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Abstract We present our design results for efficient coupling and modulation in plasmonic structures. Fiber coupling to a plasmonic slot waveguide is significantly increased by a metallic nanoantenna with additional reflectors or by the configuration of several connected antennas. We also show that the plasmonic four-layer waveguide with patterned ITO layer can modulate light with higher transmission and the same modulation depth as a waveguide with a uniform ITO layer.

Nano-scaled plasmonics is currently considered as bearing promising potential to merge photonics and electronics with a lot of opportunities in fundamental science and technology [1]. Plasmonic communication components can provide optical speed keeping the footprint of electronics. Such ambitious goal causes constant interest in plasmonic-based solutions. We present here our approach in two focus areas of plasmonics: optical fiber to slot waveguide coupling and plasmonic wave modulation. Besides the criteria of maximal coupling or modulation efficiency we challenge our designs in terms of fabrication suitability thus holding the promises for experimental characterization of our devices in the shortest time.

Nanoantenna coupler. Employing antenna systems to capture electromagnetic radiation from the free space is a common approach in radio- and microwaves. However, the concept of the antenna based coupler to plasmonic waveguide has only recently been proposed [2-3]. In the presentation we show how the coupling efficiency (CE) and effective area of the dipole antennas for coupling to a plasmonic slot waveguide can be systematically improved. Beside geometry optimization, additional reflectors, parallel and serial connected antennas can be used (see Fig. 1(a)). The effective area of an antenna system is an order of magnitude larger than of the waveguide only (see Fig. 1(b)). Additional reflectors and connection of antennas in an array helps to increase the effective area two times more.

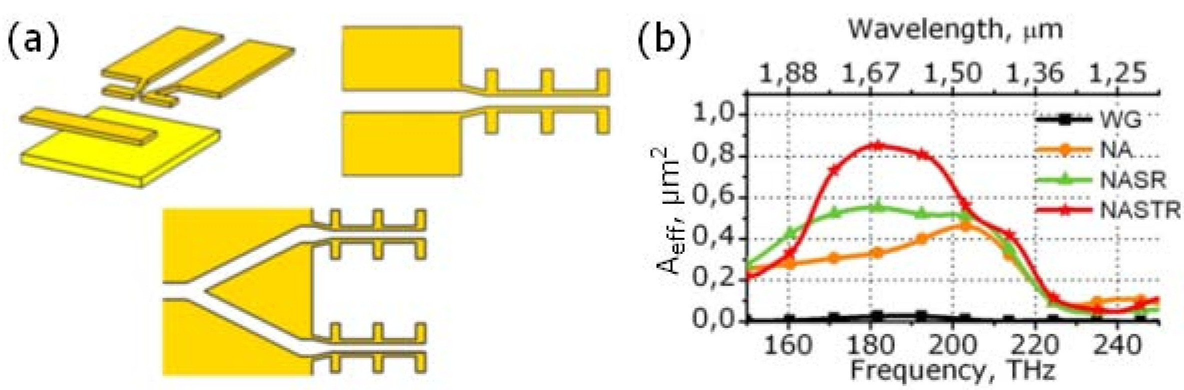

Figure 1. (a) Sketch of the regarded nanoantenna coupler solutions. (b) Effective area of the waveguide only (WG), nanoantenna (NA), nanoantenna with side (NASR) and side and top reflectors (NASTR).

Absorption modulator. It has been recently proposed a plasmonic modulator based on the two-layer core of silicon nitride (Si_3N_4) with thickness 70 nm and an ITO layer with thickness 8 nm as an ultrathin layer imbedded between two silver plates (electrodes) [4]. The carrier density in the ITO layer changes under applying voltage to electrodes according to the Thomas-Fermi screening theory. The figure of merit (FoM), which characterizes performance of the modulator is defined as FoM = $(\alpha_{off}-\alpha_{on})/\alpha_{off}$, where α_{off} and α_{on} are absorption coefficients (regarding the amplitude) in the voltage-off and voltage-on states respectively.

Improving design of the modulator we consider the system with various permittivity of the ITO layer. It is possible to achieve a range of permittivity values under different annealing conditions [5]. Results for the absorption coefficients and FoM are shown in Fig. 2(a). The FoM has the minimum for $\mathrm{Re}(\varepsilon_{off}) \approx -0.17$ and then increases for positive $\mathrm{Re}(\varepsilon_{off})$ up to FoM = 0.37 for $\mathrm{Re}(\varepsilon_{off}) \approx 0.83$.

To increase transmittance we replaced the continuous film of ITO by periodic strips (see inset in Fig. 2(b)). We define the filling factor as the ratio of strip width w to the period P of the structure, $f = w/P$. Filling fraction $f = 1$ corresponds to the continuous ITO film. Results for the transmittance in the voltage-off state and FoM for various filling factors are shown in Fig. 2(b). The FoM is almost constant, but the transmittance increases dramatically with decreasing the filling fraction. That means that the transmittance can be significantly increased preserving modulation depth by partial removing of the ITO layer.

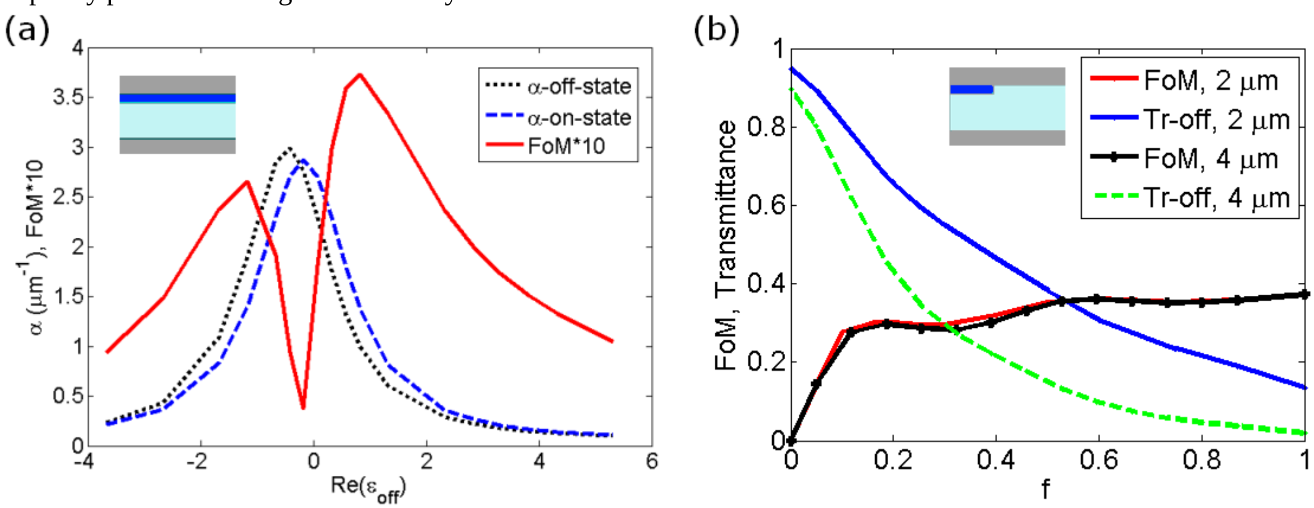

Figure 2. (a) FoM versus real part of permittivity $\mathrm{Re}(\varepsilon_{off})$. Inset: initial design.
(b). Transmission and FoM dependence on filling fraction. Inset: improved design, one period.

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