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Title

Two-dimensional polaritonic photonic crystals as terahertz uniaxial metamaterials

Source

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Abstract

Emerging technologies such as quantum cascade lasers enabled the investigation of the most interesting, yet very little explored, THz part of the electromagnetic (EM) spectrum. These THz sources impose a dire need for novel materials suitable for optical components at such frequencies, as traditional visible optics is not appropriate for THz. Here, we explore two-dimensional (2D) photonic crystals (PCs) with either or both constituents made of polar materials, having a polariton gap within or close to the THz regime. Our objective is to create polaritonic composites that behave as extraordinary effective homogeneous uniaxial media, with flexibly engineered EM wave dispersion and high transmissivity in the THz frequency region. Accordingly, it is most important to be able to identify when 2D composites act as effective bulk uniaxial media. Clearly, deviation from standard effective medium predictions does not necessarily imply bulk effective medium picture breakdown. We developed a reliable criterion which provides a clear angular signature of effective medium behavior in 2D composites, even in the presence of high losses. Relying on this criterion, we characterized polar-dielectric and polar-polar PC composites acting as homogeneous uniaxial metamaterials for any arbitrary incident angle. We selected certain cases of effective metamaterial composites which demonstrate a polarization filter behavior. In particular, our results suggest that an unpolarized source will lead to either an S- or a P-polarized wave just by changing the angle of incidence of the impinging wave, irrespective of the thickness of the composite metamaterial. Furthermore, we show that transmission through a LiF/NaCl composite can be as high as 20%, even though transmission through an identical slab made from either of the two polar constituents would be next to zero. We analyze and discuss the physical origins underpinning such extraordinary angular transmission profile of these metamaterial composites. Our results suggest that appropriate mixing of polar materials with each other or with high-index dielectrics provides a route to making advanced photonic materials that are highly attractive for THz optical components. (55 References).