JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

DETERMINATION OF REFRACTIVE INDEX OF ETHANOL USING ETCHED FIBER BRAGG GRATING

[1*]A.S.Lalasangi, [2]V. K. Kulkarni, [3]M. S. Jadhav and [4]U. S. Raikar

[1*]Department of Physics, Smt. I. S. Yadawad Government First Grade College, Ramdurg, (Karnataka), India
[2]Department of Physics, Angadi Institute of Technology & Management, Belagavi, (Karnataka), India.
[3]Department of Physics, J. S. S. Arts, Science and Commerce College, Gokak (Karnataka) India.
[4]Department of Physics, Karnatak University, Dharwad, INDIA

Abstract: In this present work, we have demonstrated the etched Fiber Bragg Grating as refractive index sensor. Using etched fiber, the dependence of the sensor sensitivity on surrounding refractive index in terms of wavelength shift and reflected output power variations are analyzed for ethanol. This type of sensors are applicable to many fields including chemical, biochemical, biomedical and environmental sensing.

Index Terms: fiber Bragg Grating, phase mask, refractive index sensor

I. INTRODUCTION:

Over the fast few years, the advancements in the optical fibers has undoubtedly improved and reshaped “fiber optic technology”. In addition to applications in telecommunications, optical fibers are also utilized in the rapidly growing fields of fiber sensors, fiber lasers and fiber amplifiers. Despite the improvements in optical fiber manufacturing and advancements in the field in general, basic optical components such as mirrors, wavelength filters and partial reflectors have been a challenge to integrate with fiber optics. Recently, however, all these challenges are overcome, with the ability to alter the core index of refraction in a single mode optical fiber by optical absorption of UV light. This photosensitivity of optical fibers allows the fabrication of phase structures in the core of fibers. These phase structures or phase gratings are obtained by permanently changing the index of refraction in a periodic pattern along the core of the fiber. A periodic modulation of the index of refraction in the fiber core acts like a selective mirror for the wavelength that satisfies the Bragg condition [1]. It forms a Fiber Bragg grating (FBG).

Fiber Bragg Gratings (FBGs) have been used extensively in the telecommunication industry for dense wavelength division multiplexing, dispersion compensation, laser stabilization and erbium amplifier gain flattening. In addition, FBGs have been used for a wide variety sensing applications including temperature, strain and pressure measurement [2]. The main advantage of FBGs for sensing is that these devices perform a direct transformation of the sensed parameter to optical wavelength.

The principle of operation relies on the dependence of the Bragg resonance on effective refractive index and on the grating pitch. In standard optical fibers, effective refractive index is not influenced by the external one; thus no sensitivity to the surrounding refractive index (SRI) is expected. Etching the cladding at the region of the Bragg grating formation lets the evanescent field of the waveguided mode interact with the immediate surrounding environment of the fiber. When the fiber grating is immersed in a sample liquid, this result in a wavelength response of the Bragg grating that is affected by the refractive index of the solution to be measured.

The wavelength response of the Fiber Bragg Grating is measured from equation

$$\lambda_B = 2n_{eff}\Lambda$$

The sensitivity of sensor of this kind depends on the change in effective index n_{eff} for the wave-guide mode, which is related to the change in refractive index of the solution. The change in the effective index can be derived by using perturbation theory for three region fibers [2]. The perturbed propagation constant of the fundamental waveguide mode is then given by [3]

$$\beta = \beta_0 + \kappa\eta_p(n_0 - n_{cl})$$

Where $\beta_0 = (\frac{2\pi}{\lambda})n_{eff}$ is the propagation constant of the waveguide mode in the unperturbed fiber with $\kappa = \frac{2\pi}{\lambda}$, where λ is the free space wavelength. The refractive index of the environment outside the cladding is denoted by n_0 and the cladding index n_{cl} The factor n_p is the fraction of the unperturbed mode's total power flowing through the cross sectional area A_p of the perturbation and is given by [3].

$$n_p = \frac{\int_{A_p} \psi^2 dA}{\int_{A^\infty} \psi^2 dA}$$

The change of effective index will be greater the greater n_p is; thus this factor affects the sensitivity of refractive index sensor applications that monitor changes in the effective index for the waveguided mode.

In the present work, the dependence of the sensor sensitivity on the surrounding refractive index (SRI) in terms of wavelength shift analyzed. Sensor fabrication has been carried out by using photosensitive optical fiber and chemical etching in a hydrofluoric acid (HF). Finally experimental characterization of the sensor response to external refractive indices for the ethanol has been carried out by using optical spectrum analyzer. The spectral changes in the grating response due to variation of the SRI have been investigated leading to new sensing configurations.

II. SENSOR FABRICATION:

The discovery of photosensitivity in germanosilicate doped fibers has attracted great interest in the fabrication of Bragg gratings within the core of a fiber [4]. The ability to inscribe intracore Bragg gratings in these photosensitive fibers has revolutionized the field of telecommunications and optical fiber based sensor technology. In the past few years interferometric [5], phases mask [6] and image processing [7] techniques have been widely used in writing different kinds of Bragg gratings.

In our experiment, FBG is written in a photosensitive fiber by the phase mask technique. Phase mask technique is the one of the most effective method for inscribing Bragg grating [8-9]. This method employs a diffractive optical element to spatially modulate the UV writing beam. Phase masks are formed either holographicaly or by electron beam lithography. In comparison with other techniques, the phase mask technique offers easier alignment of the fiber for photo imprinting, reduced stability requirements on the photoimprinting apparatus and lower coherence requirements on the ultraviolet laser beam there by permitting the use of a ultraviolet excimer laser source. Furthermore there is a possibility of manufacturing several gratings at once in a single exposure by irradiating parallel fibers through the phase mask. The drawback of phase mask technique is that a separate phase mask is required for each different Bragg wavelength.

The Fig. 1 shows arrangement for inscribing Bragg grating with a phase mask. A KrF excimer laser was using as the UV source for inscribing Bragg grating with a phase mask of period 1.064 μm, 15 mm long in a single mode photosensitive fiber (Newport F-SBG-15, step index profile of NA 0.12 – 0.14, cladding diameter 125±1μm and operating wavelength 1550 nm). The FBG growth process was monitored in real time during the inscription process by launching a broadband light into a fiber. The transmitted and reflected spectrum of FBG is shown in Fig 2a and 2b. We have fabricated FBG having reflectivity of 75%, whose Bragg wavelength is 1540.20 nm. The cladding of the grating region was etched for 50 minutes in HF solution.

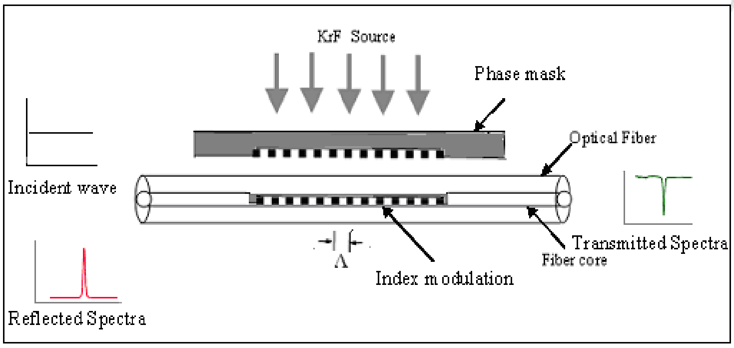
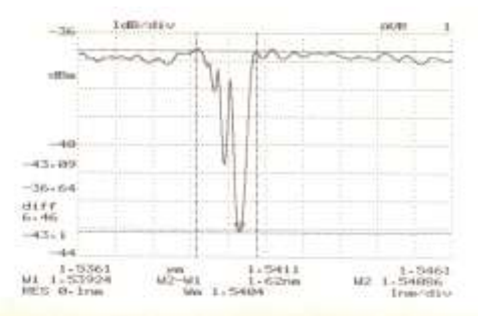


Fig 1. The schematic diagram for fabrication FBG



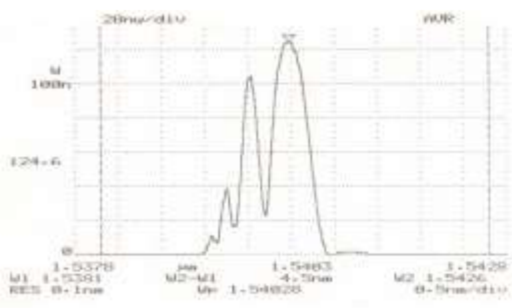


Fig 2a The transmitted spectrum of FBG **Fig 2b.** The reflected spectrum of FBG

III. EXPERIMENTS AND RESULTS:

In order to characterize the sensing performance, etched fiber Bragg grating is put in ethanol observed the reflected spectra using the optical spectrum analyzer. Experimental arrangement shown in fig3. The reflected spectra for the fiber Bragg grating sensor for different refractive indices are shown in Fig 4 to Fig 6. The refractive index is varying from 1.3393 to 1.3544 for ethanol solution Fig 4 show the relative Bragg wavelength shifts due to the surrounding refractive index changes at a constant temperature 25° C. From Fig 5 and 6 show the Bragg wavelength is shifting towards the lower wavelength and increase in power as the refractive index increases.

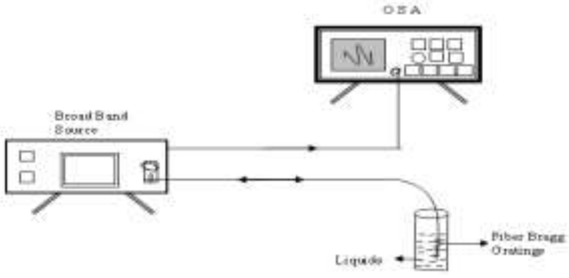


Fig 3. Schematic diagram of Experimental setup

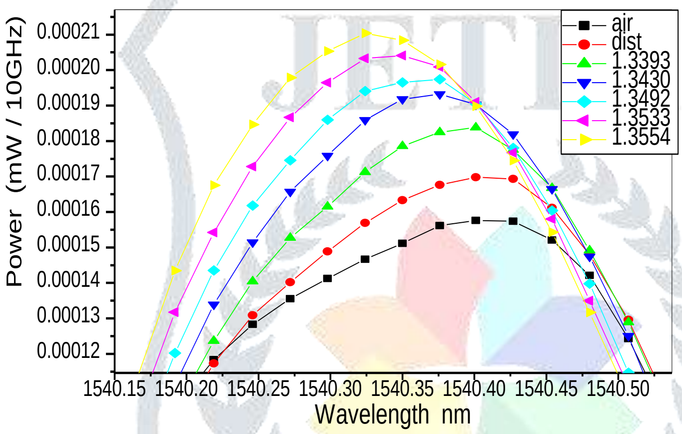
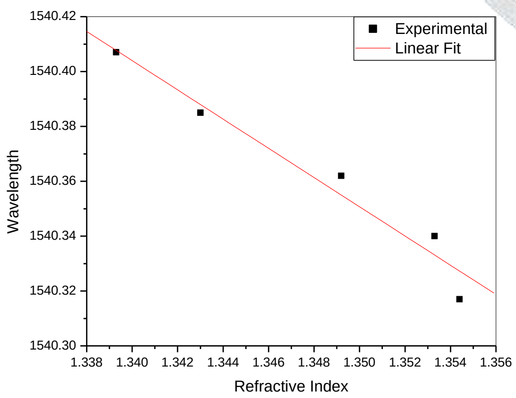


Fig 4 Shift of Bragg wavelength for Ethanol



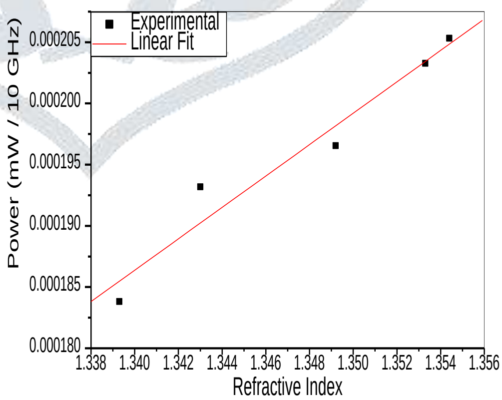


Fig 5 Shift of Bragg Wavelength with RI

Fig 6 Change in reflected power with RI

IV. CONCLUSIONS:

In this present work, we demonstrated the fabrication of the fiber Bragg grating by phase mask method. Fabrication of the sensor made by etching the grating region with HF solution (40%). Sensor sensitivity depends on the surrounding refractive index of the liquid. The dependence of sensor sensitivity on refractive index of wavelength shift has been analyzed. For ethanol and hydrogen peroxide solutions, as the surrounding refractive index increases, the Bragg wavelength shifts towards the lower wavelength and there is increase in the reflected power. In this experiment, we observed the for ethanol solution total variation of Bragg wavelength is 0.12 nm for refractive index change of 0.018. We noticed that our sensor is sensitive even for small changes in the refractive index of the order 0.0011 corresponding to the shift in Bragg wavelength 0.022nm. This sensor can be used to detect chemical changes in the surrounding media.

VI. REFERENCES:

1. Hill, K. O and Meltz G. 1997. Fiber Bragg grating technology fundamentals and overview .J. Lightwave Techno. 15 (8): 1263.
2. Snyder A. W. and J. D. Love 1991 Optical waveguide theory, pp. 378-379. London Chapman & Hall.
3. A. Asseh et al 1998 Fiber optical Bragg Grating Refractometer. Fiber and Integrated Optics 17(1): 51.
4. A. D. Kersey, M. A. Davis, H. J. Patrick, M. LeBlac, K. P. Koo, C. G. Askins, M. A. Putnam and E. J. Friebele 1997Fiber grating sensors. Journal of Lightwave Technology, 15(8), 1442.
5. K. O. Hill, fujii, Johnson D. C and Kawasaki B. S Appl. phys. Lett. 32, 674, 1978.
6. G. Meltz, W. W. Morey, W. H. Glenn opt Lett. 14, 823, 1989.
7. K. O. Hill, B. Malo, F. Bilodeau, D. C. Johnson and J. Albert 1993 Bragg grating fabricated in monomode photosensitive optical fiber by UV exposure through a phase mask. Appl. Phys. Lett.62 (10): 1035
8. S. Mihailov and M. Gower Electron. Lett. 30, 707, 1994.
9. . Suebtarkul Suchat and Preecha P. Yupapin Songklanakarin 2003. A phase mask fiber grating and sensing applications J.Sci.Technol. 25(5): 615.