**Abstract** – We report the improved Faraday effect of the twisted single mode fiber upon changing the effective length under magnetic field. The Faraday rotation angle was measured to be about 52.21° with 183 cm of the fiber at 0.142T.

I. INTRODUCTION

Recently, optical fiber based magneto-optic devices (e.g. all-optical fiber isolators) are attracting attention because of their easy handling and market potentials. Optical isolator is a non-reciprocal device which allows propagation in only one direction. Optical fiber isolators can be used in the network systems or laser systems to block reflected and unwanted optical signal or laser beam. They are also used to prevent the signal source or laser source from damages caused by back-reflections from optical devices such as fiber optic connectors and receivers. Most popular isolators are the bulk glass isolators, which need bulk optical devices such as birefringence plates, special launching lenses requiring precision alignment and careful handling [1]. Recently, some of the optical isolators using the single mode fiber have been reported [2]. Our group has also reported the development of Faraday rotation type magnetic sensor based on specialty optical fibers [3]. However, silica optical fibers show low magneto-optic property in terms of Verdet constant (~ -0.64 rad T⁻¹ m⁻¹ at 1550nm and -0.22 rad T⁻¹ m⁻¹ at 1310nm [4]). Polarization control with rotation angle of 45° is needed for all-optical fiber isolator. To improve the magneto-optic property of optical glass fibers, structure modified fibers such as spun fiber, PM fiber were developed to reduce linear birefringence [5-6]. However, these fibers have complicated fabrication process and high cost. In this paper, we address this problem by fabricating a specialty fiber proposing a Faraday effect based all optical fiber isolator. We developed the specialty optical fiber by using the easy and cost effective fabrication process. We also suggest the possibility of development of all-optical fiber type isolator by using this specialty fiber.

When the plane of polarization of the light beam passes through the medium that is under uniform magnetic field parallel to the light propagation direction, it rotates by angle θ. This Faraday rotation angle θ is given by a well-known expression.

\[ \theta = VBL \]

Where V and B are the Verdet constant of the material and the magnetic field, respectively, and L is path length in the medium over which the field interacts with the light [7].

II. TECHNICAL WORK PREPARATION

To measure the Faraday rotation of single mode optical fiber upon changing the effective length under magnetic field, we have fabricated the single mode fiber having a cutoff wavelength of 600 nm by using the MCVD (Modified Chemical Vapor Deposition) and DT (Drawing Tower) processes. This was done to take advantage of a high Verdet constant of silica glass at lower wavelength of the incident light [8]. A He-Ne Laser (633 nm, 10 mW), a linear polarizer, DC solenoid, a polarimeter for a wavelength band of 450 ~ 700nm (PA510: Thorlabs, USA), and fiber rotator were used to measure the Faraday rotation of single mode optical fiber. The experimental setup for the measurement of Faraday rotation angle is shown schematically in Fig. 1. A linearly polarized He-Ne Laser beam was launched into the single mode fiber placing it inside a solenoid. To obtain the polarization data, the polarimeter was interfaced with a personal computer (PC). To increase the effective length, the optical fiber was wound on over the solenoid 1 turn (2pass, 123cm) and 2 turn (3pass, 183cm) with twisted each fibers by 5 twists (8.3 twists/m) by using a fiber rotator. Variations of the Faraday rotation angle was measured with respect to the applied magnetic field 0.142T (40A).

![Fig. 1 Experimental setup to measure the Faraday rotation angle of the optical fiber](image)

Fig. 2 shows that the Faraday rotation angle was measured upon changing magnetic field from 0 to 0.142T.
As the effective length of the fiber increased, the Faraday rotation angle was found to increase. The Table 1 shows comparison of results for the SMF with and without twists. Faraday effect was shown to be more enhanced by about 15° by twists than just increased effective length without twists. The twist induced circular birefringence acts as a constant bias for the Faraday rotation and reduced retardation of fiber linear birefringence. When the effective length was 61cm (1 pass, unit length), maximum rotation angle was 17.704° and each of 35.602°, 52.211° at 122cm (2 pass), 183cm (3 pass), respectively. Fig. 3 shows the Verdet constant obtained from the measured Faraday rotation angle with the effective length under magnetic field. Verdet constant was found to be 3.842rad T⁻¹m⁻¹(1pass), 3.955rad T⁻¹m⁻¹(2pass), and 3.91rad T⁻¹m⁻¹(3pass) regardless of the change in effective length.

III. CONCLUSIONS

A single mode fiber with 600nm of cutoff wavelength was fabricated by using the MCVD and the DT processes and its Faraday effect was investigated. As the effective length of the fiber increased with twists, the Faraday rotation angle was found to increase. When the effective length of the fiber was about 183cm, the maximum rotation angle (52.211° at 0.142T) was approximately 3 times larger than that of the 61cm long fiber. This fiber can be used as an all-optical fiber isolator because of its greater Faraday rotation angle over 45°.

ACKNOWLEDGMENTS

This work was partially supported by the BK-21 Information Technology Project, Ministry of Education and Human Resources Development, South Korea, by the National Core Research Center Program from MOST/KOSEF (R15-2006-022-02001-0), and by the (Photonics 2020) research project through a grant provided by the Gwangju Institute of Science & Technology in 2010.

REFERENCES