[width=0.3]a.tif

Figure 1. Slab metamaterial-dielectric waveguide consisting of three layers, layer (1) is the dielectric core and regions (2) and (3) are metamaterial claddings.

Hybrid Mode Tunability in Metamaterial Nano-Waveguides

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February 2014

1. BACKGROUNDS AND METHODS

To study the metamaterial waveguides, metamaterials with fishnet unit-cells are considered in this paper. To describe the conceptual basis of metamaterial, we first describe the design of the constituent magnetic and electric properties that give rise to negative permeability μ and negative permittivity ε and then explain waveguide. The behavior of refractive index of metamaterials is as

$$n = \sqrt{\frac{\varepsilon\mu}{\varepsilon_0\mu_0}} \tag{1}$$

where ε is electric permittivity and μ is magnetic permeability that both are complex-valued such that $\varepsilon = \varepsilon' + i\varepsilon''$ and $\mu = \mu' + i\mu''$. ε_0 and μ_0 are permittivity and permeability of free space, respectively.

1.1. Slab Waveguide

Waveguides are structures constructed from core and cladding and can be made of different materials [27]. The applications of metamaterials in waveguides have attracted interest in recent years [28]. In this paper, we study nano-scale slab metamaterial-dielectric waveguide, with dielectric core and metamaterial cladding. The waveguide consists of a dielectric layer with the width $w = 4\pi c/\omega_e$, sandwiched by two metamaterial layers (figure1).

Slab waveguides can support different modes including transverse electromagnetic

[width=0.8]fig1.eps

Figure 2. The plot of real part (solid lines) and imaginary part (dashed lines) of refractive index (n) of the metamaterial as a function of frequency using the set of metamaterial parameters: $\omega_e = 1.37 \times 10^{16} s^{-1}$, $\omega_0 = 0.2\omega_e$,$F = 0.5$ and $\Gamma_m = \Gamma_e = 2.73 \times 10^{13} s^{-1}$. The shaded region is negative refractive index.

(TEM), transverse magnetic (TM) and transverse electric waves (TE) [7]. Studies show that metamaterial-dielectric waveguides can have three modes behavior as ordinary, surface plasmon polariton (SPP) [29] and hybrid ordinary-SPP modes (we call them hybrid modes in this paper) [10], where hybrid modes are the combination of of SPP and ordinary modes.