Hi-Bi optical fiber for Rocking Filter formation

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Abstract

We report the Rocking Filter formation in an elliptical core fiber internally exposed to 514,5 nm circularly polarized light. When compared with stress induced birefringent fiber for similar exposure parameters the use of elliptical core fiber lead to higher efficiency couplers.

Introduction

Also known as polarization coupler, Rocking Filter is a fiber optic device that couples two polarization modes in a specific wavelength band. This coupling is based on the resonance between a periodic birefringent refraction index modulation and the modes involved. Such device can be used in temperature[1] and pressure[2] sensors, as well as in optical communications systems, acting as router or demultiplexer[3].

There are two main techniques used to fabricate Rocking filters: internal and external exposure. Both of them rely on the permanent photoinduced refraction index change after exposure to green, blue or UV radiation. This change is related to GeO_2 defect bands around 240 nm[4,5] and is possible in the visible wavelength due to a two-photon absorption process[6]. One important issue is that this change is also birefringent.

For internal method, the periodicity of the exposure corresponds to the beat between cross-polarized modes propagating in the fiber. In high birefringent (Hi-Bi) fibers, the propagation constant for these cross-polarized modes is different. When the two orthogonal modes are excited, the state of polarization evolves periodically along the fiber. In the regions where the phase between these modes is a 2π multiple, the polarization is linear, with the electric field oscillating at 45 degrees in respect to the fiber birefringence axis. In these regions the photo-sensibilization of the fiber core achieves its maximum. Using this technique the coupling wavelength is the same as the writing beam wavelength.

Experiments and Results

The AD137 fiber used is 80 cm long and has an elliptical core diameter of 3.24 μm with an ovality of 46%. It is monomode above 750 nm and contains germanium and aluminum as dopants. Figure 1 shows the experimental setup used for the coupler fabrication. The quarter wave plate (QWP) converts the linearly polarized light from a CW Ar^+ laser in circularly polarized which is coupled using a 40x objective lens (L). The launching efficiency was approximately 45%. Using this method, an equal excitation of the polarization modes is guaranteed. The fiber was exposed to an incore intensity of 150 mW at 514,5 nm for 30 minutes. A power meter (PM) was used for monitoring the power coupled to the fiber during the exposure since misalignments are common, probably caused by the thermal expansion of the fiber coating. The coupling spectrum was measured using the setup showed in figure 2.

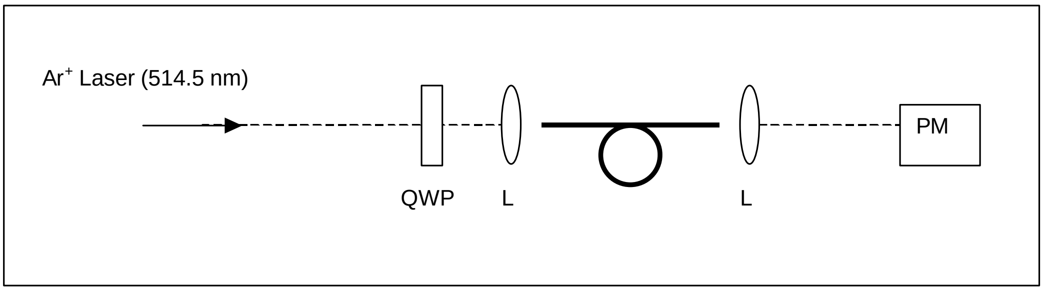

Figure 1. - Experimental setup used for the fiber exposure

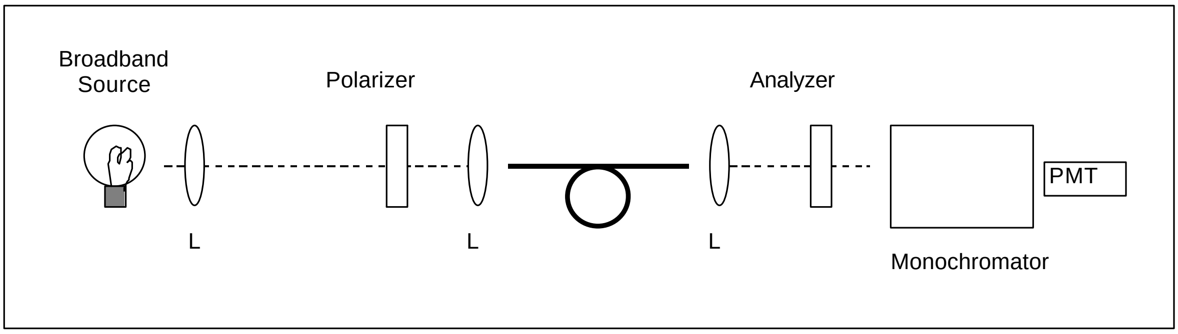

Figure 2. - Experimental setup used to measure the coupler

Figure 3 shows the coupling spectrum obtained with a ScienceTech 9050 monochromator set for a resolution of 0,5 nm. The polarizer angle is set parallel to one axis of birefringence of the fiber. The sum of the crossed polarized components at the fiber output corresponds to the total intensity launched into the fiber. The intensities were measured, after the monochromator, using a photo-multiplier tube (PMT) and rotating the analyzer to the proper axis. The efficiency of the coupler corresponds to the percentage of the total intensity in the fiber core, which couples to the crossed polarization at the resonance wavelength:

$$e\% = \frac{I_x}{I_x + I_y}$$

Where I_x and I_y are the intensity measured for the coupler with the analyzer placed respectively perpendicular and parallel to the input polarizer at the resonance wavelength. The efficiency was calculated to be 60% at 514.5 nm.

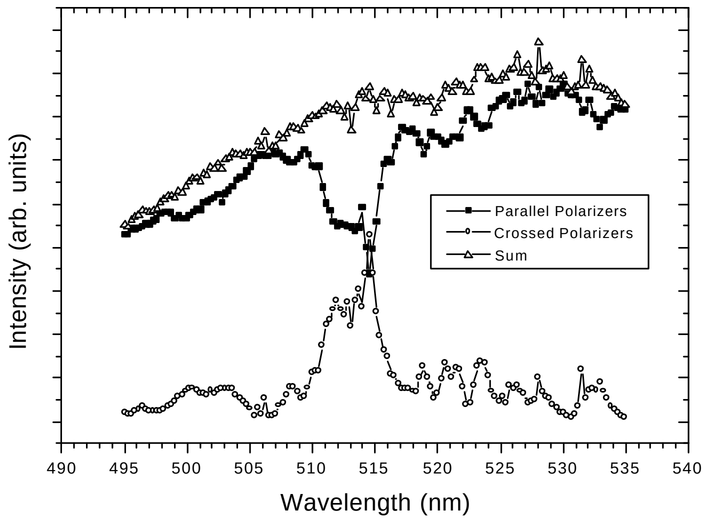

Figure 3. - Coupling spectrum

Previous experiments carried out in our laboratory using intrinsic stress induced Hi-Bi fibers and external curvature induced birefringent fibers[7] lead to low efficiency couplers. It is known in the literature[8] that the mechanical stress somehow disables the photoinduced birefringence in one axis of the fiber. Another approach used to overcome this issue employs the external exposition method, but using low birefringence fibers where the linear birefringence is produced by winding the fiber after exposure[9].

The main concern in producing the Rocking Filter is the ability to change the refraction index and this change must be birefringent. The maximum coupling occurs when the periodic photoinduced birefringence is aligned at 45 degrees with the intrinsic birefringence axis[10]. Perhaps the orientation of the beam is a special concern for the external method, using the internal method it is automatically obtained.

Conclusion

For the internal method of production, the use of elliptical core fiber to promote the periodic interaction between the modes to be coupled seems to be the determinant factor in obtaining couplers with higher efficiency. In such fibers, the intrinsic birefringence, necessary to promote this interaction, is originated in the ellipticity of the core. Since the operating wavelength of the elliptical core fiber used is below the cutoff wavelength (750 nm), it operates in a multi-mode regime, further study will be dedicated to determine more accurately the modes involved in the coupling. Measuring the coupling spectra, the peak efficiency of 60% between modes of crossed polarization was verified.

Acknowledgements

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