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Transmission characteristics of a Y-shaped MIM plasmonic waveguide with side-coupled cavities

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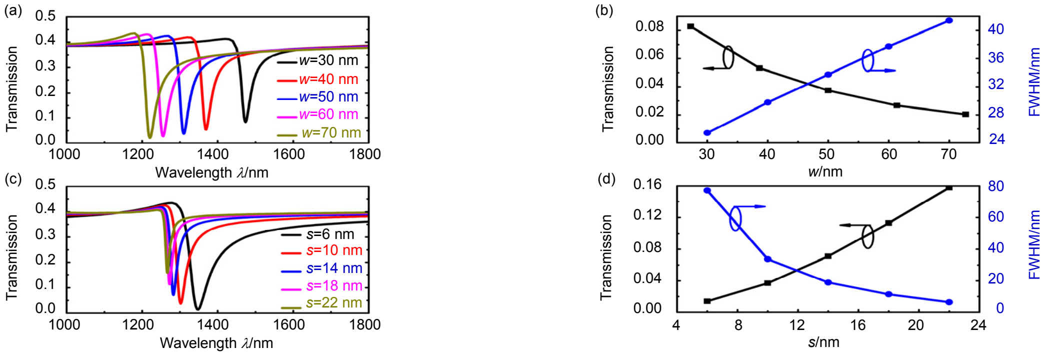

Transmission spectra of (a) different resonator width (c) different coupling distance. Transmission dip wavelength and FWHM as a function of (b) resonator width w, and (d) coupling distance s. Here, L_1=L_2=420 nm, s=10 nm, h_1=170 nm, h_2=120 nm, and w=50 nm.

Abstract: Surface plasmon polaritons (SPPs) is a type of collective electron oscillation along metal-dielectric interface. Based on the coupling between the incident light and the free electrons metal surface, it can propagate along the interface with an exponentially decaying field distribution on both sides. SPPs may be one of the most promising candidates in the area of nano integrated optics because of the subwavelength optical confinement with the ability of breaking the diffraction limit. During the past years, advancements in novel plasmon waveguide configurations have led to the proposal and demonstration of numerous plasmon waveguide structures, which combine the advantages of both semiconductor and plasmon waveguides and enable light transmission in the deep sub-wavelength scale to achieve long distance propagating with very tight mode confinement. Among these waveguides, the metal-insulator-metal (MIM) waveguides have attracted considerable interests because of their smaller mode size, stronger confinement of SPPs and lower propagation loss. They are promising structures for design of nanoscale all-optical devices due to their relatively easy fabrication according to the current state of the art. Optical resonant cavities based on the MIM structures are crucial structural components in plasmonic wavelength-selective devices and plasmonic all-optical switches owing to their simplicity. A plasmonic Y-shaped metal-insulator-metal (MIM) plasmonic waveguide structure with two side-coupled Fabry–Perot (FP) resonant cavities is proposed. The finite element method (FEM) is used to study the transmission properties of the waveguide. Simulation results show that two stopbands occur respectively on the transmission spectrum of each output port and which is helpful to the potential applications of narrowband filter. In addition, at other locations in the spectra away from the stopbands, the transmission rates of the two output ports are always equal indicating obvious effect of optical splitting. By tuning the lengths of the two cavities, the locations of the stopbands can be effectively controlled, and an interesting phenomenon is that the transmission peak of one output port corresponds to the transmission dip of another output port. Based on this result, the effect of all-optical directional transmission, switching and filtering can be obtained and adjusted by changing the geometry parameters. Finally, the applications of the structure in the area of refractive index sensing are investigated. For this purpose, the sample to be measured can be filled in two the cavities. During the simulation, the refractive index of the medium filled in the cavities is changed from 1.00 to 1.05 with a step of 0.01. It is found that the transmission spectra of the two output ports have a clear redshift, and the calculated sensitivity can reach 1280 nm/RIU with the quality factor up to 208. The proposed compact waveguide structure has potential applications in the field of integrated photonic devices, such as plasmonic filters, switches, power splitters and refractive sensors.

Keywords: surface plasmonic waveguide; transmission spectrum; resonance

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