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A photonic crystal fiber with zero dispersion at 1064 nm

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Abstract: We report on the dispersion properties of a single mode, large core photonic crystal fiber. Using white light interferometry the fiber is found to have zero dispersion at 1064 nm.

Introduction

One of the reasons for the recent interest in photonic crystal fibers [1] is their nonlinear response which can be tremendous compared to conventional optical fibers. This is evident in e.g. the supercontinua produced in photonic crystal fibers using sub-nanojoule femtosecond pulses [2]. The enhancement of the nonlinear response is mainly determined by the phase matching properties of the fibers. The phase matching of nonlinear effects is determined by the dispersion profile of the fiber and this can be widely tuned through the design of the fiber i.e. the size and patterns of the airholes surrounding the fiber core. Second, the core of photonic crystal fibers can be made smaller than in conventional optical fibers. The smaller modesize increases the intensity in the core which in effect increases the nonlinear response of the fiber. The large design degrees of freedom open up possibilities for having fibers made with phase matching properties fitting the laser sources at hand and the design of a photonic crystal fiber with a much higher nonlinear coefficient seems very possible. In this paper we present dispersion measurements of a photonic crystal fiber with zero dispersion at 1064 nm i.e. at the Nd:YAG laser wavelength.

Experimental Set-up

We measure dispersion using a homebuilt white light interferometer [3]. A sketch of the apparatus is seen in Fig. 1. Briefly, the apparatus works as follows: White light from a halogen light bulb is transported to a Mach-Zender interferometer through a standard optical fiber and collimated by a microscope objective. Before impinging on the input beamsplitter the beam is sent through a polarizer. In one of the interferometer arms the light is coupled through a short piece of fiber (typically 25 mm) using microscope objectives. The dispersion in the microscope objectives is compensated with a block of glass in the reference arm. The slightly birefringent fiber piece is aligned with a principal axis parallel to the polarization axis. A translation stage provides control of the optical delay. The optical delay is calibrated with a Mach-Zender HeNe interferometer (not shown) overlaid the white light interferometer. The white light interferograms are recorded using two

photodetectors and lock-in detection. The visible part is measured with a silicon avalanche photodiode whereas the infrared part is covered with a InGaAs photodiode. With these two detectors the wavelength range 500-1700 nm can be covered. Experimentally, interferograms with and without the fiber present are recorded. By Fourier transforming the interferograms the spectrum and relative phase of the spectral components of the white light is found. The phase imposed on the white light by passing through the fiber is found by subtraction of the two data sets. The phase is fitted to a polynomial and the fitting coefficients are directly related to the dispersion [3].

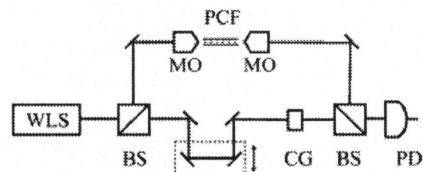


Figure 1 Schematic overview of the white light interferometer. WLS: white light source, BS: beamsplitter, MO: microscope objective, PCF: photonic crystal fiber, CG: compensating glass, PD: photodetector.

Results

The fiber under investigation is a photonic crystal fiber made from fused silica. A SEM picture of the central region of the fiber is shown in the inset in Fig. 2. The core diameter is 5.8 μm and the surrounding airholes have a diameter of 1.1 μm with an interhole spacing of 2.5 μm . To test the fiber for single mode operation, a short piece of the fiber was placed in the interferometer and a HeNe laser was used as the light source. A resulting clear interference pattern with high fringe visibility indicates that only a single mode has been excited in the fiber [4].

Figure 2 shows the measured dispersion curve. The zero dispersion wavelength is found to be 1064 nm with an uncertainty of 3 nm. In the telecom region at 1550 nm the dispersion is 46 ps/nm*km. In the visible region the dispersion is dominated by material dispersion. By rotating the polarizer in front of the interferometer we measure the dispersion along either of the two principal axes. Throughout the entire IR region and well into the visible the dispersion profiles along the two axes are identical within the experimental uncertainty. A slight difference between the two states is observed below 750 nm.

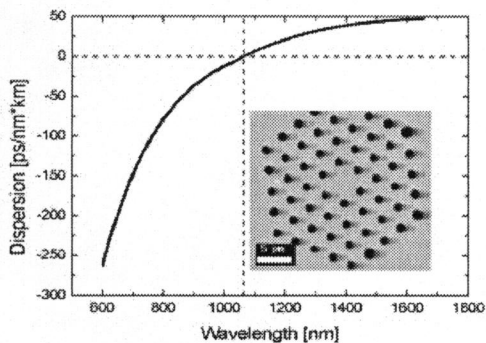


Figure 2 Dispersion profile of the investigated photonic crystal fiber. The zero dispersion wavelength is 1064 nm. The inset shows a SEM picture of the fiber core.

A zero dispersion wavelength of 1064 nm indicates that this fiber is well suited for generating a nonlinear response when pumped with Nd:YAG lasers. We note that slight modifications of the fiber design will allow for a fiber with the same dispersion properties but with either a smaller or a larger core. A smaller core will increase the intensity of the light in the fiber thus enhancing the nonlinear response whereas a larger core will decrease the nonlinear response and making the fiber useful for other purposes i.e. transportation of pulses from modelocked Yb fiber lasers with a minimum influence from dispersion.

Conclusion

In conclusion we have investigated the dispersion properties of a large core, single mode photonic crystal fiber using white light interferometry. The zero dispersion wavelength is 1064 nm. Further experiments will elucidate the functionality of the fiber when pumped by Nd:YAG lasers. The fiber for the experiment was kindly provided by Crystal-Fibre A/S. HNP thanks NKT Academy for financial support.

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