Development of FBG Sensor for Structure Deformation Measurement

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Abstract

In this paper, we manufacture Fiber Bragg Grating (FBG) sensor and study its applying to the structure deformation measurement. FBGs are manufactured using the 248nm excimer laser and phase masks. To enhance the photosensitivity of the core, we have loaded Hydrogen in the fiber. Then its reflectivity has improved about 8 dB. Experimental results based on comparative measurements with electric strain gauge sensors installed on the structure show that FBGs can be replaced the electric strain gauge sensors.

Keywords:*.FBG sensor, Electric strain gauge, Structure deformation Measurement, Cantilever displacement.*

1. Introduction

Deformation measurement system used to strain gauge for secure management of the structure. However, the electromagnetic environment, moisture, corrosion caused by humidity, etc. have been pointed out several problems. With the alternative, there is proposed electromagnetic and optical sensor of no oxidation in a way.

Fiber optic sensors is light amplitude, phase, polarization of light such as the optical phenomena though the optical fiber using to detecting for physical quantity to be measured by detecting changes in the structure displacement, temperature, pressure, water level, sound and physical quantity. A Fiber Bragg Grating (FBG) by G. Meltz in 1989 has developed among fiber optic sensors that domestically and internationally widely using study in secure management of the structure. FBG sensor is achieved by creating a periodic variation in the refractive index of the fiber core. Due to their low loss optical fiber sensor technology, most of the research is in progress technology.

It show change by linear Bragg wavelength with respect to stress and temperature by characteristic of the FBG, small size and the type of behavior have characteristics of wavelength encoding, It's real-time detection that deformation by environmental factor for installed in internal and external of structure etc. The phase mask has proposed K. O. Hill and D. Z. Anderson etc., in 1993. It's method to make large quantity production more easily than the conventional method. This method is currently being studied in a wide range of worldwide [1-3]. Recently, FBG has been accepted widely throughout the civil

infrastructures, especially for bridges. A new case study, FBG-based intelligent monitoring system of the Tianjin Yonghe Bridge is introduced [4].

In this paper, we manufacture for foundation optics theory and principle with respect to optical fiber and FBG. We manufacture polyimide patch type of sensor for understanding by characteristic of the manufacture FBG, and the sensor were tested for stress and temperature change.

Based on the results of experimental measurements used in structures with electric strain gauge sensors measured by comparing the likelihood of structures using FBG was verified.

2. Optical Sensor Manufacture and System Configuration

We used phase mask that FBG wavelength is 1550nm. It is shown actual manufactured FBG in Figure 1 for center wavelength of 1549.710nm and Reflection level of about -20dBm. It estimates of error for stress by optical fiber with distance by optical fiber and phase mask. FBG fiber is formed by using a polyimide patch type FBG sensors were fabricated.

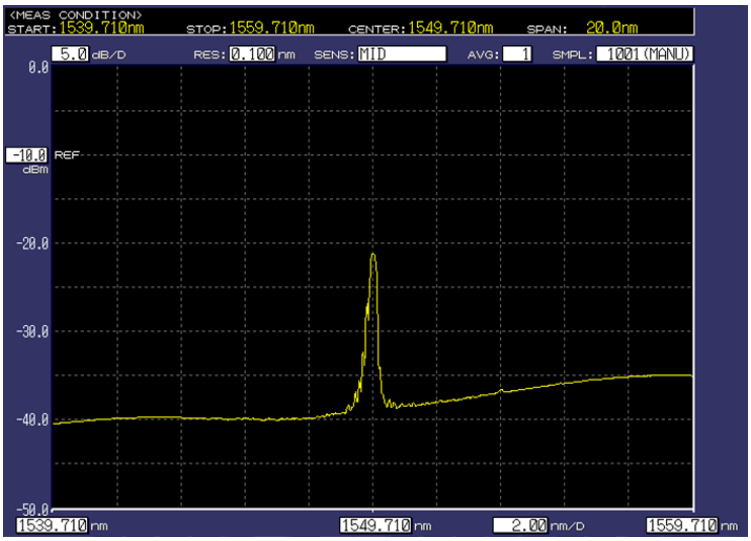

Figure 1. Designed Wavelength of FBG (OSA Output)

We had compared at measurement of characteristic for the electric strain gauge (KFS-S-120-C1-11L1M2R, KYOWA, JAPAN) and FBG sensor that we manufactured FBG sensor. Configuration as shown in Figure 2, the measurement system can be divided into two parts.

FBG sensors,

- After passing circulator out light from the ASE Broadband Source,

- After passing circulator of wavelength of reflected light from FBG sensor,

- Bragg wavelength detected by Tunable Optical Filter and Data Logger,

- measured using a PC.

Electric strain gauge connect to Bridge(DB-120A, KYOWA, JAPAN) circuit to detect cha nges in resistance, oscilloscope(Wave Surfer, LECROY, USA) were measured the voltage val ue in Digital Signal Process(DSP) use electric strain gauge Amp.(MCD-16A, KYOWA, JAP AN).

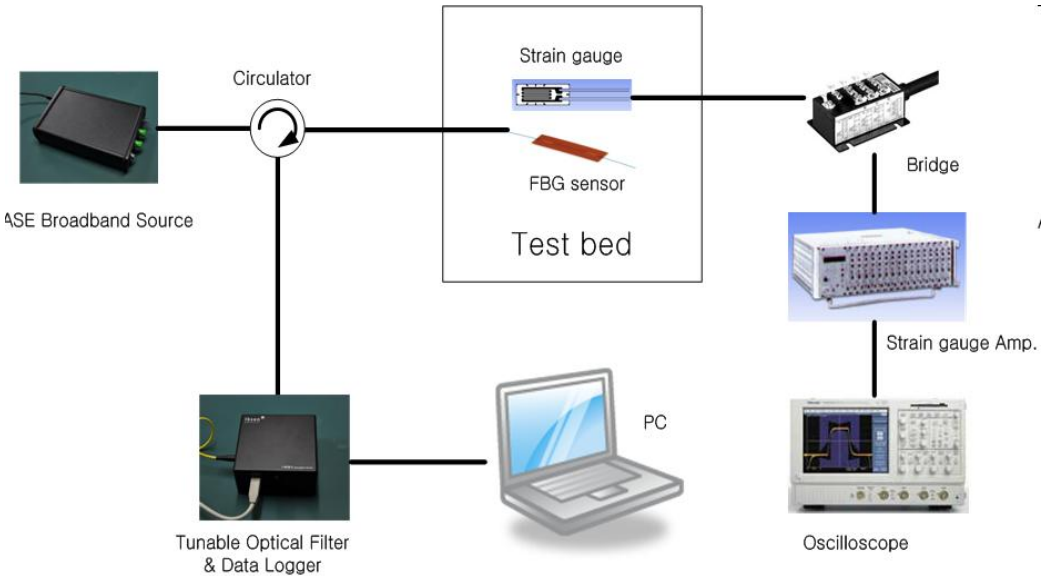

Figure 2. Characterization of FBG Sensor System Configuration

In this paper, polyimide patch type FBG sensors designed to measure the characteristics of the applied load or displacement and vibration tests is to conduct experiments using cantilever made of aluminum were measured. Measuring device was configured at the end of the cantilever displacement can be measured displacement experiments were installed in the ruler.

Cantilever attach FBG sensor and Electrical strain gauge as in Figure 4, 15cm away from anchor point to the center of the sensor, attach the two sensors, the static stress applied to the cantilever displacement were measured. When the horizontal displacement of the cantilever is measured as 0, and then up and down in increments of 10mm in the direction of displacement was measured to ± 50mm.

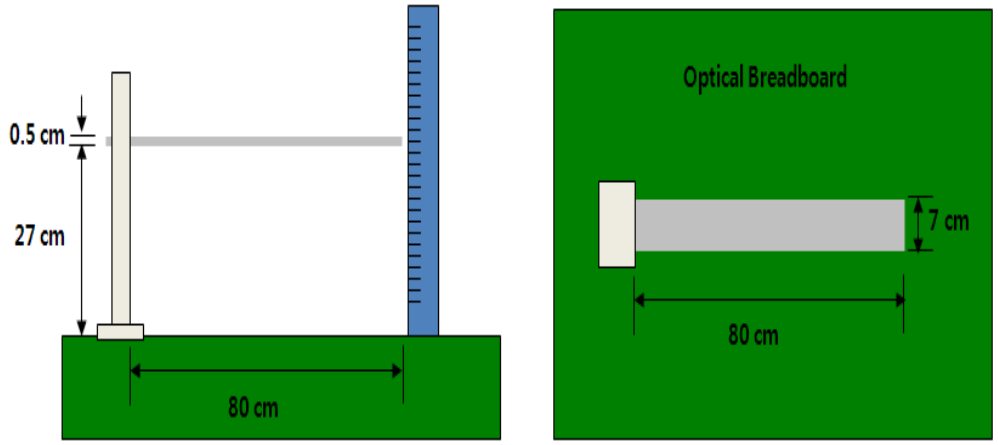

Figure 3. Characteristics of FBG Sensors for Measuring the Cantilever

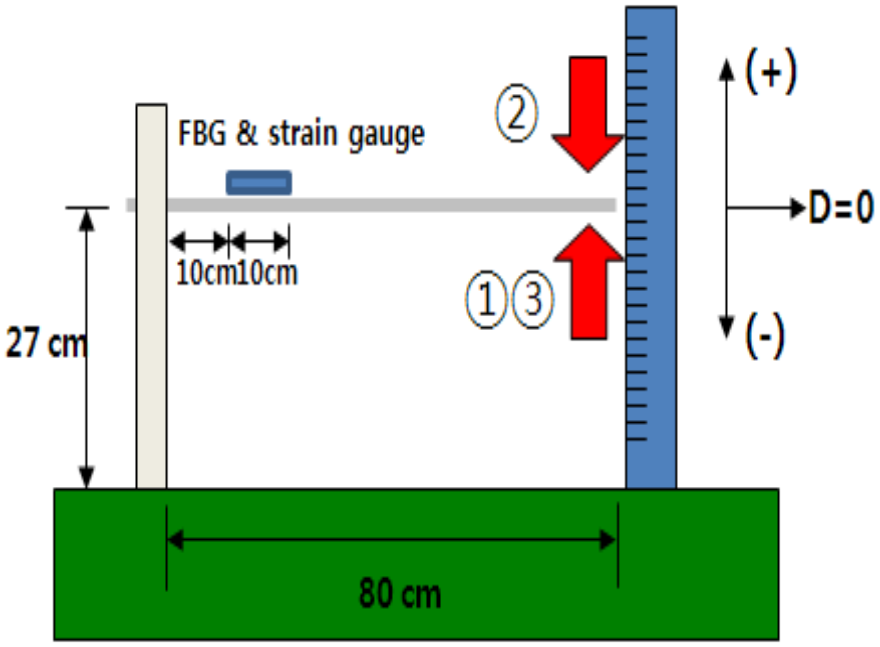

Figure 4. For the Measurement of Static Stress Sensors Attached to the Cantilever

3. Experiment Result

As shown in Figure 5, an electric strain gauge and displacement output characteristics are a s follows: A positive value of the displacement results in a negative output, and vice versa.

In the same way, FBG sensors also have a positive value of the displacement results in Bragg reflection wavelength was shifted to shorter wavelengths. Vice versa, Bragg reflection wavelength was shifted to longer wavelengths.

These characteristics appear all the FBG sensors and electric strain gauge attached to the top of the cantilever, when you have increasing of the displacement the compressive force applied, when you have decreases of displacement the tensile force is being applied.

If you compare the characteristics of the two sensors on the displacements according to the change of the cantilever electric strain gauge output and the Bragg reflection wavelength variation showed the same trend.

4. Conclusion

In this paper, we manufacture Fiber Bragg Grating (FBG) sensor and study its applying to the structure deformation measurement. FBGs are theoretically analyzed through a coupled-mode theory, and computer simulations are performed to determine the spectral characteristics of the FBG. FBGs are manufactured using the 248nm excimer laser and phase masks. To enhance the photosensitivity of the core, we have loaded Hydrogen in the fiber. Then its reflectivity has improved about 8 dB. Experimental results based on comparative measurements with electric strain gauge sensors installed on the structure show that FBGs can be replaced the electric strain gauge sensors.

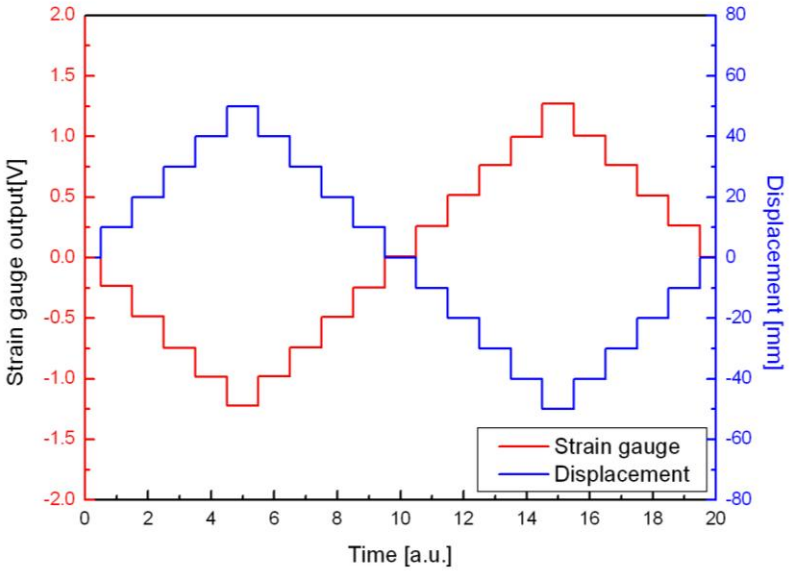

Figure 5. Characteristics of the Electric Strain Gage in Cantilever Displacement

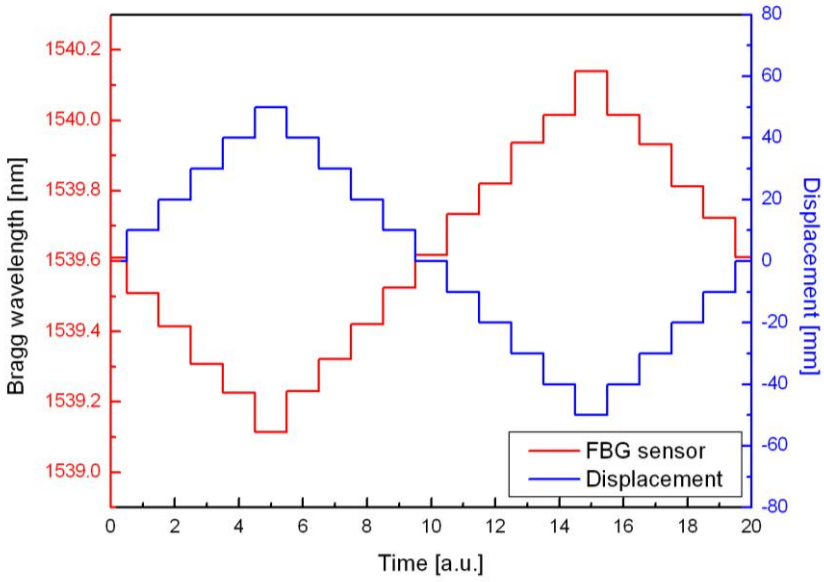

Figure 6. Characteristics of the Bragg Reflection Wavelength by FBG Sensor in Cantilever

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