IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

HYDROGEN PEROXIDE CONCENTRATION SENSOR USING FIBER BRAGG GRATING

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

[1]Department of Physics, Angadi Institute of Technology & Management, Belagavi, (Karnataka), India
[2*]Department of Physics, Smt. I. S. Yadawad Government First Grade College, Ramdurg, (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: The concentration measurements of various solutions are of great interest in many of industrial processes as a mean of quality production control. In this paper the Fiber Bragg Grating is fabricated by phase mask technique on single mode Ge-B co-doped photosensitive fiber with KrF (248 nm) source. The grating region etched with HF (40%) to act as a concentration sensor, which affects the resonance wavelength with change in surrounding media (hydrogen peroxide) concentration. We have analyzed hydrogen peroxide for various low level concentrations in the range of 1-12 ppm level. The sensor acts effectively sensitive to small changes in hydrogen peroxide concentration.

Index Terms: Fiber Bragg Grating, hydrogen peroxide, Sensor, optical spectrum analyzer

I. INTRODUCTION

The research field in optical fiber grating technology has opened a new platform in both communication and sensor field. These fiber optics have originally developed to multiple signals in optical networks and are now being widely used in the field of sensors, such as to measure strain, temperature, pressure and as a chemical sensor [1-3].

The fiber gratings are classified as Long period grating (LPG) and Fiber Bragg gratings (FBG) depending on their grating period. The grating period in LPG is of the order of more than 100 μm, where as in FBG it is of the order of less than 1μm [4]. The FBG is a periodic modulation in refractive indices of the core of the fiber. When a broadband light is connected to FBG a narrow band of wavelength centered at one certain particular wavelength known as Bragg wavelength λ_B is reflected. The FBG works on the principle of reflected wavelength λ_B and is given by

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

Where n_{eff} is the effective refractive index of the core and Λ is grating period.

The reflected wavelength mainly depends on parameters like grating length, grating pitch and effective refractive index. When cladding region is reduced along the length of grating region, the n_{eff} is significantly affected by surrounding refractive index (SRI) [5]. By reducing the cladding part of fiber gratings can be made to act as chemical sensor [6,7].

The chemical formula for hydrogen peroxide is H_2O_2 The hydrogen peroxide ion consists of a single bond between two oxygen atoms. Hydrogen peroxide solution appears like water and it can be dissolved in water unrestrainedly. When compared with water molecule hydrogen peroxide molecule contains one extra oxygen atom and its structural formula is H-O-O-H. Hydrogen peroxide is a strong oxidizer and acts as bleaching and sterilizing agent and is widely used in paper and textile industry for bleaching purpose. Hydrogen peroxide is used for processing food, minerals and petrochemicals. It is used in municipal water treatment and in cleaning of swimming pools. This is one of the waste products in atomic power station. Many of the methods like chemical, electrochemical and spectroscopy methods are adopted in finding the concentration of hydrogen peroxide in lower concentration [7,8]. We are presenting a FBG based fiber optic sensor to measure the concentration of hydrogen peroxide in lower range at ppm level.

II. FABRICATION TECHNIQUE

Two methods are widely adopted for fabrication of FBG, Interferometer technique and phase mask technique [1-3,9-10]. Phase mask technique is proved to be advantage over interferometric technique. Phase mask is used to photo-imprint the gratings on photosensitive fiber and which is relatively simple, flexible, and low-cost and can be produced in large-volume. So phase mask technique is being most reliable method and is being now widely adopted for the fabrication of FBG.

A single mode Ge-B co-doped photosensitive fiber ((Newport F- SBG -15, step index profile of NA 0.12 – 0.14, cladding diameter 125 ± 1 μm, and operating wavelength 1550 nm) is chosen to form gratings, which are formed using phase mask technique. Phase mask is a diffractive element (on silica slab) exposed through UV source to produce interference pattern, which inturn produces a permanent change in refractive index of the photosensitive fiber core, which is immediately kept behind the phase mask in proximity and parallel [2].

The acralyte coating of the Ge-B co-doped photosensitive fibers is removed carefully with razor. The cleaved Ge-B co-doped photosensitive fiber is placed on a platform for the exposure to the KrF source of wavelength 248 nm. The schematic arrangement for the fabrication of FBG is shown in fig 1. The cleaved Ge-B co-doped photosensitive fiber, which is placed behind very close to phase mask is exposed to KrF source. The grating formation can be monitored using optical spectrum analyzer. The gratings are formed in a very small time interval of 20 second. The advantages of Ge-B co-doped photosensitive fiber is that the exposure time for grating formation is remarkably reduced to a UV source [3].The reflected spectra is shown in fig 2.

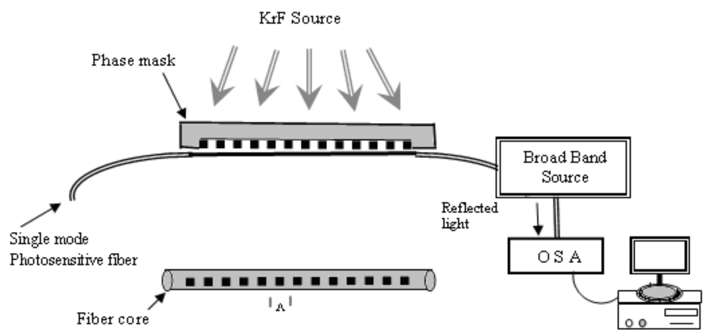

Fig 1. The schematic diagram FBG on photosensitive single mode fiber

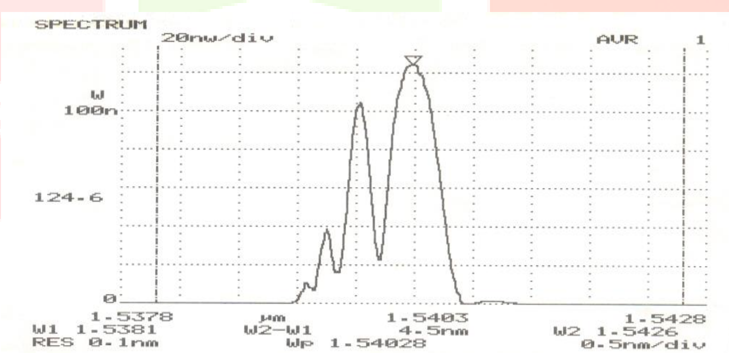

Fig 2. The reflected spectra of FBG

For proper designing of FBG to act as concentration sensor the cladding region has to be etched where the gratings are formed. This leads to direct interaction of core mode with surrounding media. This result in a wavelength shifts of FBG and varies in accordance with change in refractive index of surrounding media. The 40% HF is used for etching the cladding region for around 55 minutes. The change in wavelength was closely monitored during etching process. A lot of care has to be taken with etched fiber region. Any mishandling may results in breaking of etched region.

III. EXPERIMENTAL SETUP

The experimental setup for hydrogen peroxide concentration sensor using FBG is as shown in fig 3. In order to characterize the FBG sensor sensitivity to the surrounding media concentration changes, the different solutions of hydrogen peroxide concentrations varying from 1 ppm to 12 ppm are prepared. FBG is immersed in test tube containing hydrogen peroxide solution, which is connected to broadband source through coupler. The care has to be taken that FBG should be completely dipped in to the hydrogen peroxide solution. The broadband source was injected into the fiber and the reflected spectrum from FBG is observed through optical spectrum analyzer (OSA). As the concentration of surrounding hydrogen peroxide solution is changed, it changes the effective refractive index of FBG and results shift in Bragg wavelength (λ_B). A reflected spectrum is recorded for air, distilled water and for different concentrations of hydrogen peroxide solution ranging from 1ppm to 12 ppm. Each time the grating region is cleaned with methanol solution properly before exchanging the different concentration of hydrogen peroxide solution concentration to avoid contamination.

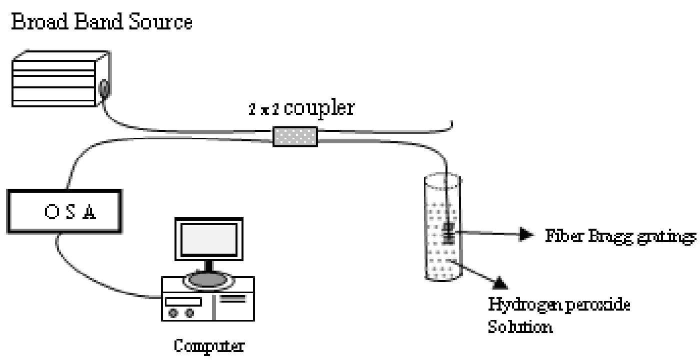

Fig 3. Experimental setup for concentration measurement of hydrogen peroxide Solution

IV. RESULTS AND DISCUSSION

The spectral response of change in wavelength with concentration of hydrogen peroxide is shown in fig 4. It can be observed that as the concentration of surrounding media increases the reflected spectrum shifts towards shorter wavelength. This can be visualized interms of an increase in the n_{eff} of the cladding which changes to the resonance condition leading to the decrease in resonance wavelength**.** By measuring the shift in Bragg wavelength λ_B with the corresponding concentration of hydrogen peroxide solution, we can plot a graph of wavelength shift versus concentration (ppm) as shown in fig.5. It is observed that sensor is very sensitive for lower concentration of hydrogen peroxide in 1 to 12 ppm level. From these results, it is able to discriminate wavelength shifts with a resolution of pico meter range at lower concentrations.

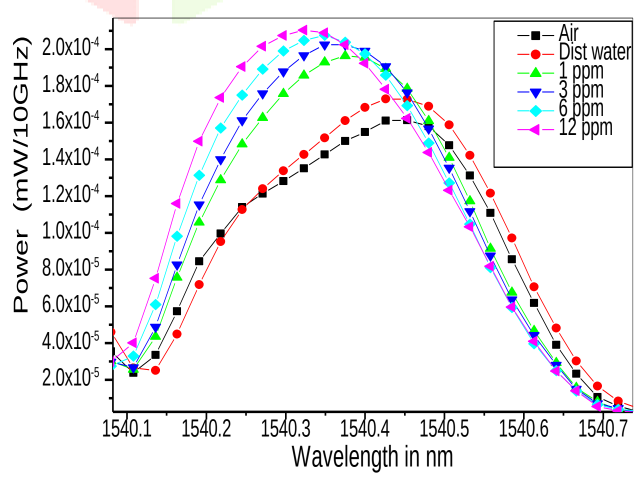

Fig 4 The spectral response of change in wavelength with concentration

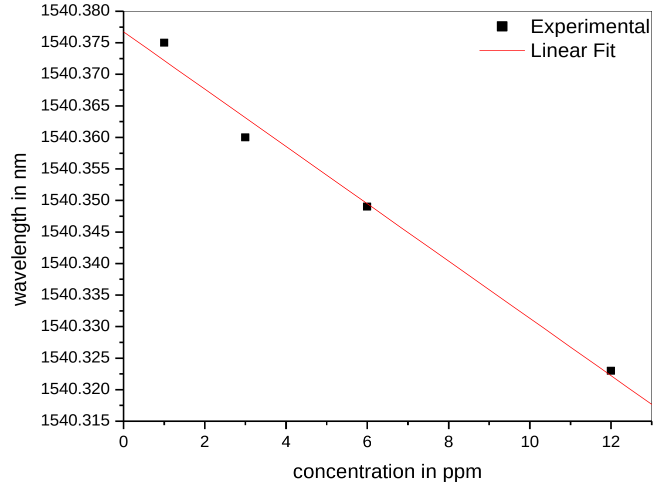

Fig 5. Wavelength shift Vs concentration (ppm) of hydrogen peroxide solution

V. CONCLUSION

We have fabricated a low cost and cost effective FBG for the concentration measurements of hydrogen peroxide in ppm level. The FBG can be used successfully to measure the low-level concentration of hydrogen peroxide. The sensor can be used to detect biological or chemical changes in the environment. These sensors can be used for medical, pharmaceutical, industrial fluid, photochemical and food industry applications.

VI. REFERENCES

1. Hill, K. O and Meltz G. 1997. Fiber Bragg grating technology fundamentals and overview .J. Lightwave Techno. 15 (8): 1263.
2. Rao, Y..J.1997. In-fiber Bragg grating sensors .Meas.Sci.Technol. 8: 355.
3. Andreas, O. 1997. Fiber Bragg gratings. Rev.Sci.Instrum 68(12): 4309.
4. Raman, K. Fiber Bragg gratings . Academic Press
5. Wei, L., Yanyl , H., Yong, X., Reginald, K. L., and Amnon, Y.2005 Highly sensitive fiber Bragg grating refractive index sensor. Applied Physics letters. 86: 151122.
6. Iadicicco, A., Cusano, A., Campopiano, S., Cutolo, A., and Giordano, M. 2005.Thinned fiber Bragg grating as refractive index sensor. IEEE Sensor Journal 6:1288.
7. Ignacio, D V., Ignacio, R. M., Francisco, J. A., and Richard, O. C.2005. Fiber-optic hydrogen peroxide nanosensor. IEEE sensors Journal . 5(3): 365.
8. Ignacio, D V., Ignacio, R. M., Francisco, J. A., and Richard, O. C.2003. ESA based fiber –optic sensor for continuous detection of hydrogen peroxide concentration. Proceedings of IEEE sensors .1:393.
9. Hill,. K. O., Malo .B., . Bilodeau, F., Johnson, D. C., and . Albert, J. 1993.Bragg grating fabricated in monomode photosensitive optical fiber by UV exposure through a phase mask. Applied Physics Letters. 62(10):1035.
10. Suchat, S., and Preecha, P.2003. A phase mask fiber grating and sensing applications J.Sci.Technol. 25(5): 615.