Rocking Filter formation in circular core monomode optical fiber

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Abstract

In this work we report on the Rocking Filter formation in a low cost commercial circular core monomode optical fiber that was made birefringent, and thus polarization maintaining, by winding the fiber around a cylindrical mandrel. A circularly polarized CW Ar^+ laser at 488nm was used as the writing beam source. The photoinduced modifications into the fiber lead to a selective coupling between the two polarisations of the fundamental propagation mode in the region of the writing wavelength. A bandwidth of about 3 nm was achieved for a 52 cm long fiber.

It is well known that the refractive index is changed permanently in many types of doped optical fibers after a convenient exposure of the core to intense optical fields [1]. The origin of this photoinduced effect is not yet fully understood; however, it can be used in a variety of practical devices in the field of optical communications and sensing such as WDM systems, wavelength selective switches and temperature, stress and pressure sensors [1,2]. In this way, fiber photosensitivity has been used to fabricate both Bragg gratings [2] and polarization sensitive couplers (the so called Rocking Filters) in polarization maintaining (PM) optical fibers.

The photosensitivity in optical fibers is believed to be due to the presence of GeO_2 working as a dopant [3,4]. In 1989 Meltz *et al*. [5] showed that a strong index of refraction change occurred when a germanium-doped fiber was exposed to UV light close to the absorption peak of germania-related defect at a wavelength range of 240-250nm. Also refraction index changes after exposing the fiber to laser light at 488nm have been reported, which is possible due to a nonlinear two-photon absorption process [6].

The principle of inducing a periodic grating inside the fiber is as follows. The technique relies on the periodic evolution of the polarization state with distance for a launched optical electric field circularly polarized on the fiber. As the light propagates the polarization state evolves through left-circular, linear (orthogonal to the incident direction), and right-circular back to the initial linear state. This pattern repeats at the beat period of the birefringent fiber. The perturbation induced by exposure is axially periodic, and permits a small component of the electric field in the fast (slow) mode to radiate into the orthogonal slow (fast) mode at positions where the two modal fields are in phase. The result is phase-matched power conversion between the modes.

The optical fiber used in our experiment was a circular core optical fiber, model F-SA, cutoff wavelength around 380nm, purchased from Newport Corporation. By winding the fiber around a 0.62cm diameter cylindrical mandrel it was made birefringent and thus polarization maintaining [7]. The light source used was a circularly polarized CW Ar^+ laser beam at 488nm. We exposed 52cm of the fiber to a power of about 1W during 10 minutes. The coupling spectrum was obtained by launching white light into the fiber and the output signal was dispersed by a monochromator and detected by a photomultiplier.

Figure 1 shows the transmitted signal through the fiber placed between crossed polarizers. Both polarizer and analyzer were aligned to the birefringence fiber axis. From this figure one can observe the light induced birefringence around the writing wavelength region. The high transmitted intensity in the lower wavelengths reflects the responsivity of the experimental setup, i.e., light source spectrum, monochromator and photomultiplier response.

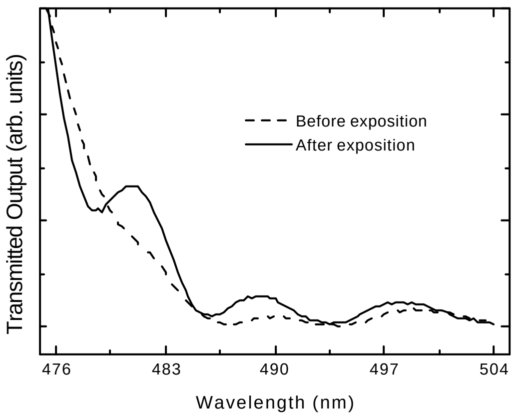

Figure 1- Transmitted output through the fiber, before exposition (dashed line) and after laser exposition (solid line).

By taking the ratio of the two spectra from Figure 1, in order to minimize the system responsivity effects mentioned above, a more evident indication of the photoinduced changes in the core fiber can be seen. The most efficient coupling between the two ortogonal polarisation modes (of the fundamental one) is around 488 nm, the writing wavelength.

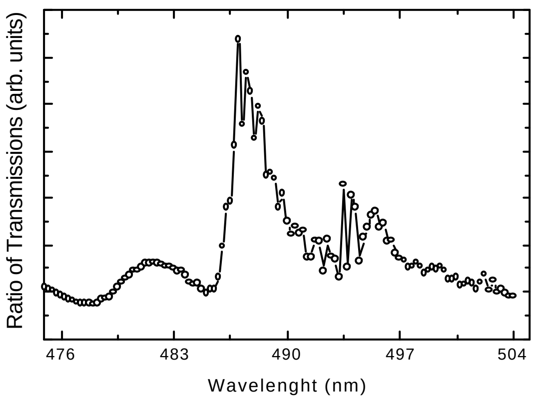

Figure 2- Division between the transmitted output through the fiber after exposition and before exposition (the solid line is just a guide to the eye).

With this method it was possible to measure a 3nm bandwidth and 17% efficiency for the Rocking Filter at 488nm for a 52 cm long fiber. Our preliminary measurements also indicate a temperature dependent wavelength coupling, which probably allows its use as a fiber-optical based temperature sensor. Theoretical works are already in progress in our group to better explain the experimental data. Also further experiments are under way to assess this method in obtaining Rocking Filter based sensors.

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