A Design of Optical Fiber Bragg Grating Sensor for Pressure and Temperature Monitoring

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ABSTRACT---- *In this paper, types and working principle of optical fiber sensors and these advantages of using them were studied. Fiber bragg grating sensor whose characteristic wavelength changes by pressure, temperature or stress, transmission of the sensed information were studied. the spectrum of the transmitted and reflected light in sensor, The wavelengths of the Bragg gratings, Optical fiber systems were become highly prevalent in both military aircraft and commercial, getting applications in niche area where the properties of optical fibers were essential[1].We studied a fiber-optic temperature monitoring system with an array of more than 4 sensor gratings.. Differential measurement with a Gaussian curve-fitting algorithm and temperature-stabilized reference gratings had been use to enhance measurement accuracy, which obtained temperature resolution and linearity error. We study temperature-induced Bragg wavelength variations were exactly monitored with a scanned tunable wavelength filter.*

I.INTRODUCTION

A. Fiber Bragg Grating (FBG)sensor

A FBG is a spectrally reflective component which use the principle of Fresnel reflection. The grating was made up of alternating region of lowerand higher refractive indices. The periodic grating behave as a filter, reflecting a thin wavelength range, centered about a peak wavelength .This wavelength isknown as a Bragg wavelength (λ_B),

$\lambda_{B=2n\Lambda}$ *…….(i)*

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The initial advantage of spectral encoding of measured is the immunity to optical power fluctuations.

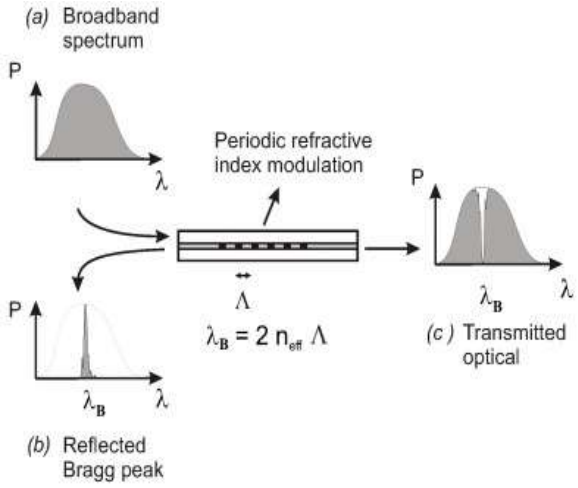

Fig.1 Reflected light wavelength dependent on grating spacing. Stress applied to fiber changes spacing[1].

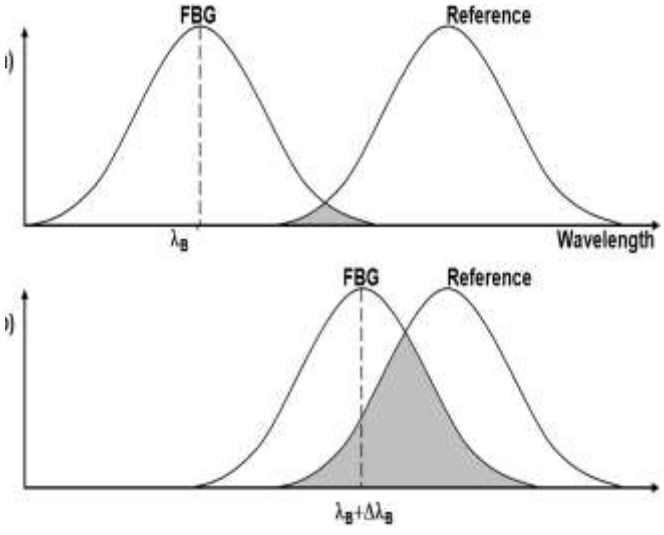

Fig.2 Intensity interrogation principle of an FBG, using a spectrally dependent reference, either a light source, other FBG, or other type offilter. The change in the shaded region from (a) to (b), as themeasurandchanges the Bragg wavelength, indicates the change in total optical power reflected [3 5].

However, spectral decoding may not be used for high frequency signals, such as ultrasound, as the methods are slow. To overcome this matter, for very high frequency signals FBG sensors were used as intensiometric devices. Here the sensor signal was recover either edge filter detection or power detection a spectrally dependent filter or light source, respectively. Fig. shows the intensity based interrogation principle for FBG sensors. As the spectrum of the FBG is moved due to the given measure and, the total optical power reflected from the FBG and the reference will decrease or increase. The reference might be a light sources with a spectrum which is wavelength dependent (power detection), or using a reference filter with a spectrum which is wavelength dependent.

B. Functional principle

The wavelength of that peaks was sensitive to temperature and strain of the fiber[4]. The sensitivities were varying lightly by the type of FBG. For the FBGs used in that work the properties listed can be considered:

II. FBG Sensors and Experiments

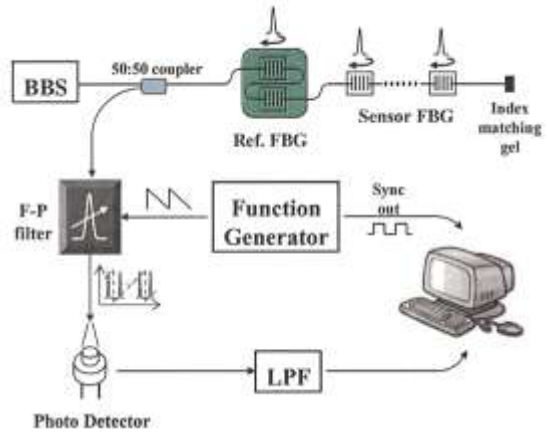

Fig. 3. Schematic diagram of FBG temperature sensor system[5].

The reflected light from the FBGs go through the FP filter of that pass band has modulate with a ramp signal. Then the light was detected after moving through the FP filter, transformed the wavelength-domain profile into time-domain. then the Bragg wavelength movement were measured with locating the peaks in the PD signal.

A. Thermometry

The results for the thermometry were shown in Fig. 4TheFBG used has a Bragg wavelength of 1553nm. As expected, the shift was linear, with a sensitivity of 10.92pm/oC; that correspond to the range of values expected in the literature, between 8 and 16 pm/oC, depending on variables ascoating etc .

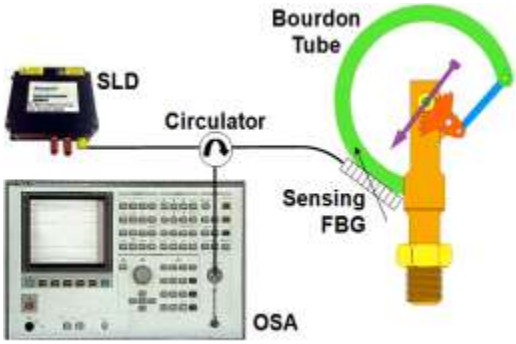

Figure 4. The bourdon tube pressure transducer showing the attached FBG strain sensor, and the corresponding experimental setup used to calibrate the pressure sensor [6].

B. *Sensor designs*

Two types of temperature transducer and dual pressure
differ in the FP sensor construction are concurrently designed. In the “glass construction”, the FP sensor was made from two cleaved optical fibers facing each other and a fused silica capillary embracing the FP cavity created between the fiber. In the “metallic construction” a metaliccapillary was used to embrace the FP cavity created between a metal coated fiber and a metal wire. The FBG can be placed either shielded from the influence of pressure by placing it inside the capillary or right before the capillary .

C. Sensors demodulation

Two techniques are taken to demodulate a FP sensor illuminated by a broadband electricity source:
1. arelative measurement depends on the tracking of the fringe spectral position;
2. an exactly measurement of the cavity length realized by measuring the distance between the spectral positions of minimum two adjacent maxima (or minima) of the interferometric fringes.

III.TRANSDUCER

Aneroid capsules were typically utilize in altimeters as before mentioned. The principle advantage of the capsule was that it converts a change in pressure into a linear displacement. We can directly convert displacement into strain ~~to facilitate~~ measurement through a strain sensor[3].. In this place, a

piezoresistive element was typically utilised in conjunction by a pressure diaphragm, and hence that was selected as the preliminary transducer design in that work.

This is, there were two dimensions to specify with a circular diaphragm, the diameter and the thickness. A schematic of the diaphragm and corresponding dimensions are show in Fig. 5.

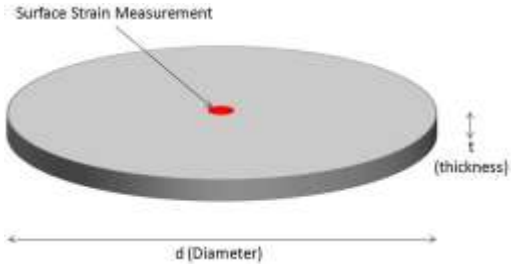

Fig. 5. Pressure diaphragm, shown these parameters use in the parametricstudy, and the location of that strain measured.[6].

IV. Aircraft Altitude Measurement

That was there the measurement of interest was pressure, expressed like a force per unit area. That was useful in weather instrumental, aircraft automobiles and any else machinery that has been implementing pressure functionality. That is used in aircraft, rockets, satellites, weather balloons, and many other applications. all the applications can use of the relationship between changes in pressure relative to the altitude.

$H=(1-(P/P_{ref})^{0.190284})*145366.45$ ft…..(ii)

This equation is given for an altimeter, up to 36095 feet(1100 m). Outside thisrange ,an error will be occur that can be calculated different pressure sensor. The error calculations will affect in the error introduces by the change in temperature as we go up. Barometric pressure sensor have an altitude resolution of smaller then 1 meter, that is significantly good then GPS system.

Fig.6. Barometer[3].

V. Applications of FBG

- Telecommunication-Filters.
- Wavelength Division Multiplexed system
- gain flattening filters
- highly selective filters
- chromatic dissipation compensators
- Sensors-Simultaneous measurement of strain

Fig.7. Application chart[7].

Developing applications…..

- Aerospace
- Bragg Grating Sensors in oceanic Applications
- Civil Engineering Structural Monitoring
- Distributed strain sensors , small , long lasting.
- Medical Applications
- Nuclear Power Industry
- Power Transmission Lines

VI. ADVANTAGES

- Greater Flexibility.
- Lower insertion loss.
- Lower price.
- Lower transmission loss.
- Electrically inert.
- Peak reflectivity in OFBG can be as high as 99%Explosive environments- no electricity to start fires (ie. pressure sensors in rocket fuel tanks)[5].

Corrosive environments- silica fiber was chemically resistant, unlike copper.

Hot environments- many of these sensors work above 760 F. (405 C) The sensor can be cast into aluminum metal.

Remote sensing- signal detection/processing can be done miles from active part of fiber sensor.

Short size.125um fiber same thickness as 36 AWG wire.

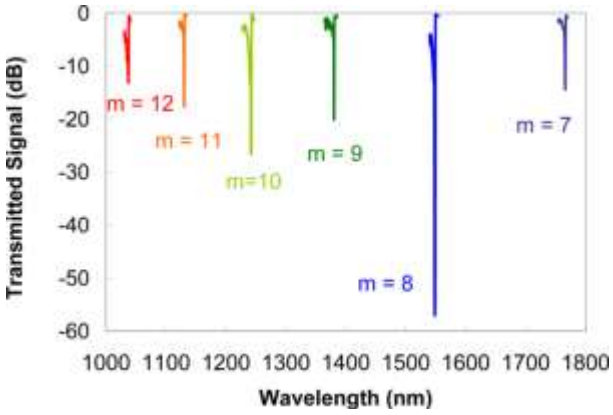

Fig.8 *Graph between transmitted signal and wavelength* [7 5]

VII. CONCLUSION

This paper have been provided a description of the possible designs of the high-pressure high-temperature sensor and the demodulation method for a highly accurate optical sensor system for permanent monitoring of pressure and temperature .we studied about thermometry, sensor design, transducer, aircraft altitude measurement. As a first step for the development of a resident health monitoring system for aircraft components. we studied the spectrum of the transmitted and reflected light in sensor. We conclude that the temperature-induced Bragg wavelength were exactly monitored

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