Improvement of Temperature Sensitivity Based on the GO-PMMA Coating Technique

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***Abstract*—The coreless D-shaped fiber that is transferred by graphene oxide (GO) and polymethyl methacrylate (PMMA), is demonstrated to be highly sensitive to temperature due to the evanescent field penetration into the PMMA, which possesses an extremely high negative thermal optical coefficient. Experimental results show a high sensitivity of 4.816 nm/℃ with a linear correlation of 0.9974 over a wide temperature range.**

Keywords*—*D-shaped fiber, graphene oxide, polymethyl methacrylate, temperature sensitivity

I. Introduction

Temperature measurement is playing an increasingly important role in fields such as chemistry, physics, agriculture, machinery and aerospace, environmental protection, and biomedical. Due to their features of anti-electromagnetic interference, corrosion resistance, high sensitivity, and long-distance distributed measurement, various fiber-optic temperature sensors can be schemed such as fiber interferometers [1-2], fiber gratings [3-4]. Owing to the low thermal optical coefficient/thermal expansion coefficient of quartz material, the relative temperature sensitivity is, however less than dozens of pm/°C [5]. Su et al. proposed a suspended core microstructure fiber optic temperature sensor, whose sensitivity is about 0.05 nm/°C [6]. In order to improve the sensitivity, coating materials with high thermal optical coefficients can be involved [7-9]. For instance, Xue et al. reported a sensitivity of -3.88 nm/°C by encapsulating the fiber in a capillary filled with isopropanol [10]. However, these methods require additional manufacturing processes such as splicing, filling and precise alignment, which leads to extremely high production costs and then the complexity.

Due to advantages of simple structure, easy fabrication and low cost, D-shaped fibers (DFs)-based sensors [11-12] are widely used. Here, a high-sensitivity temperature sensor based on a coreless D-shaped single-mode fiber is proposed, where the evanescent field can be improved with the help of graphene oxide (GO) and PMMA coating. Within the temperature range of 30-50°C, the temperature sensitivity for the heating process was measured to be 4.816 nm/°C with a high R2 of 0.9974. This indicates that this temperature sensor has relatively high temperature sensitivity.

II. Sensing scheme

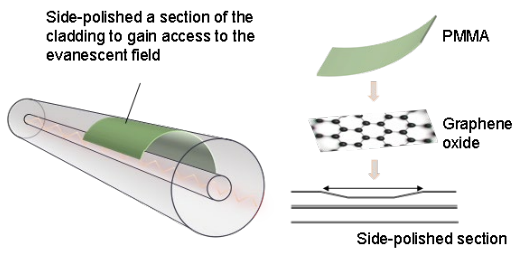

Fig. 1 the sensing scheme

Figure 1 indicates the three-dimensional structure of the DF-based sensor. Initially, the coreless D-shaped SMF is manufactured by homemade polishing device, where the optimized scheme can effectively excite higher-order modes, and then involve multimode interference. Furthermore, the evanescent field is dramatically penetrated into the PMMA film with the help of graphene oxides.

III. Experimental results

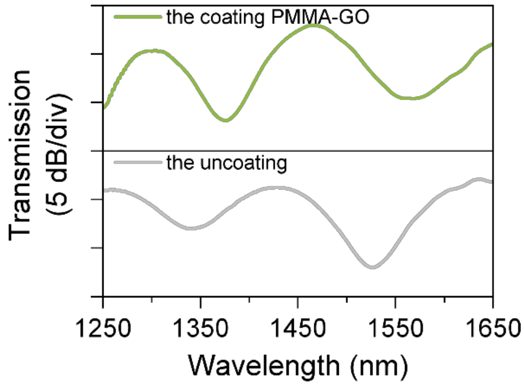

Fig. 2 Transmission spectra with/without the coating PMMA-GO

The comparison between the coating GO-PMMA and uncoating structure is shown in Fig.2, where a spectral analyzer (OSA, AQ6317C, with a resolution of 0.02 nm) and a broadband source (ASE, with a spectral range of 1250-1650 nm) are employed to record its transmission spectra.

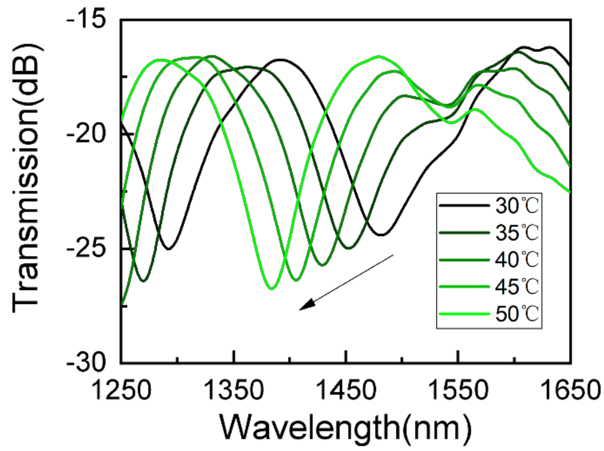

Fig. 3 the temperature measurement

Furthermore, the spectra present a significant red shift in response of the increased temperature when placed the sensor in a column oven (LCO 102 DOUBLE). The test results demonstrate that the transmission spectra indicate a significant blue shift, as shown in Fig. 3. It also means the PMMA with a highly negative thermal optical coefficient plays an important role.

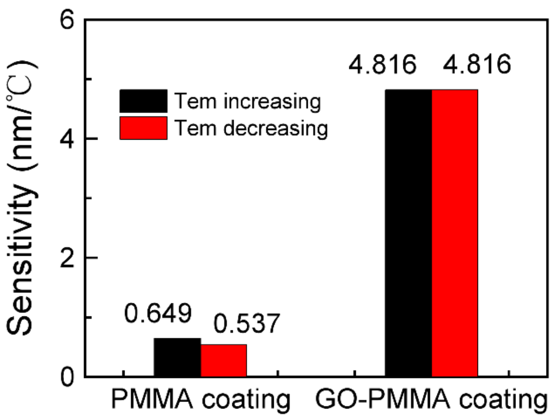

Fig. 4 Comparison of performance with/without the GO coating

Moreover, our proposed scheme shows advantaged performances in the aspects of sensitivity and stability in comparison with only the PMMA coating, which can be found in Fig. 4.

IV. Conclusion

A highly sensitive sensing scheme is proposed. The PMMA coating can be replaced with other materials, like electro-optic materials, magneto-optic materials, etc.

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