Novel Optical Cross Polarization Converters Based on Slotted Nanoantennas

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The capability to manipulate the polarization state of electromagnetic waves and light is important in optical systems. Metamaterial (MM) as an alternative to manipulate the wave polarization state have drawn considerable attention due to its attractive characteristics, such as near zero refractive index, cloaking, etc. Thus a number of electromagnetic wave polarizer and wave plate have been realized through anisotropic and chiral MMs. Researchers have discovered that the strong polarization dependence is highly related to the localized surface plasmon excitations induced by the nanoscale composite element in these MMs. Correspondingly, it is found that the resulting polarization converters based on MMs suffer from narrow operating bandwidth. Therefore, it is highly desirable to design broadband and multiple-band polarization converters that can realize different polarization conversions.

To address the above issue, we presented highly efficient and multiband/broadband cross polarization converters (CPC) based on metamaterials working in a reflective mode in the infrared regime, which are composed of a layer of slotted L-shaped metallic nanoantennas, and a layer of dielectric spacer backed by a gold ground plane. The first proposed slotted L-shaped CPCs can convert a linearly polarized wave to its cross polarized wave at three different resonant frequencies, which are the results of the mode hybridizations between the slot and the metallic nanoantenna. By increasing the substrate thickness, the second resonant frequency could gradually move toward the first one, which makes the first two sub-bands merge into a broad one. However, the efficiency within the original third band decreases significantly. This issue could be addressed by replacing the L-shaped slot with a stepped one, which widens both bands and achieves much higher conversion efficiency in the second broad band. Furthermore, the angle independence of the polarization conversion effect has been validated, and it is found that the first broad band (or the first two resonant frequencies) of the proposed broadband (or multi-band) converters appears to be independent of the incident angle (up to 47º). The proposed multiband/broadband cross polarization converters may have great potential for the design of efficient wave manipulation components in microwave, terahertz, and optical regimes.