-number. Note: $n_1 < \tilde{n} < n_2$, $n = \beta/k_0$ and $V = a\sqrt{{p_m}^2 + {q_m}^2} = \frac{2\pi a}{\lambda}\sqrt{{n_1}^2 - {n_2}^2}$
2. (10 points) Calculate and show the field components of guided modes of the fiber.
3. (10 point) Characterize the modes: *TE* mode/*TM* mode/*HE*mn/*EH*mn.
4. (25 points) What are the $E_{z,m}(\rho, \phi, z)$ components in the core ($\rho \leq a$) and the cladding ($\rho > a$)? Present the analytical derivation and show the numerical field distributions.
5. (10 points) Draw $E_{z,m}(\rho, \phi, z)$ components in the core ($\rho \leq a$) and the cladding ($\rho > a$) as a function of: a) radial component, b) azimuthal component and c) in propagation direction.
6. (10 points) Draw $H_{z,m}(\rho, \phi, z)$ components in the core ($\rho \leq a$) and the cladding ($\rho > a$) as a function of: a) radial component, b) azimuthal component and c) in propagation direction.
7. (15 points) Calculate the: a) effective core area (4 points), b) confinement factor Γ (4 points), c) group velocity dispersion (7 points).

Light-on-a-Chip Group
School of Electrical and Computer Engineering, Ben-Gurion University, Beer-Sheva, 8410501, Israel
Email: alinak@bgu.ac.il , www.alinakarabchevsky.com