Proposal of Two Tangent Air Hole Structure for Higher Sensitivity Gas Sensor

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Breath gas analysis emerged as a promising technique which is serving as biomarkers [1]. The optical method is a very sensitive and accurate method for the analysis of a variety of biomarkers. In this way, the use of PhC resonators as gas refractive index (RI) sensors is concerned, a strong light-matter interaction between the optical field and the analytes is preferred. However, in typical PhC-based sensors, the optical resonance mode is strongly confined to the high-index material (dielectric region) in order to achieve a high-quality factor ($Q \sim 10^6$) [2]. For these structures, the sensitivity (S) is low because the analyte is located in the air or liquid region where the strength of the confined light field fully overlaps with the analytes. Therefore, the RI sensitivities of most geometries are generally limited to around 100-200 nm/RIU (RIU, refractive index unit) [3-4].

The designed higher sensitivity gas sensor based on two tangent air hole structure is shown in Fig. 1. The structure is designed via the following two phases. First, the photonic crystal cavity region has a 21-tangent air hole defect consisting of a quadratic decreasing in hole radius, decreased from R_1 = 120 nm on both ends to R_2=100 nm in the center. Second, on each side of the cavity is the mirror region, which consisting of 10 tangent air-hole mirrors with the same radius of R_1 =120 nm. The separation distance (Λ period) of each tangent air hole arrays is 600 nm. The width of bus waveguide is 500 nm wide and 24 μm long. Figure 2 shows the resonance peak shift of the proposed tangent air hole structure with increased methane gas concentration. As seen, the methane gas detection sensitivity is 2.16 nm/%, which corresponding to the RI sensitivities is 353 nm/RIU. The proposed two tangent air hole structure improves sensitivity to 2.16 nm/% compared to the single air hole structure (0.67 nm/%) [5].

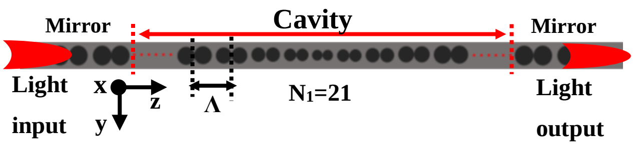

Fig. 1. Device configuration

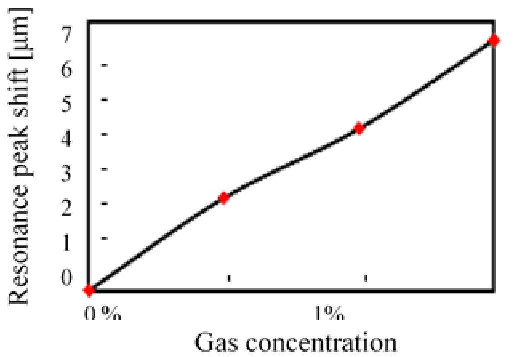

Fig. 2. Methane gas detection sensitivity

Reference

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