Dispersion Compensated Optical Fibers for Long Haul Communication

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Introduction: Optical fibers are the quintessential transmission lines in modern day communication system, which have enabled Terabit data transfers and long haul inter-continental internet networks. A key requirement in such systems is to have optical fibers that can transmit data over long distances with least attenuation and dispersion.

Computational Methods: Waveguide dispersion is negative and is used to tailor the refractive index profiles, to get zero overall dispersion at a particular wavelength, resulting in Dispersion Shifted Fibers (DSF), else low overall dispersion over a range of wavelengths, giving Dispersion Flattened Fibers (DFF).

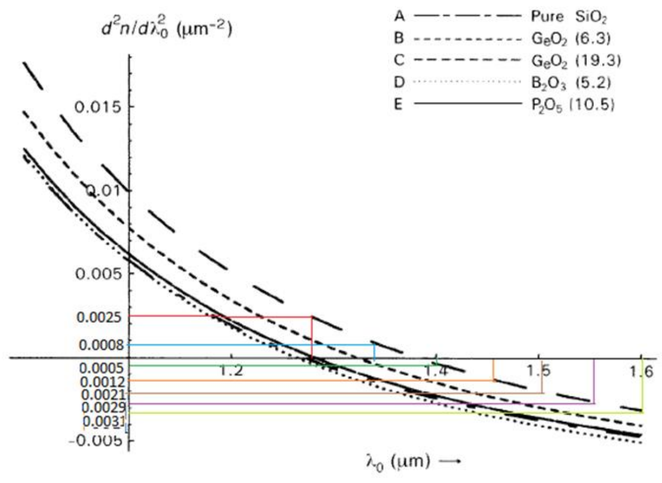
$$b = \frac{{n_{eff}}^2 - {n_2}^2}{{n_1}^2 - {n_2}^2}$$

$$b \approx \left(A - \frac{B}{V}\right)^2 \quad A = 1.1482 \; B = 0.996$$

$$\Delta T_w = \frac{-n_2 \Delta}{3\lambda_0}.10^7 \left(V \frac{d^2(bV)}{dV^2}\right) \text{ps/km-nm}$$

$$V \frac{d^2(bV)}{dV^2} \approx 0.080 + 0.549(2.834 - V^2)$$

Fig. 6.4: Variation of $d^2n/d\lambda_0^2$ for pure and doped silica. The labels A–E correspond to various samples given in Table 6.2. Observe that doping changes the ZMDW slightly.



variation of $d^2n/d\lambda_0^2$ with λ_0 is shown in Figure 6.4. As can be seen, material dispersion changes with doping.

Figure 1. Important formulas used for arriving at the results

In Comsol Multiphysics 4.4, the optical fiber was modeled using 2-Dimensional Electromagnetic Waves-Frequency Domain
Library. We modeled 2 different Dispersion Flattened Fiber profiles (Fig. 2 profile 1) and 1 Dispersion Shifted Fiber profile (Fig 3), and obtained optimum total dispersion results.

Results: Different refractive index profile for DSF and DFF fibers were obtained using Comsol Multiphysics 4.4. By tailoring the refractive index profiles of step index optical fiber, the dispersion was reduced and kept within 3 ps/km-nm.

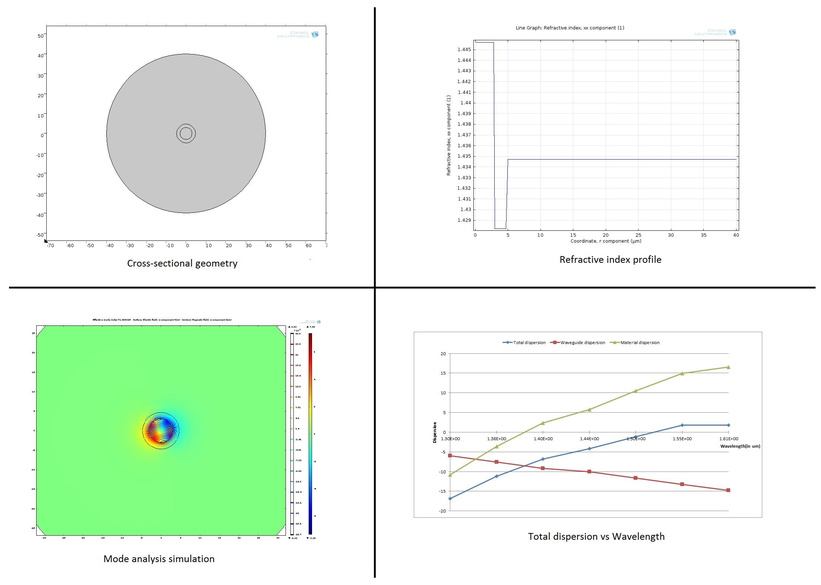


Figure 2.DFF Profile 1

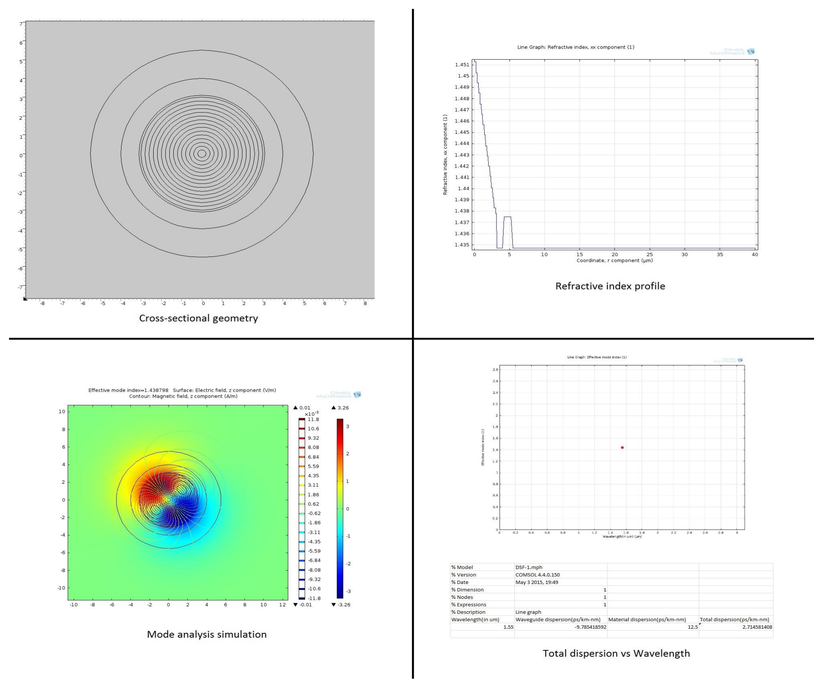


Figure 3.DSF Profile 1

Conclusions: These single mode dispersion compensated fibers are of great importance in long distance communication, since they offer very low attenuation and low dispersion around 1.5 micrometer ranges. This study enables us to design the DSF and DFF fibers which help in reducing the dispersion in optical fibers.

References:

1. Ghatak, Thiyagrajan, “Introduction to fiber optics”, fig 6.4 page 83.