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ORIGINAL PAPER

Effect of thermal expansion mismatch in grating material and host specimen on thermal sensitivity of FBG sensor

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Abstract Authors have studied thermal sensitivity characteristics of FBG temperature sensor attached to the surface of targeted host specimen (Lee and Lee in J Korean Phys Soc 59(5):3188–3191, 2011; Yu-Lung and Han-Sheng in Meas Sci Technol 9:1543–1547, 1998; Reddy et al. in Opt Appl 40(3):685–692, 2010). In their mathematical analysis, the coefficient of thermal expansion of grating material is ignored due to its contribution to the shift in the wavelength is small as compared to shift because of CTE of host specimen. However, we find that the Bragg's wavelength shift used for measuring temperature in FBG sensor is dependent on difference in thermal expansions of grating and targeted host specimen materials. We have investigated the effect of the expansion in the material of the grating as well as that of host material and have found that at low temperature the difference in the shift in wavelength is indeed very small of the order of 0.67 pm at 26 °C, but the difference in the shift in the wavelength at higher temperature say 350–400 °C is quite large of the order of 250 pm and cannot be neglected as it will result in error reading of the temperature for higher ranges.

Keywords Fiber Bragg grating (FBG) · Temperature sensor · Thermal expansion

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1 Introduction

FBG is widely accepted as temperature sensor in many applications over a decade [1–4]. In FBG, the temperature is monitored in terms of shift in the position of reverse reflected Bragg's wavelength and the shift in wavelength is dependent on FBG period. The grating period depends on the separation between grating planes and index density of the core [5]. With the increase in temperature around FBG sensor, the separation between grating planes varies due to thermal expansion and density varies due to thermo optic property of fiber material [6]. Thus, grating period changes and responds a shift in Bragg's wavelength position used to estimate temperature sensitivity. Some researchers have studied characteristics of FBG as temperature sensor in their experimental designs [6–8,10]. The mounting or fixing ends of FBG as done in references [6–8] leads to an extra shift in reflected Bragg's wavelength of FBG due to mismatch in thermal expansions of fiber grating material and host specimen. Because the difference in expansions induces an axial strain in FBG termed as thermal strain [7,9] which in turn changes the grating period and finally shifts the position of Bragg's wavelength [8]. The work reported in references [6–8] has not accounted the mismatch in CTEs in their mathematical analysis. There the CTE of the fiber grating material has been ignored, and only the effect of induced strain in FBG because of thermal expansion in specimen is considered.

In our study, we have considered this mismatch in CTEs in the analysis of sensor and have estimated the error caused in measurement of temperature in terms of reflected Bragg's wavelength shift. The temperature range in our study is from room temperature to 400 °C. In this analysis, regenerated FBG (chemical composite FBG) is assumed to be bonded (ceramic adhesive) with two host specimens platinum (Pt) and Yttria stabilized Zirconia (YSZ) separately. Moreover,

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