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Simulation study of a temperature-calibrated double-sided polished optical fiber SPR refractive index sensor

WANQI ZHAO,[1,2,†] MIN XIONG,[1,2,†] MING CHEN,[1,2,†] YU CHENG,[1,2,*] SHIJIE DENG,[1,2] HOUQUAN LIU,[1,2] CHUANXIN TENG,[1,2] HONGYAN YANG,[1,2] HONGCHANG DENG,[1,2] AND LIBO YUAN[1,2]

[1]School of Optoelectronic Engineering, Guilin University of Electronic Technology, Guilin 541004, China
[2]Guangxi Key Laboratory of Optoelectronic Information Processing, Guilin University of Electronic Technology, Guilin, China
*Corresponding author: chengyu@guet.edu.cn

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The temperature of the environment directly affects the accuracy of refractive index (RI) measurement. Therefore, we propose a double-sided polished surface plasmon resonance (SPR) RI fiber sensor, which is available for simultaneous measurement of the RI and temperature in real time. The proposed sensor uses single-mode fiber as a special double-sided polishing structure. The double-sided polishing regions are coated with a gold–silver hybrid film; one side is additionally coated with graphene layers to increase detection sensitivity, and the other side is coated with polydimethylsiloxane on the metal layer for temperature sensing. The simulation result shows that in the range from 1.33 to 1.35, RI sensitivity reaches as high as 2600 nm/RIU. In the range from 15°C to 85°C, temperature sensitivity reaches as high as −3.5 nm/°C. The full width at half maximum is 65 nm. Compared with previous studies, the sensitivity is slightly improved, and an excellent temperature compensation effect can be achieved. It is suitable for high-precision measurement of the environment and biochemical aspects.

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1. INTRODUCTION

Surface plasmon resonance (SPR) fiber optic sensors have the advantages of high sensitivity, easy and fast detection, compact structure, low cost, label-free sensing, good stability, etc. They have been widely used in materials science, environmental protection, the food industry, and many other fields directly related to human survival and development [1–4].

Currently, refractive index (RI) detection based on the SPR principle can be divided mainly into two categories: basic RI sensors and hybrid RI sensors [5–9]. With the development of SPR technology, RI measurements based on SPR principles and using a variety of optical fibers are becoming more and more popular. For example, Wang *et al.* [6] proposed a single-layer air-hole D-shaped micro-structured fiber sensor based on SPR to achieve high sensitivity in detecting RI. Yu *et al.* and Song *et al.* [7,8] designed optical fibers into structures that make SPR easier to produce, such as D-type fibers, U-shaped fibers, etc. The metal film was combined with 2D material to improve the sensitivity of RI detection. More and more researchers want to simplify the operation steps and processes, so they are starting to design dual parametric measurement sensors that can detect two or more variables at the same time. For instance, Teng *et al.* [9] performed RI measurements along with liquid level measurements. However, it is difficult to eliminate the influence of temperature cross talk on detection accuracy during the measurement process, which will cause some errors in the sensor.

Based on the above reasons, the existence of temperature compensation techniques is necessary. The current methods of temperature compensation include the sub-region detection method, optical fiber interferometry, and dual-channel method [10–16]. For example, the adopted sub-region detection [10–12] divides the region with the cladding into detection of the temperature region or temperature complementary region and detection of the other regions to be measured. However, the sensing region of this structure is generally longer than the normal single sensing region, leading to a wider full width at half maximum (FWHM) and poorer sensor performance. Some studies have applied a different technical route than partition detection. Chen *et al.* [13], based on Fabry–Perot (FP) interference, used a reference channel to compensate for external temperature effects. In addition, temperature compensation based on long-range SPR (LRSPR) can also be performed [14]. In recent years, a dual-channel has been utilized for temperature compensation of RI. Different forms of double-sided polishing