Available online at www.sciencedirect.com

ScienceDirect

Optics and Lasers in Engineering 46 (2008) 546–549

OPTICS and LASERS in ENGINEERING

www.elsevier.com/locate/optlaseng

Dynamic strain monitoring by wavelength locking between two fiber Bragg gratings fiber sensing system

Ming Chang Shih*, C.L. Ko, C.Y. Yang

Department of Electrical Engineering, National University of Kaohsiung, ROC No. 700, Kaohsiung University Road, Nan Tzu Dist., 811 Kaohsiung, Taiwan, ROC

Received 20 October 2007; received in revised form 8 January 2008; accepted 15 February 2008
Available online 26 March 2008

Abstract

We demonstrated a fiber sensing system using the method of wavelength locking of two identical fibers Bragg gratings (FBG) to interrogate the wavelength shift by directly measuring the intensity of the reflection from the sensing Bragg grating. The light source of the fiber sensing system is an EDFA fiber ring laser pumped by a 980 nm laser diode and a narrow bandwidth fiber Bragg grating for the filter of the ring laser resonator. The wavelength shift is converted to the intensity deviation of the reflection from the sensing FBG under strain variation, and is able to achieve real-time sensing of the dynamic strain sensing in civil engineering. The characteristics and key factors to maintain stability of the dynamic strain sensing system are discussed.

Keywords: Fiber Bragg grating; Fiber ring laser; Fiber sensing

1. Introduction

Fiber Bragg grating (FBG) because of its low insertion loss, narrow band pass, and the flexibility of manipulating desired spectral characteristics has been attracted much attention for applications in remote sensing and environment monitoring system [1–5]. The signal obtained from a FBG sensor is encoded directly in wavelength domain which is, in general, an advantage over other sensing schemes with facilitates wavelength division multiplexing. The FBG sensor devices are simple, and have all the advantages normally attributed to fiber sensors, such as electrically passive operation, EMI immunity, high sensitivity, and potential low cost. A transducer of the FBG sensor converts the variation of temperature or strain into Bragg wavelength shift which can be measured by wavelength interrogating, or other sophisticate spectral analysis methods [6–8]. Thought, direct wavelength interrogation by a spectrometer is an effective approach to measure the wavelength shift of a perturbed Bragg grating, issues of implementation of fiber sensing system for practical applications, such as robustness of the sensing system, stability of light source, and cost of measuring might affect to the efficiency of the fiber sensing system for real applications. We demonstrated a low cost and stable fiber sensing system by using the wavelength locking between two FBGs to interrogate the wavelength shift of the sensing FBG directly measuring the reflection of the erbium-doped fiber ring laser (EDFRL) with another FBG.

2. The fiber ring laser sensing system

Fig. 1 shows the structure of the EDFRL sensing system. A 10 m long erbium-doped fiber amplifier is pumped by a 980 nm laser diode with maximum power of 160 mW, a narrow band FBG is fixed on a piezoelectric controlled stage to form a resonator, and the output of the fiber ring laser is then connected to the other FBG for the sensing element. The fiber optics power meter (EXFO 1600) is used to measure the reflection form the sensing FBG, thus the time variation of the signal can be recorded by the Agilent 54622D storage oscilloscope. High pressure D_2 loaded fibers are used for fabricating FBGs with phase mask exposed by the KrF excimer laser at 248 nm of 60 mJ/cm^2.

*Corresponding author. Tel.: +886 7 5919237; fax: +886 7 5919399.
E-mail address: mingshih@nuk.edu.tw (M.C. Shih).

0143-8166/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.optlaseng.2008.02.005

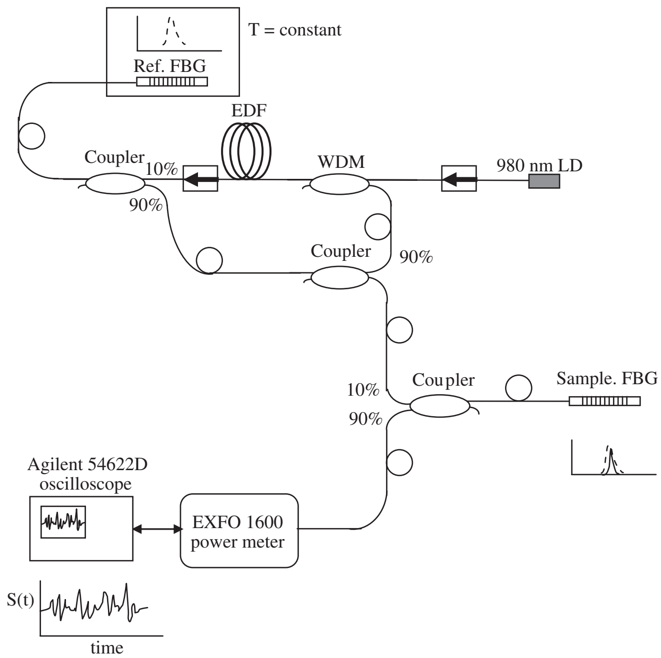

Fig. 1. Schematic of the double Bragg gratins fiber ring laser-sensing system.

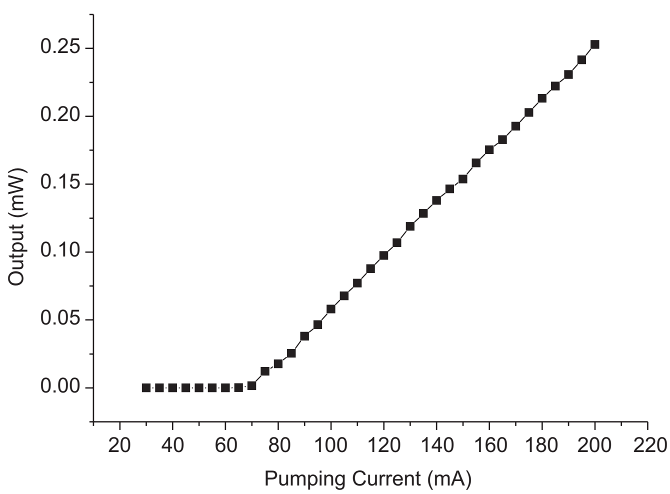

Fig. 2. Measurement of the light output-pumping characteristics of the erbium-doped fiber ring laser.

Bragg's wavelength at 1558.85 nm and spectrum width of 0.4 nm has been routinely achieved. Fig. 2 shows the light output-pumping characteristics of the EDFRL. The threshold pumping current of the 980 nm laser diode is 70 mA, which corresponds to about 40 mW of the pumping power. Fig. 3 shows the output spectrum of the EDFRL at lasing. It is lasing at Bragg wavelength of the FBG with spectral width of 0.1 nm, and has very long time stability of the peak power and lasing wavelength that provides an ideal light source for use in fiber sensing system. To test the performance of dynamic strain sensing, an uncoated FBG for sensing element is fixed on a test features of a cylindrical fiber holder which can be driven

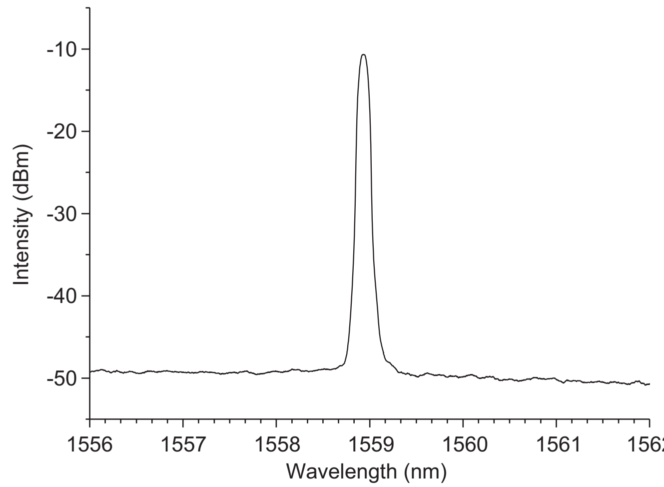

Fig. 3. Output spectrum of the erbium-doped fiber ring laser at lasing.

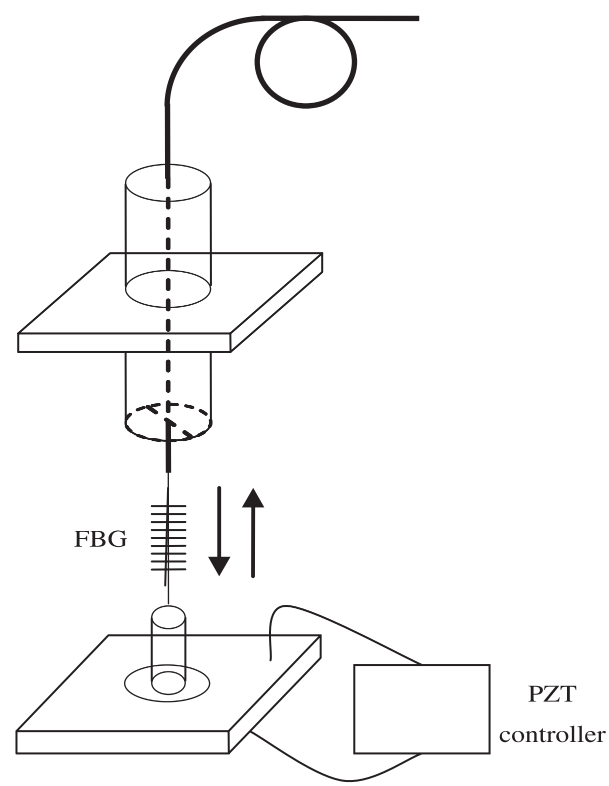

Fig. 4. Schematic of the test features for the dynamic strain sensing.

vertically by a piezoelectric controlled stage as shown in Fig. 4.

3. Results and discussions

To interrogate the wavelength shift of the sensing FBG from the intensity variation of reflection, it is assumed that the output of the EDFRL can be approximated by a Gaussian profile, thus the reflected power variation due to the wavelength shifting of the sensing