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568

PHOTO-INDUCED BIREFRINGENCE IN OPTICAL FIBERS: A COMPARATIVE STUDY OF LO-BI AND HI-BI FIBERS

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Abstract

A study of photo-induced birefringence reveals that stress-induced high birefringence fibers, in contrast to low-birefringence fibers, are photo-insensitive along the fast axis. The induced birefringence in high-birefringence fibers is permanent, whereas the change in low-birefringence fibers is reversible.

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Summary:

Photo-induced birefringence (PIB), reported some time ago by Parent *et al.* [1], was recently used for the first time to realize (via polarisation mode interference) "rocking" filters in high- birefringence (Hi-Bi) fibers that function as polarization mode converters in a narrow spectral band [2]. These devices have subsequently been demonstrated in elliptical-core fibers at 514.5, 488 and 532 nm [3], with much higher efficiencies.

Ouellette *et al.* have recently characterised the PIB in Lo-Bi germanosilicate fiber [3]. In this paper we present results of a detailed comparative study between low-birefringence (Lo-Bi) and Hi-Bi fibers. The results reveal a number of interesting differences, including the reversibility of PIB and the

insensitivity of Hi-Bi fibers to light polarized along the fast axis, which explains the higher efficiencies of rocking filters in elliptical core fibers. We also report the first measurement of the sign of PIB.

A pump-probe setup, illustrated in Figure 1, was used to measure the birefringence changes. Linearly polarized, CW mode-locked 532 nm light from a frequency-doubled Nd:YAG laser was launched into the fiber, with its polarization state aligned along one of the principal axes of the fiber. The induced birefringence was monitored by launching a linearly polarized, 633 nm He-Ne probe beam at 45° to the principal axes. By measuring the power transmitted through an analyzer, also aligned at 45°, changes in the birefringence could be measured.

The induced birefringence, ΔB, is plotted as a function of time for Hi-Bi and Lo-Bi cases in Fig. 2(a) and Fig. 2(b), respectively. After the first 45 minutes the polarization of the 532 nm pump beam was rotated by 90°, i.e., from the x-direction to the y-direction. Then after another 45 minutes the polarization of the green light was turned back to the x-direction; after a further 45 minutes the green light was blocked. For the Hi-Bi fiber the x and y directions correspond to the slow and the fast axes, respectively.The slow and fast axes could not be determined for the Lo-Bi fiber.

We find that during the first 45 minute period the behaviour for the Hi-Bi and Lo-Bi fibers is similar. When the polarization is rotated, however, the Hi-Bi fiber exhibits a rapid transient change, after which there is no further change in the bi-refringence. Then, when the pump polarization is returned to its original direction (x-direction), the induced birefringence, ΔB, continues to grow as it did during the first 45 minute period.

For the Lo-Bi fiber, on the other hand, the change in second 45 minutes is approximately twice the change in first 45 minutes. This is due to the superposition of bleaching out of the ΔB created by the pump along the x-direction and the new ΔB created by the pump along the y-direction. Hence, we conclude that PIB is reversible in Lo-Bi fibers; whereas the change in Hi-Bi fibers is permanent.

A maximum PIB of 10^{-5} has been attained in both the Hi-Bi and the Lo-Bi fibers. The sign of the birefringence was measured to be negative by implementing a Michelson's interferometer.

Our results suggest that two possible mechanisms may be involved. While stress seems to be playing a role in the observed asymmetry of PIB in Hi-Bi fibers, the reversibilty of PIB in Lo-Bi fibers suggests an electronic redistribution type mechanism. Further experimentation, including a more detailed study of the dynamics of the process, is necessary before more certain conclusions can be drawn.

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Figure captions

1. Experimental setup. HWP: Half-wave plates. BS1,BS2: Beamsplitters, L: Lenses. GP: Glass plate. PM: Power meter. F: Filter, D1,D2: Detectors. AN: Analyzer. The signal from detector D2 was divided by the signal from detector D1 to obtain a normalized signal which was independent of the launch conditions.

2. The normalized transmission through the analyzer converted to a birefringence change ΔB for a) Hi-Bi fiber and b) Lo-Bi fiber.

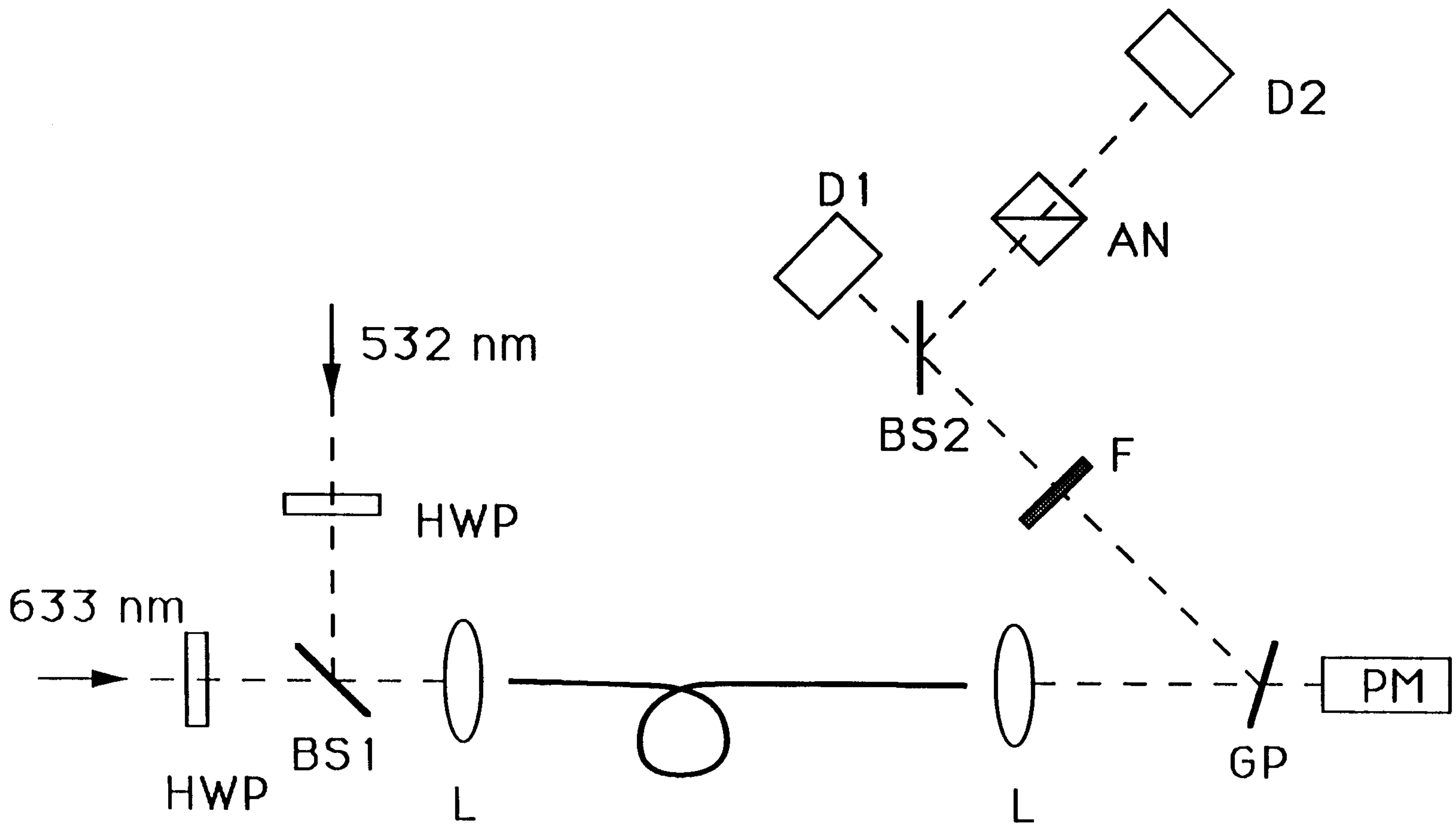
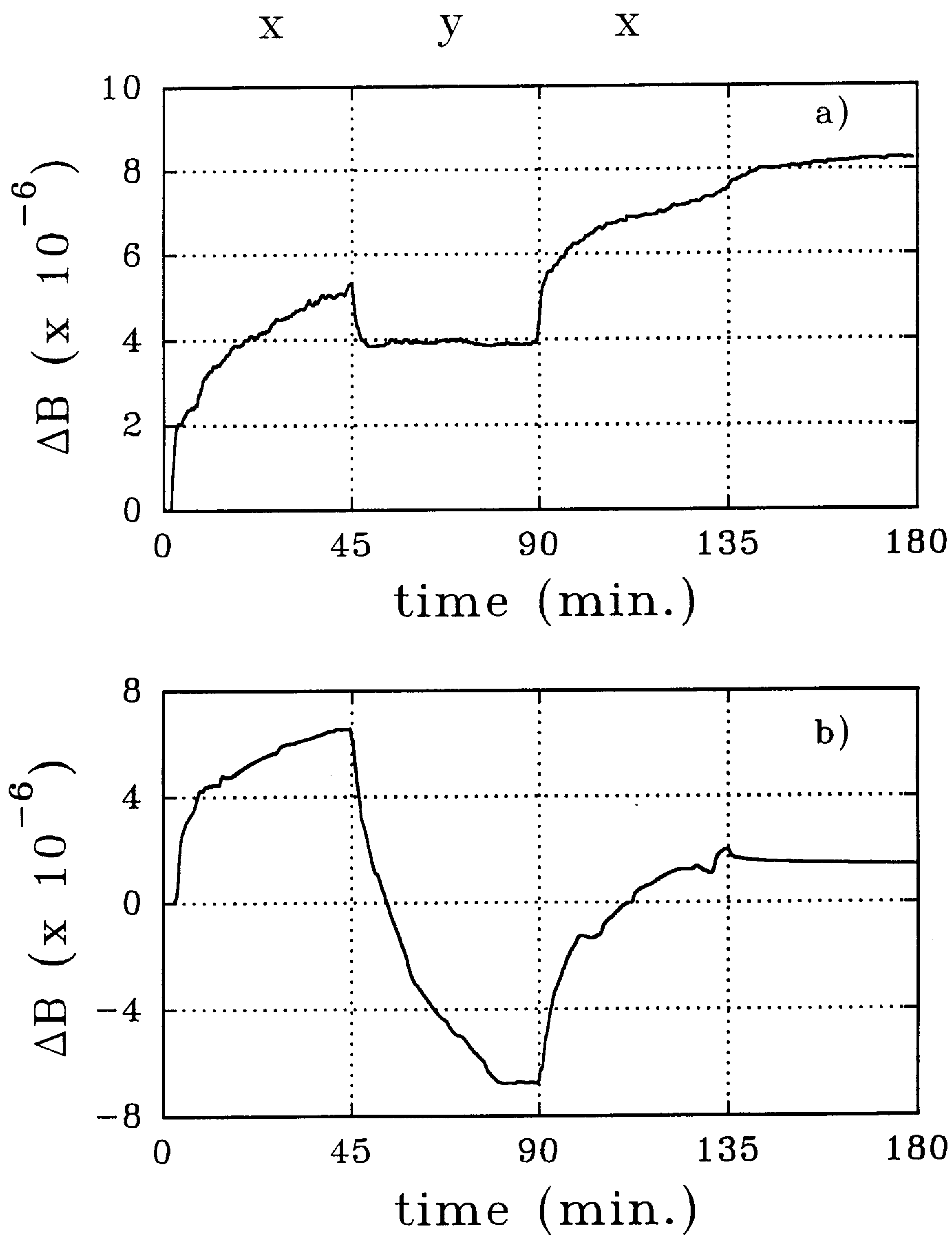

532 nm
HWP
633 nm
HWP
BS1
L
L
D1
D2
AN
BS2
F
GP
PM

Fig. 2


x
y
x
a)
ΔB (x 10^-6)
10
8
6
4
2
0
0
45
90
135
180
time (min.)
b)
ΔB (x 10^-6)
8
4
0
-4
-8
0
45
90
135
180
time (min.)