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Development of a fluidic pressure sensor by using a surface modified fiber Bragg grating

Junda Lao[1], Pengfei Zheng[1], Liuwei Wan[2], Qianqian Zhang[2], Chao Wang[2], Chi Chiu Chan[2,*]

[1]Sino German Institute of intelligent manufacturing, Shenzhen Technology University, Shenzhen, Guangdong 518118, China
[2]Julong College, Shenzhen Technology University, Shenzhen, Guangdong 518118, China

ABSTRACT

Based on the sensing characteristics of fiber Bragg grating（FBG）, a double flange cylinder structure is designed and fabricated, and a new type of an optical fiber fluidic pressure sensor is presented in this paper. In low pressure aqueous environment, the measurement sensitivity is enhanced significantly. The proposed sensor configuration described in this paper exhibit sensitivity of about 10 nm/MPa through the experimental verification, which is 3333 times of the bare FBG sensitivity. In addition, the sensor has the advantages of simple fabrication and assembly, high stability, good linearity and repeatability, etc.

EXPERIMENTAL STRUCTURE AND DEVICE

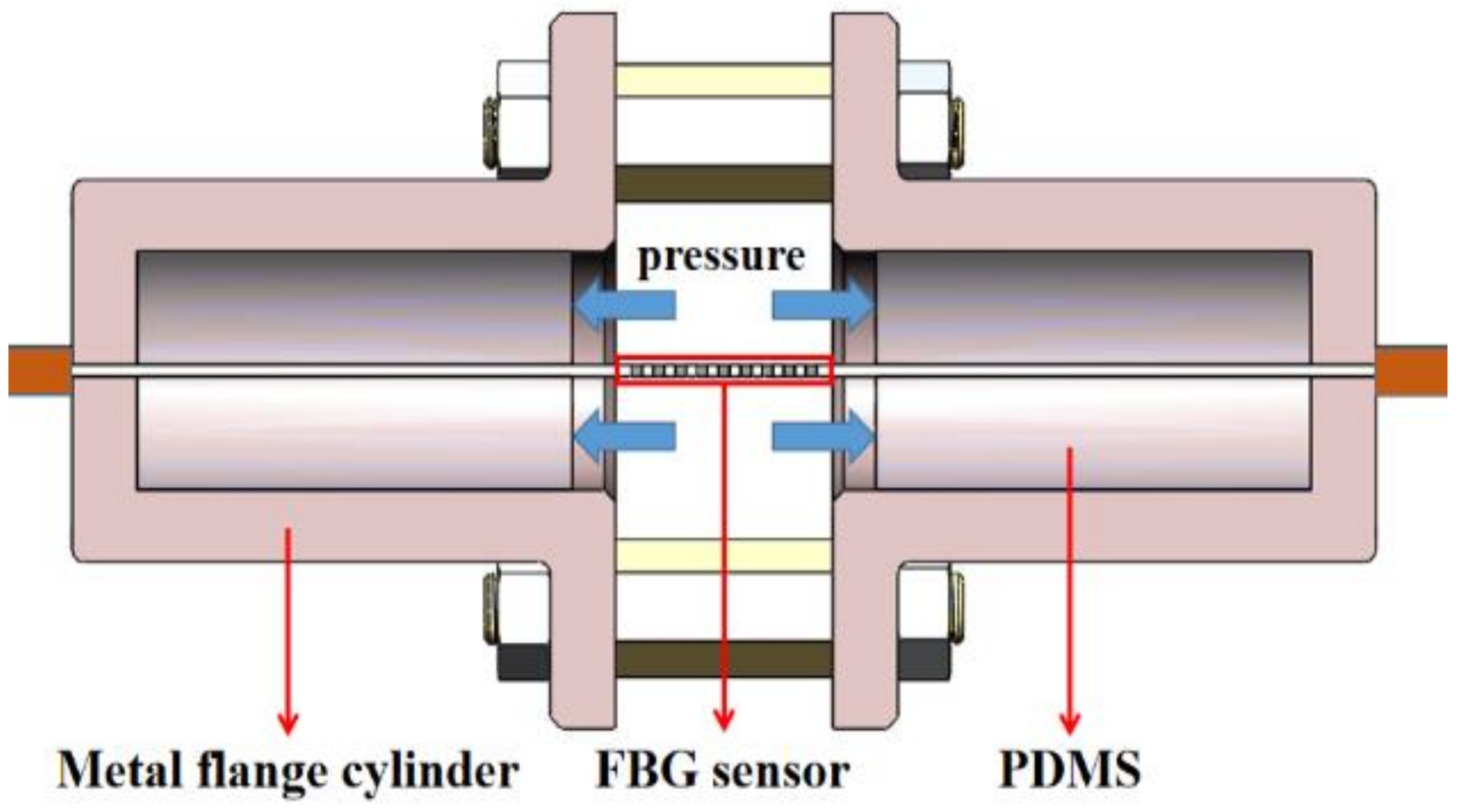

Fig 1. Structure diagram of optical fiber fluidic pressure sensor

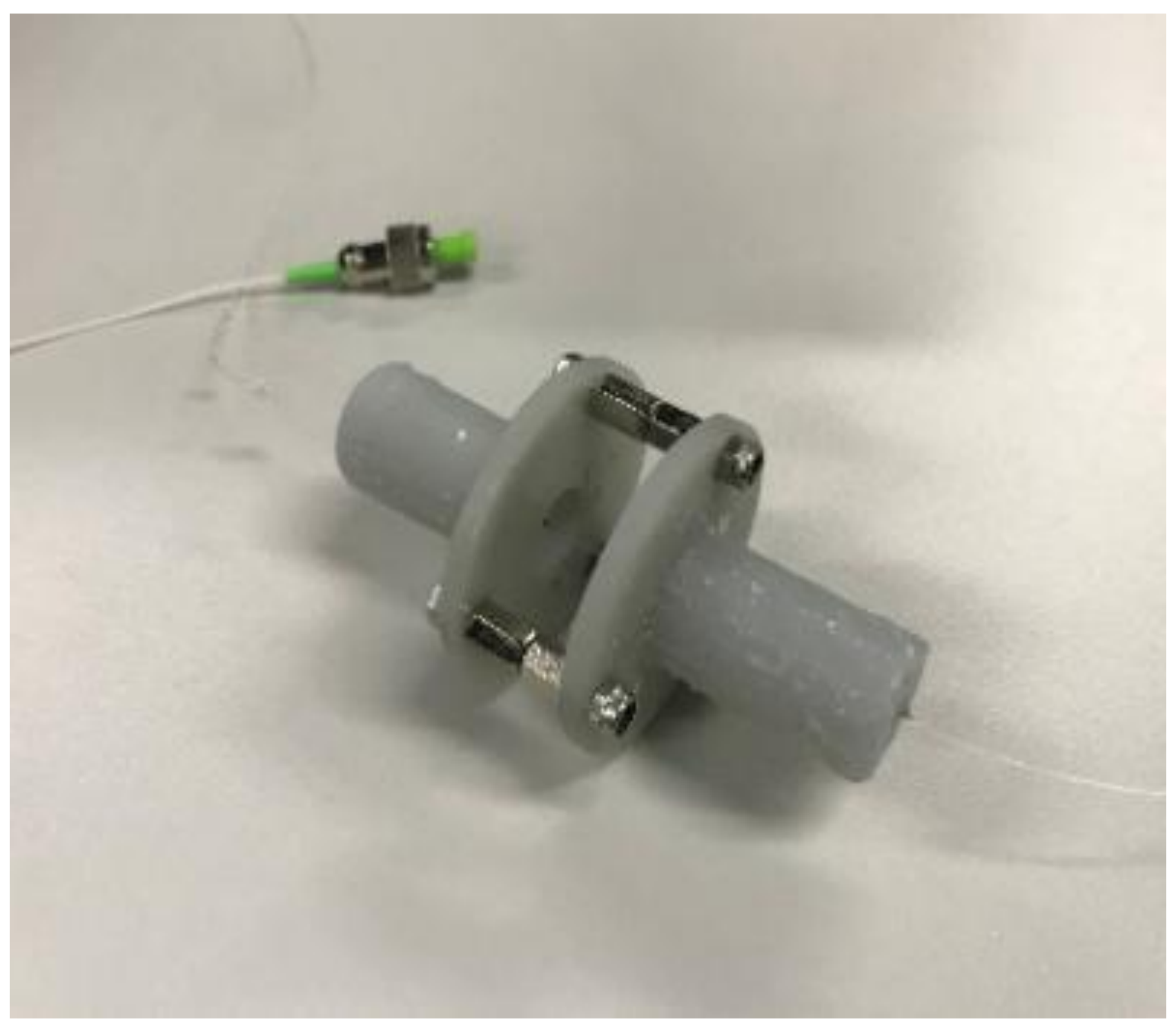

Fig 2. Prototype of an Optical fiber fluidic pressure sensor

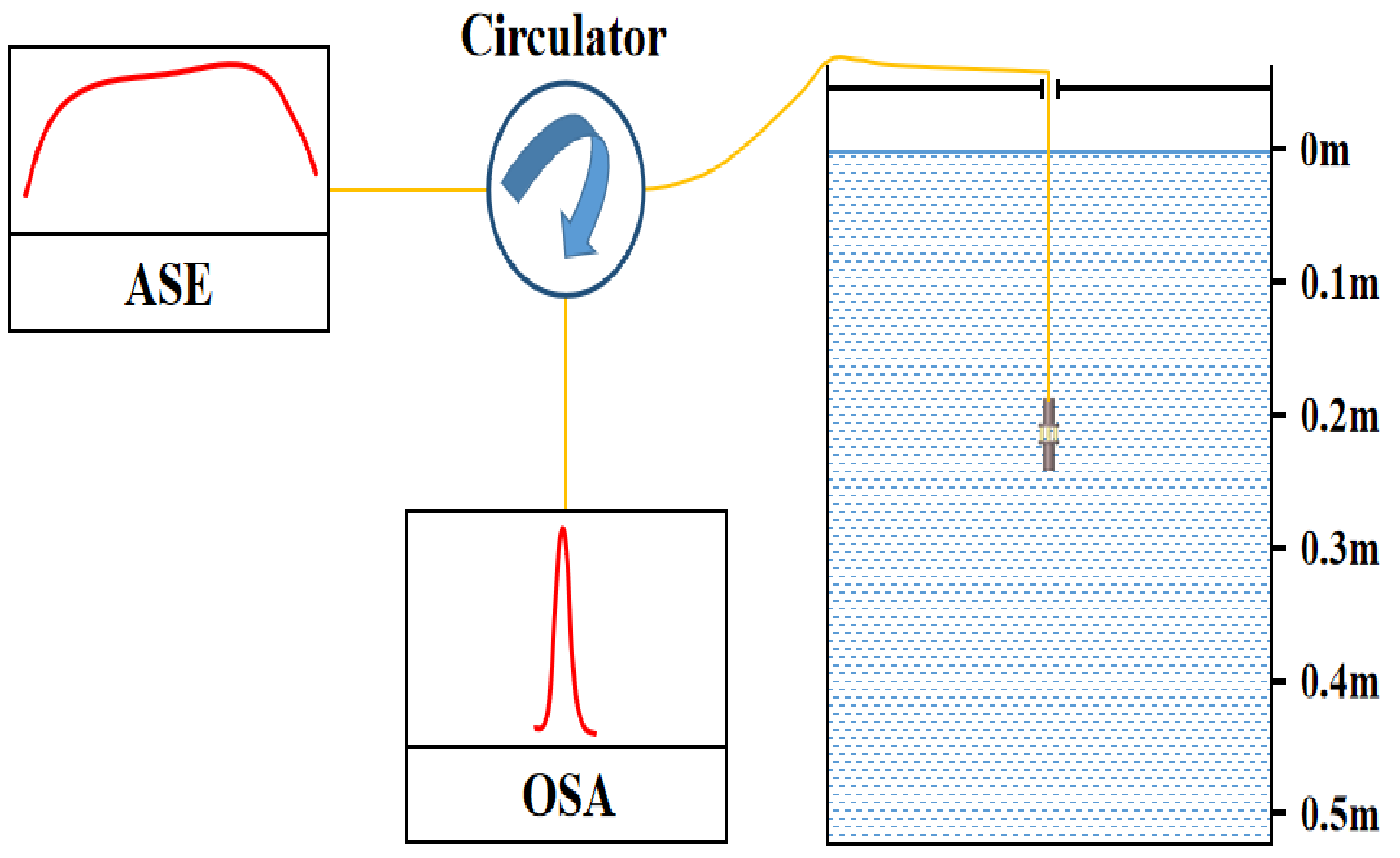

Fig 3. Schematic diagram of the experimental setup

The encapsulating structure is shown in Fig. 1. The encapsulation structure of the sensor is mainly composed of double flange cylinder and the polymer polydimethylsiloxane (PDMS). The FBG is located in the middle of double flange cylinder, and its two ends are fixed by filling the polymer PDMS inside the flange cylinder, and the flange cylinders at both ends are locked by screw nuts. When the sensor is placed in the liquid, the liquid enters into the sensor from the middle gap of the flange cylinders on both sides and the pressure is applied to the end faces of the polymer PDMS on both sides. So, the polymer PDMS will deform along the axial direction accordingly. Due to the sufficient adhesion between polymer PDMS and fiber surface, the polymer PDMS along the axial deformation will lead to the axial deformation of the FBG, which will cause axial strain on the FBG.

Fig. 2. shows a sensor sample with 10 mm diameter flange cylinders. The optical fiber fluidic pressure sensor was connected with an amplified spontaneous emission (ASE) light source and the optical spectrum analyzer (OSA) through the circulator. This experiment mainly tested the sensitivity of the sensor to fluidic pressure, and the experimental setup is shown in Fig. 3.

EXPERIMENTAL RESULTS

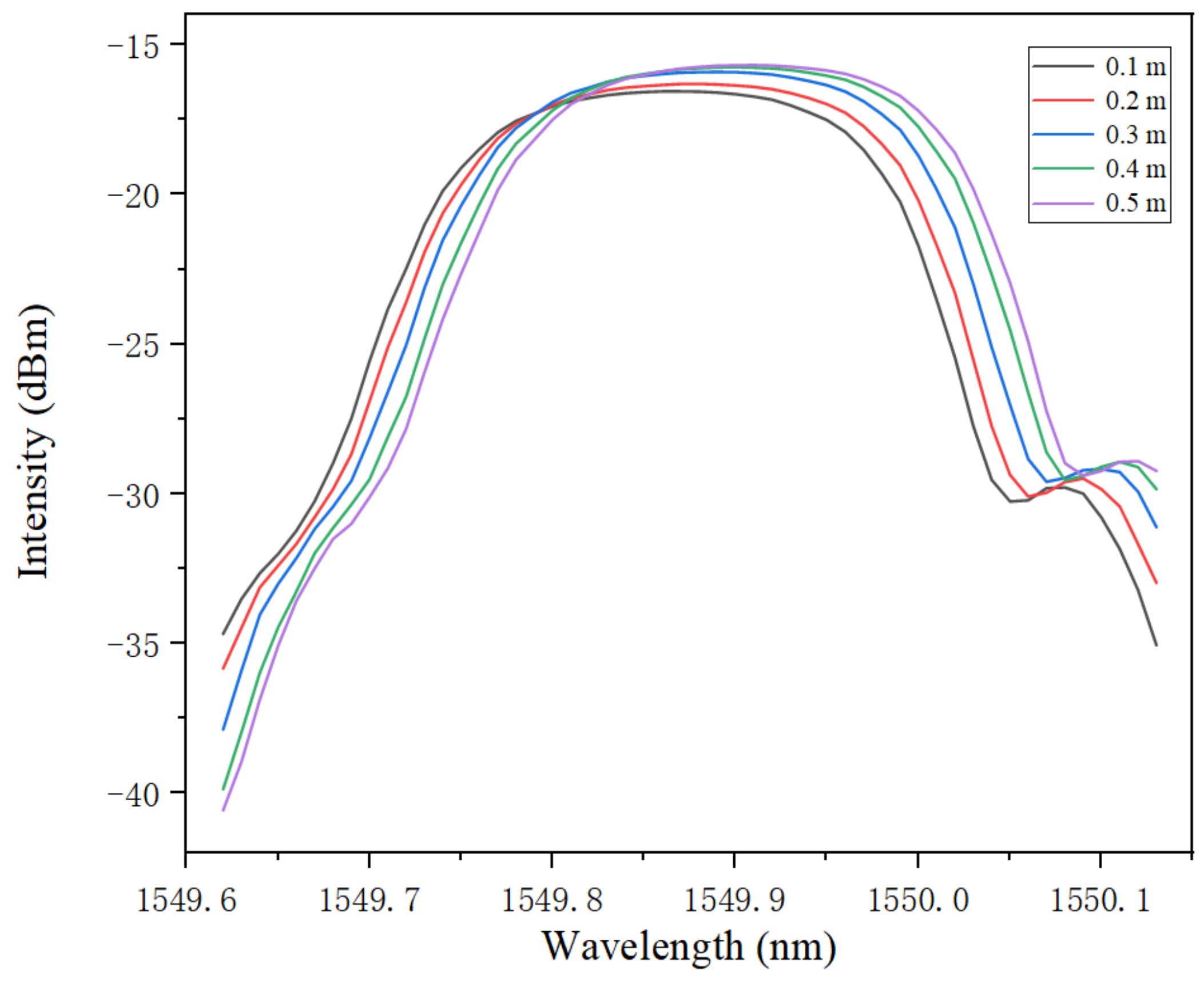

Fig 4. Spectral response of different water depth

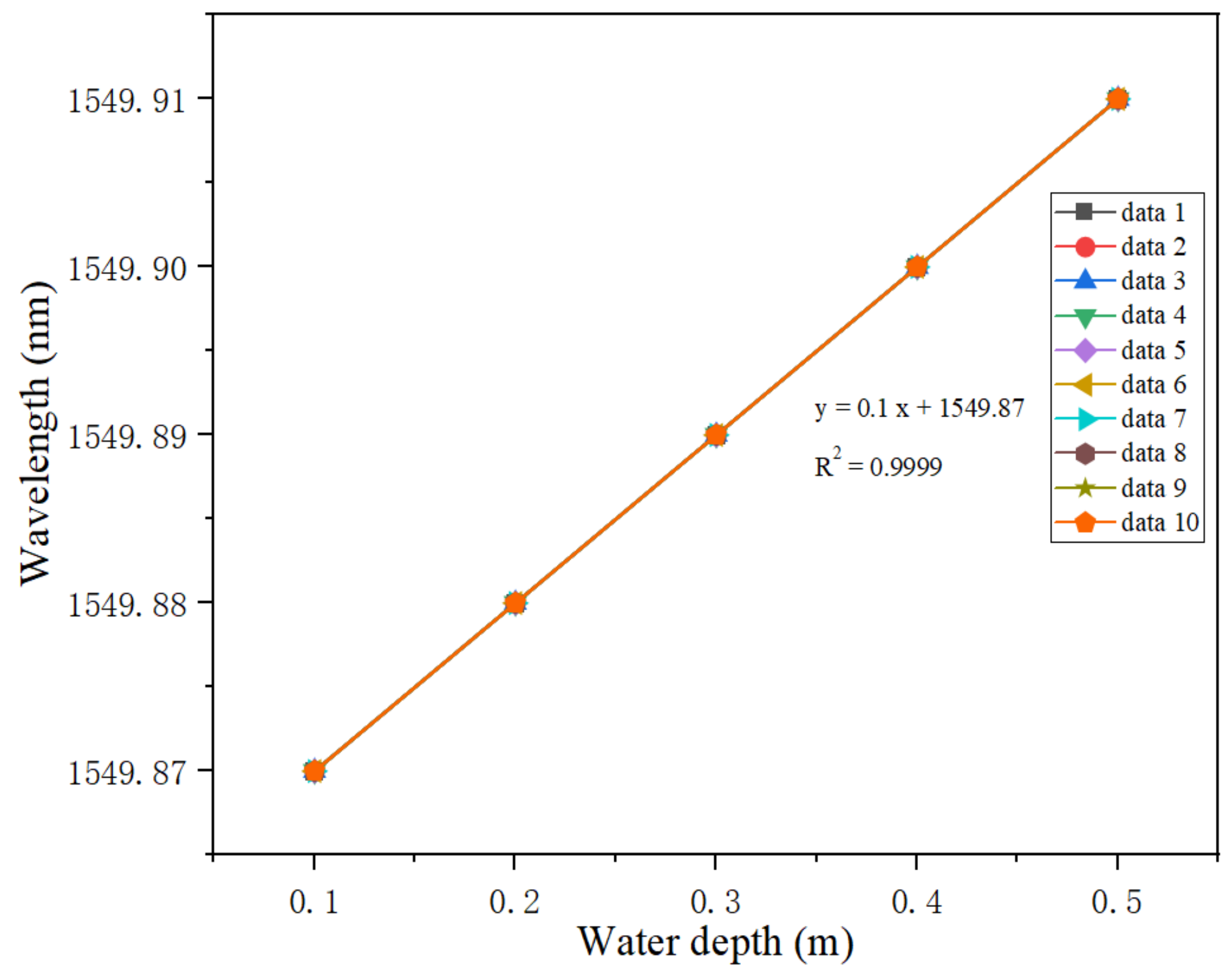

Fig 5. The linear relationship between water depth and wavelength shift

The proposed sensor was placed into a water tank with a height of 0.5 m, the sensor was moved in a step of 0.1 m, kept for 5-10 seconds for stabilize for data recording. The spectral collected by the OSA as Fig. 4. shown. It could be noticed that the peak shifts to the right as the water depth increases. The relationship between the Bragg wavelength of the FBG and the water depth can be obtained as shown in Fig. 5. by analysis 10 groups of recorded data. By converting the water depth in Fig. 5. into fluidic pressure, the measurement sensitivity of the sensor to fluidic pressure is about 10 nm/MPa, and the linearity is as high as 99.99%.