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Design and Characterization of a Pressure Sensor Based on FBG on Steel Substrate †

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Abstract: In this paper a new optical, Fiber Bragg Grating (FBG) based, pressure sensor is presented. The sensor adopts a stainless steel membrane with a FBG sensor attached and is thought to be used in a multi parametric multi-sensor system aimed at the detection of water leakages in potable water networks. The sensor has been experimentally characterized on a reference plant in the range of pressure 0–6 bar. Main metrological characteristics of the lab-scale prototype developed are: a sensitivity of 0.314 nm/bar, an accuracy of about 39 mbar and a resolution of about 1.5 mbar.

1. Introduction

Water leak detection systems is of increasing interest because of increasing deterioration or damage to the distribution systems, which involve a significant economic loss for the water network managing authorities. A number of methods of leak detection have been proposed in the literature as, for example, tracer gas, thermography, flow and pressure modelling [1], ground penetrating radar (GPR) [2], acoustic through the use of hydrophones [3].

Optical sensors based on FBGs exhibit advantages, such as intrinsically safety, chemical and electromagnetic passivity, high sensibilities and precisions. Moreover, biocompatibility, remote sensing and possibility to be optically multiplexed enabling the construction of sensors networks with a high number of sensing elements [4], are of high importance for the sake of the monitoring leakages in potable water networks. A Bourdon tube with attached a couple of FBGs to detect the pressure leakage [5], a solution exploiting a FBG sensor embedded in a composite fiber reinforced plastic membrane presented in [6], are just examples of pressure sensors available in the literature.

In this paper an optical pressure sensor developed in the framework of the FIBRA project is presented. The device, shown in Figure 1a, uses a FBG based sensing strategy to measure the strain exerted by the pressure (inside the monitored pipe) onto a 500 μm thick circular stainless steel (316L) membrane. The membrane thickness has been suitably designed to assure a linear response in the range of pressure of interest. Figure 1b shows the circular membrane with the FBG attached on top and a second rectangular membrane with a second FBG sensor used for the sake of temperature compensation. A top view of the sensor, during the assembly phase is shown in Figure 1c, while Figure 1d shows the sensor mounted on the test plant.

2. Results and Conclusions

The sensor has been experimentally characterized on a reference plant, in the range of pressure 0-6 bar, using a commercial reference manometer. Data have been acquired using an I-MON USB 256 interrogation monitor by Ibsen Photonics and the dedicated management software developed in NI LabVIEW. The FBGs have been illuminated by a broadband source DenseLight DL-BP1-1501A employing a 1550 nm superluminescent light emitting diode. Figure 2 shows a calibration diagram of the optical pressure sensor, together with the uncertainty band estimated in the 3σ level (considering a coverage factor of 3). Moreover, a linear fitting model is reported. Main metrological characteristics, experimentally evaluated, are given in Table 1.

In conclusion, experimental results have demonstrated the capability of the sensor to provide an estimation of the pressure in water pipes with an high resolution (1.5 mbar) and accuracy (39 mbar, evaluated considering a coverage factor k = 3). Further experiments will be dedicated to the evaluation of the sensor performances in the context of water leakage detection.

(**a**) (**b**) (**c**) (**d**)

Figure 1. (**a**) The optical pressure sensor; (**b**) The two FBG sensors bonded on the stainless steel membranes; (**c**) a top view of the sensor during the assembly phase; (**d**) the FBG sensor mounted on the experimental setup.

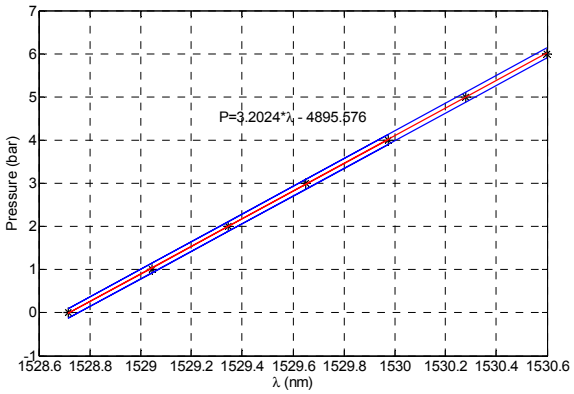

Figure 2. Calibration diagram of the optical pressure sensor.

Table 1. Metrological characteristics of the pressure sensor: sensitivity, S, accuracy, σ and resolution dP.

S (nm/bar)	σ (mbar)	dP (mbar)
0.314	39	1.5

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