DOI: 10.3969/j.issn.1003-501X.2017.02.007

Subwavelength filter and sensor design based on end-coupled composited ring-groove resonator

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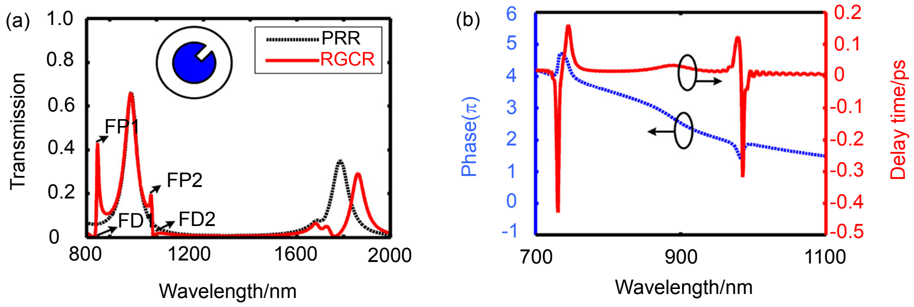

(a) Transmission spectra of PR resonator and RGCR structure with φ=90° and L=100 nm, and (b) phase response and delay time.

Abstract: Based on the metal-insulator-metal (MIM) waveguide structures, a plasmonic filter and a sensor are designed by using an end-coupled ring-groove composited resonator (RGCR). It is well known that the perfect ring (PR) cavity can be regarded as a Fabry–Pérot resonator, and the transmission wavelengths of all the resonance modes are determined by its perimeter. According to the magnetic field distributions of the 1st and the 2nd resonance modes inside the PR cavity, a groove is added in the horizontal or the normal position of the ring cavity to manipulate the wavelength of the only expected mode in this paper. Specifically, when the groove locates at the anti-node of magnetic field, SPPs will be captured into the groove, and then the resonance wavelength is changed by the groove. On the contrary, when the groove locates at the node, the corresponding SPP mode will not be affected by the groove. When the inner and outer radius are 150 and 220 nm, the 1st and the 2nd resonance wavelengths for the PR cavity are 890.6 and 1784.4 nm, respectively. To manipulate the wavelengths of the modes, the groove is firstly placed at the top of the PR, where are the anti-node and the node for the 2nd and the 1st modes, respectively. The wavelength for the 2nd mode is linearly changed by the length of the groove, while the 1st mode keeps no change. Secondly, the groove is placed in the horizontal position, where the anti-nodes for both SPPs modes emerge. Likewise, it is investigated that the center wavelengths for both modes have linearly redshifted by increasing the length of the groove. In this case, the structure can be used as an on-chip optical filter with flexible wavelength manipulation. In addition, when the groove is rotated with an angle of π/4, Fano resonance will arise due to the mode interferences. Dual asymmetric sharp transmission peaks are achieved around the wavelength of the former 2nd resonance mode, and the resonance wavelengths for both Fano peaks are also tuned by the length of the groove. High figure of merit of 4.1×10^4 and high refractive-index sensitivity of 970 nm/RIU are obtained for the structure. Therefore, it is believed that the device can find wide applications in the biochemistry sensing area. It is also investigated that normal and abnormal dispersions are available at the peaks and dips, respectively. The corresponding spectra and the propagation characteristics are numerically investigated by using the finite-difference time-domain method. The proposed structure can provide important support for the development of highly integrated photonics circuits and on-chip optical sensors.

Keywords: plasmonic filter; sensor; Fano resonance

Citation: Wen Kunhua, Hu Yihua, Chen Li, *et al*. Subwavelength filter and sensor design based on end-coupled composited ring-groove resonator[J]. *Opto-Electronic Engineering*, 2017, **44**(2): 192-197.

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