Q-factor enhancement in photonic crystal cavities based on trapezoidal slotted nano-sticks for refractive index sensing

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Abstract: We present the design of slotted high-Q factor photonic crystal cavity in which an improvement of 2 orders of magnitude in the Q factor, as a function of angle sidewalls and number segments, is demonstrated.

The shift of resonance wavelength in PhCs, induced by changing in the background refractive index, can be used for refractive index sensing. Besides the strong light-matter interaction, high-Q factor cavities make these resonators suitable for complete integrated sensing platforms. To achieve this goal, we numerically study the influence of oblique sidewalls and number segments on the Q factor of a Silicon slotted nano-stick based PhC [1-3]. Figures 1(a), (b) and (c) show the sketch for the slotted 1D PhC stack mode-gap cavity considered in this work where the widths ($W_y(i)$) of the dielectric blocks are quadratically modulated ($W_y(i) = W_y(0) + i^2(W_y(i_{max})-W_y(0))/i_{max}^2$, from the center to both sides where i increases from 0 to i_{max}. The refractive indexes of the silicon stack and the silica substrate are 3.46 and 1.44, respectively.

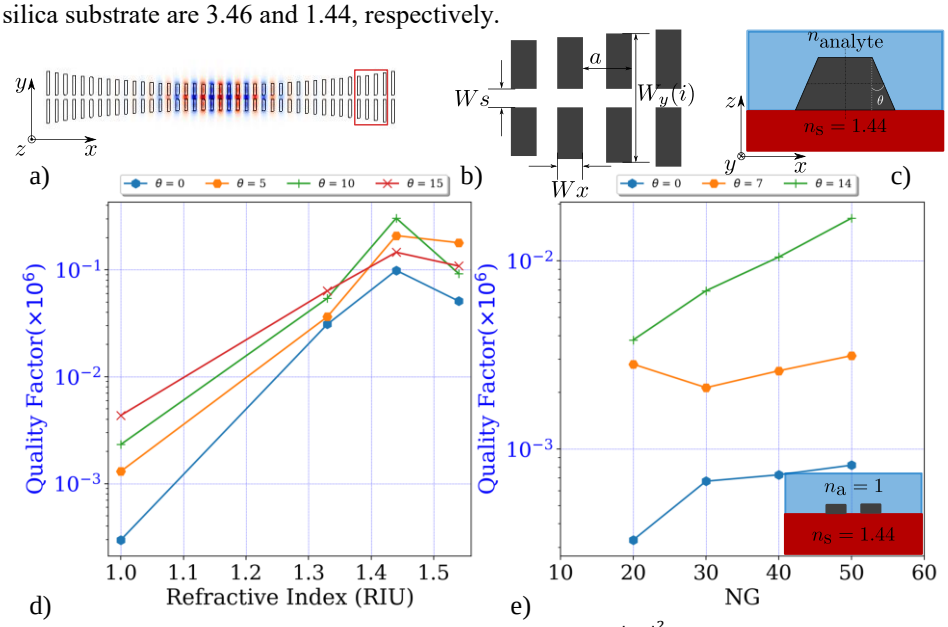

Fig. 1 (a) Schematics of proposed cavity, in which the electric field intensity ($|E_y|^2$) at 1547.8 nm is imposed; (b) Zoom in picture (a), where a = 410 nm, W_s = 200 nm, $W_x = 0.4a$ and W_y parabolically modulated from $W_y(0) = 3.0a$ in the center to $W_y(20) = 6.0a$ on either side;(c) Analyte and substrate distribution joint with a lateral view of segment shape, (d) Q-factor for different analyte refractive index sweeping the angle(θ) of sidewalls; (e) effect of the number of Gaussian mirror segments (NG) on the Q-factor for $n_a = 1$.

Fig.1(d) shows the enhancement of Q-factor with respect to vertical sidewalls (blue) for different analyte refractive indexes. The main significant increment is achieved at $n_a = 1$. In this regard, Fig. 1(e) shows the effect of the number of segments (NG) on the Q factor when n_a is fixed equal to 1. Consequently, the combination of oblique angles and number of segments allows to achieve an improvement of 2 order of magnitudes in terms of Q factor. The proposed approach could be very attractive for gas sensing applications.

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