Photonic Crystal Fibers for Visible Light Generation

D. Aydin[1], S. J. Cordette[1], C. Brès[1]

[1]EPFL, Lausanne, Vaud, Switzerland

Abstract

There has been a growing interest in optical parametric amplifiers (OPA) for light generation and amplification in because of the possibility for arbitrary operation wavelength and wideband tenability [1]. PCFs are of particular interest in such nonlinear optics applications because of the enhanced light confinement and the resultant high nonlinearity (γ) achievable with air-cladded designs. Additionally, the geometric parameters of PCFs provide multiple degrees of freedom for dispersion engineering. In turn, a tunable dispersion profile enables phase-matching in arbitrary wavelength regimes to take advantage of interesting nonlinear effects, such as four-wave mixing (FWM).

Here we simulate a PCF design for its use as a fiber-optical parametric amplifier medium to generate a relatively high-power, fiber-based, continuously tunable visible light source using a near-IR pump and a 2μm signal. Starting from PCF designs which are shown to operate around 1μm [2], we have chosen a hexagonal lattice, solid-core silica PCF with a highly Germania doped (20% mol.) core.

In tailoring PCF dispersion, the relevant design parameters are the pitch (Λ), diameter of the air holes (dhole), doped-core size (dcore) and the doping concentration. We have run the COMSOL Multiphysics mode solver to explore the effects of these parameters on the λZDW. For this, we have used the mode solver and extracted the effective refractive index (neff) for the guided modes. From frequency derivatives of neff, dispersion profile of the waveguide was determined. An important design metric is the air hole diameter to pitch ratio (dhole/Λ, also known as the air filling fraction) which controls the number of guided modes as well as the zero-dispersion crossing [3] Additionally, reducing the core size to below 1 μm can also cause two zero dispersion crossings to occur [4].

Our simulations show that a suitable dispersion profile in PCF can be achieved with a high filling fraction, which pushes the ZDW into the near IR (shown in Fig.1) for access with high power pumps. Fig. 2.a-c show the excellent guided mode localization for the designed PCF for all of signal, pump and idler wavelengths.

Reference

R. Jiang et al., “Translation of Gbps phase-modulated optical signal from near-infrared to visible band,” in Journal of Lightwave Technology, 2008, vol. 26, no. 1, pp. 131–137.

G. Mélin et al., “Highly-nonlinear photonic crystal fibre with high figure of merit around 1 [micro sign]m,” Electron. Lett., vol. 48, no. 4, p. 232, 2012.

K. Saitoh and M. Koshiba, “Empirical relations for simple design of photonic crystal fibers.,” Opt. Express, vol. 13, no. 1, pp. 267–274, 2005.

J. M. Dudley and J. R. Taylor, "Supercontinuum generation in optical fibers. Cambridge University Press, 2010."

Figures used in the abstract

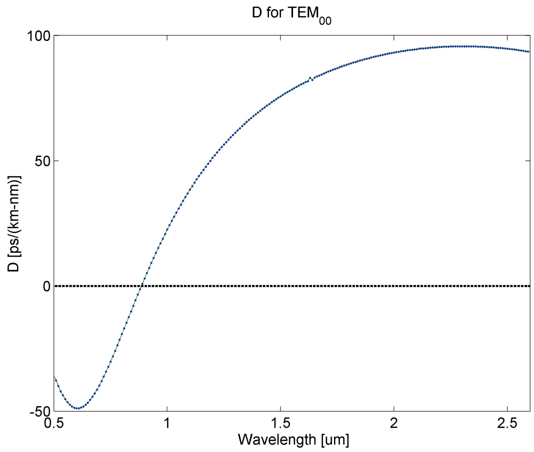

Figure 1: Fig.1. Dispersion profile of a PCF capable of accessing 2um and visible bands through FWM with a near-IR pump.

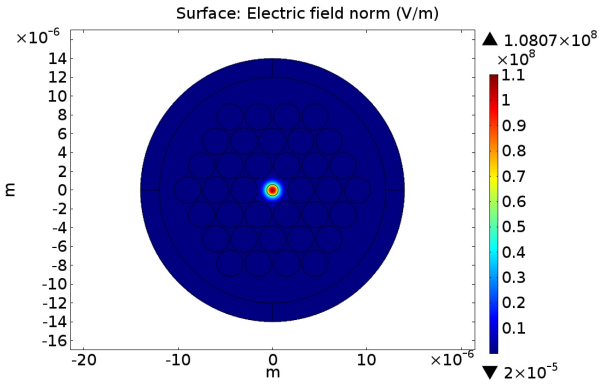

Figure 2: Normalized E-field (V/m) distribution at 640nm for the waveguide with dispersion in Fig.1.

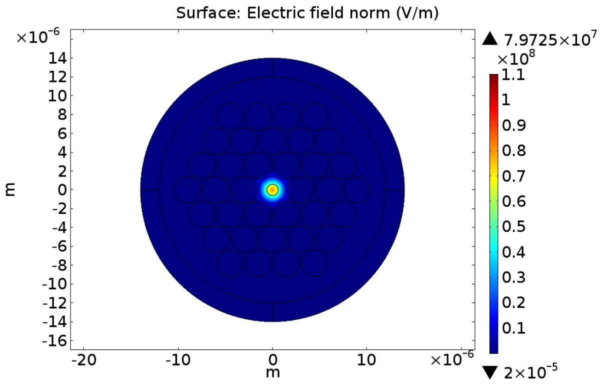

Figure 3: Normalized E-field (V/m) distribution at 1040nm for the waveguide with dispersion in Fig.1.

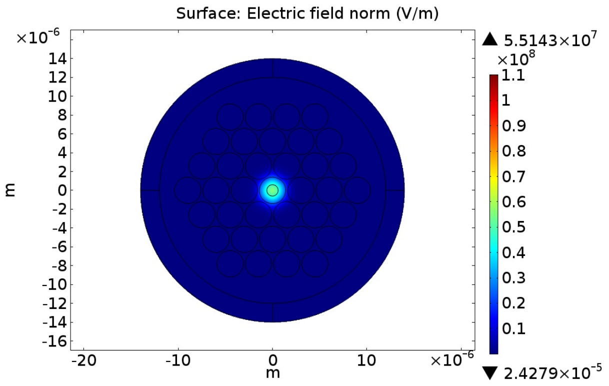

Figure 4: Normalized E-field (V/m) distribution at 2260nm for the waveguide with dispersion in Fig.1.