A novel pressure sensor with a Fabry-Perot interferometer

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ABSTRACT

A novel pressure sensor using a fiber Fabry-Perot interferometer (FFPI) has been developed in this paper. We use the internal F-P cavity pressure sensor in our research. Micromachined Fabry-Perot microcavity structures have been investigated for use as a pressure sensor. The single-mode fiber containing the interferometer is bonded at one end to the stainless-steel diaphragm and is also attached under longitudinal tension beyond the interferometer. An analysis relating the expected interferometer phase change to pressure is presented . And the dynamic response of FFPI sensor to pressure changes produced by an air pump is in good agreement with that measured with a conventional pressure sensor. The sensor is suitable for operation with other signal-processing and multiplexing schemes.

Keywords Fabry-Perot interferometer, A single-mode fiber, internal F-P cavity pressure sensor

1.INTRODUCTION

The optical fiber has been widely reported as a class of sensing medium for the measurement of physical parameters[1] such as temperature, pressure, flow, liquid level and rotation, etc. Fiber-optic sensor[2] with the Fabry-Perot interferometer configuration have been widely investigated because they combine the high sensitivity of an interferometer with compactness and relative immunity from environmental perturbation and the ability to operate at elevated temperatures. In this paper we concentrate primarily on the measurement of pressure using fiber-optic sensor with the Fabry-Perot interferometer. Fiber-optic sensor is an alternative to piezoelectric sensors are usually used at the temperature from -190℃ to 200℃ . And Fiber-optic sensors have operated continuously at temperatures above 1000℃ . So the optical sensors are not affected by extreme temperatures that cause rapid degradation of piezoelectric devices. The internal F-P cavity sensors in the measurement of pressure are described in this paper.

2.PRINCIPLE OF THE FFPI

Fabry-Perot cavity pressure sensor has two forms: internal F-P cavity pressure sensor and external F-P cavity pressure sensor. Figure.1 and Figure.2 are the construction of the two forms. When the beam in the fiber reach the two mirror it reflex respectively, and it interfere at the end of the fiber. When the length of the cavity changes with the pressure, the figure of the interference range will change. This kind of transducer have lots of advantages, such as light,soft and flexible， especially the internal F-P cavity pressure sensor[2,3].

The sensing part is a Fiber-Perot interferometer (FFPI) fabricated in single-mode fiber. The pressure is

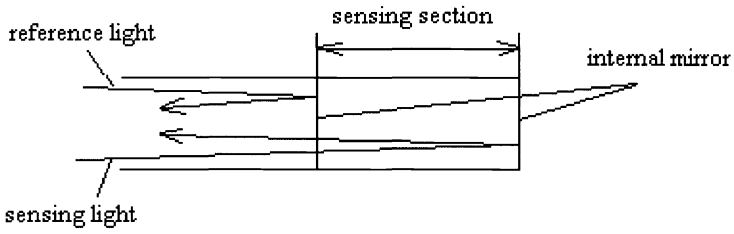

Figure.1 internal cavity pressure sensor

determined by the optical signal from the FFPI, which is a sensitive strain transducer. The FFPI consists of two internal mirrors separated by a length L of fiber.

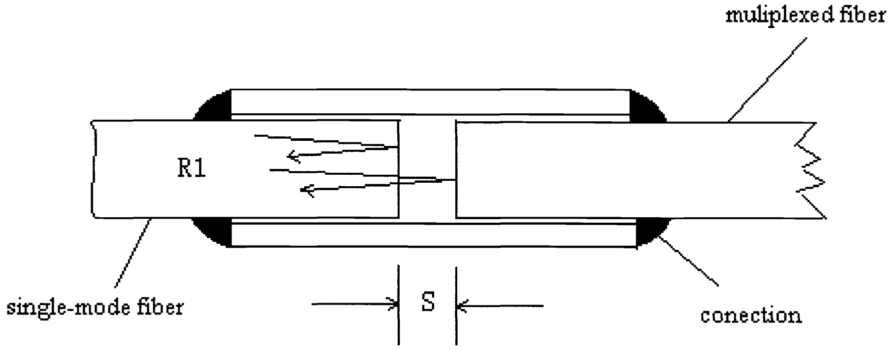

Figure.2 external cavity pressure sensor

The configuration Fig.3 is the configuration for the high-sensitivity pressure sensor. One end of a stainless-steel hypotube serves as the sensor housing and is covered by a stainless-steel diaphragm. Each diaphragm has a hole at the center for mounting the FFPI . One end of the 1.5-um –diameter fiber is inserted through the hole and attached to the diaphragm with a small amount of epoxy. Under pressure the optical fiber experience longitudinal strain. The phase difference between the reference and sensing reflections is expressed as

$$\phi = \frac{4\pi n L v}{\lambda} \qquad (1)$$

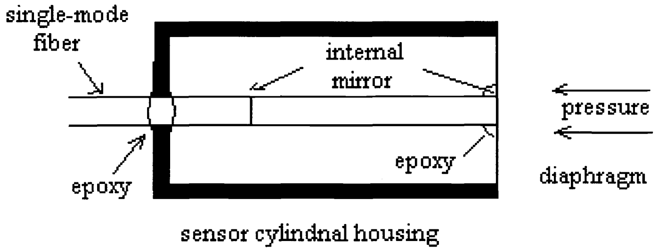

Figure.3 Configuration of the FFPI pressure sensor

Where L and n are the length and refractive index of the FFPI, respectively. And λ is laser wavelength in vacuum, ν is the laser frequency.
From eqt.(1) ,ϕ is proportional to nL . We use the single-mode fiber which n=1. Then ϕ is proportional to L. The pressure included phase change is expressed as

$$\Delta\phi = \frac{4\pi\nu n\Delta L}{\lambda} \tag{2}$$

where ΔL is the change of the cavity length of the FFPI. Only perturbations that affect the fiber in the region between the mirrors are sensed. If the induced change in L for the FFPI is proportional to pressure P , then

$$\Delta\phi = \frac{4\pi\nu nk\Delta P}{\lambda} \tag{3}$$

where k is a constant that depends on the sensor configuration.

3.EXPERIMENT

The experimental setup shown in Fig.4 is used for monitoring a FFPI pressure sensor. A high frequency-stabilized He-Ne laser (λ =632.8nm,P=2mN,intensity noise<0.1%,linear polarization ratio>700:1) is used as the light source. Light from the laser is coupled into a single-mode optical fiber. After passing through an optical isolator, the light pass through a fiber coupler that splits the light into two equal amplitude components, a portion of the light is reflected from the FFPI. After passing through the coupler once again, the light modulated by the FFPI is converted by an InGaAs photodiode to an electrical signal. Then the electrical signals are amplified by a amplifier. After passing through the filter, the light modulated by the FFPI is converted by an InGaAs photodiode to an electrical signal that is displayed on an oscilloscope. If the output of amplifier is obtained, the signal can be calculated with a 12-digit A/D converter, a 8098 microprocessor and a computer.

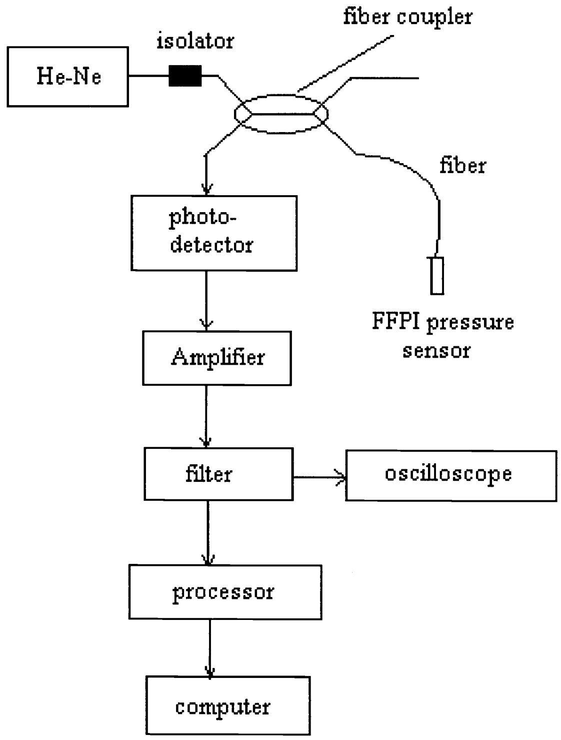

Figure.4 Scheme of the experimental setuo

4.CONCLUSION

A novel pressure sensor with Fabry-Perot interferometer has been presented. We have studied,both theoretically and experimentally, the properties of a single-mode fiber-optic pressure sensor which uses a internal Fabry-Perot interferometer. The experimental setup has been given.

5.REFERENCES

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