Tunable Broadband in Supercontinuum Spectrum Based on Polarization Effects

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Abstract: We demonstrated that the bandwidth control in supercontinuum source is possible through polarization effects induced on a PCF. The spectral width obtained can be selected from 740 nm-1430 nm while it maintains a good flatness.

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1. Introduction

Actually, the control of supercontinuum (SC) spectral characteristics is crucial for many scientific and technological applications, for example, in gas sensing usually it is necessary to isolate a spectral region in order to minimize background effects and absorptions from different gasses. For this reason, several authors are working with different designs of supercontinuum sources, taking advantage of the very fast development of special fibers and pump sources capable of emitting ultrashort pulses with durations in the order of picoseconds and femtoseconds. In particular, designs based on photonic crystal fibers (PCF) are being widely studied for their interesting properties.

This work seeks to improve the experimental results obtained previously by using pulses with a duration of 700 picoseconds in a piece of PCF. With the proposed optical setup we obtained an adjustable SC spectrum, which presents improved characteristics compared with other sources [1,2]. It is important to note that the effect of polarization changes in SC generation is an issue not studied in detail, so that the analysis can be of great interest.

2. Experimental setup

In Fig. 1 a pump source based on a microchip laser at 1064 nm was used. The proposed optical design consists in the use of pulses with high energy and wide-spectrum facilitating the spectral broadening. The laser beam is coupled into a piece of 2 m of PCF. A quarter wave retarder (QWR) and a half wave retarder (HWR) inserted in the experimental setup allowed to control the polarization state, analyzing a linear and circular polarization in the fiber input. Finally, mechanical effects are induced at the beginning of the PCF which was twisted and wrapped around a mechanism, by changing the polarization state of the pump pulse, with the number of turns and the diameter of the device we can select the spectral width by controlling fiber losses and birefringence.

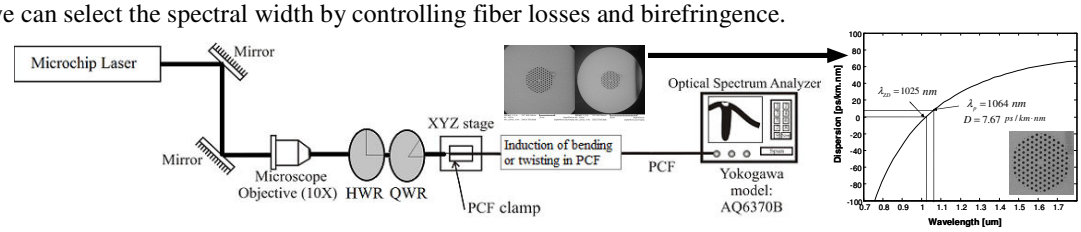

Figure 1. Experimental setup

3. Experimental results and discussions

The PCF used in this work is a solid core fiber with an air hole diameter (d) and a pitch (Λ) of 1.23 µm and 2.87 µm respectively. We estimate the dispersion parameter as a function of wavelength (Fig. 1) using

$$D = -\frac{\lambda}{c}\frac{d^2 n_{eff}}{d\lambda^2} + D_m, V\left(\frac{\lambda}{\Lambda},\frac{d}{\Lambda}\right) = A_1 + \frac{A_2}{1 + A_3 \exp(A_4 \lambda/\Lambda)}, \quad W\left(\frac{\lambda}{\Lambda},\frac{d}{\Lambda}\right) = B_1 + \frac{B_2}{1 + B_3 \exp(B_4 \lambda/\Lambda)} \tag{1}$$

equations based in a method proposed by K. Saitoh [3]. At the pumpping wavelegth (λ =1064 nm), we find D = 7.67 ps/nm.km, indicating that dispersion is slightly anomalous at that wavelength. In relation to the zero-dispersion wavelength (λ_{ZD} = 1025 nm), we have that $\lambda > \lambda_{ZD}$.

The experimental results shown in Fig. 2 were obtained adjusting the twist and bending in the PCF. In all results we can appreciate the signal produced by microchip laser without the influence of nonlinear phenomena. The evolution of the SC spectrum for different adjustments of twist in the PCF with linear and circular polarization in the fiber input is appreciated in Fig. 2(a) and Fig. 2(b) respectively. In the case of bending, we can appreciate the evolution on SC spectrum for some adjustment based on changing the diameter of curvature in the PCF for linear (Fig. 2(c)) and circular polarization (Fig. 2(d)) in the fiber input.

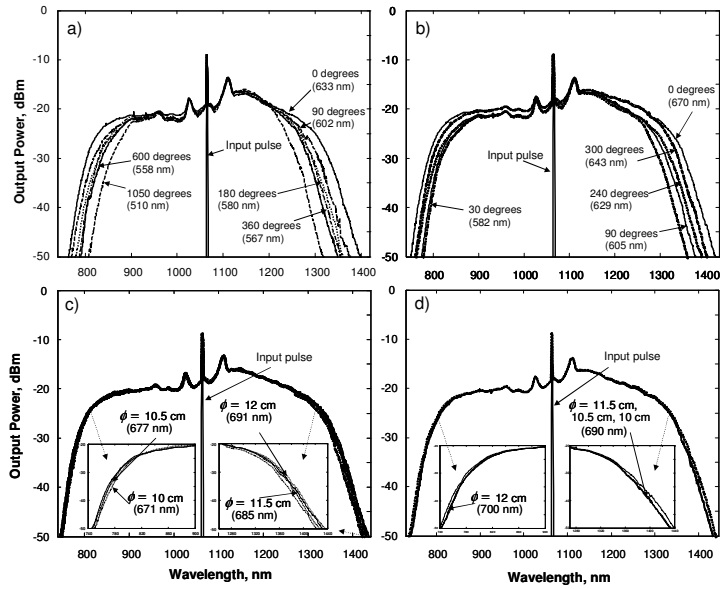

Figure 2. Supercontinuum light source spectra obtained for different values of twist in the PCF with a) linear polarization, b) circular polarization in the fiber input, and different values of bending in the PCF with c) linear polarization, d) circular polarization in the fiber input.

Through the analysis of the experimental results, we observe that the most notable change ocurred in the case of twist adjustments obtaining a control over the spectral width of more than 120 nm. In the case of bending, the spectral width can only be adjusted over a few tens of nanometers, however in this process a finer tuning in the spectral evolution is obtained. The possible explanation for such small variations in the case of applying bending to the fiber is related to the properties of the PCF, mainly its low sensitivity to bending losses even for high mode areas, however, some works show that a low effective area has a positive effect on the bending losses [4], while some studies shows that the twist generated more intense changes in the spectrum of PCF [5].

4. Conclusions

We proposed an easy and flexible way to control on the spectral width of a supercontinuum ligth source based on polarization effects. The possibility to get a spectral control on supercontinuum ligth sources with stresses applied in the PCF was demonstrated through induction of mechanical effects, such as bending and twisting. The experimental results show that we can increase or decrease the spectral width with the advantages of obtaining a wide and flat spectrum., which are very useful characteristics in many of the applications mentioned in this work.

Acknowledgments

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5. References

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