Broadband Optical Antennas for Arbitrarily Polarized Light Waves

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In this paper, broadband optical antennas with very robust performance will be studied. Both electrical and magnetic optical antennas will be designed. The proposed optical antennas will be able to provide broadband performance under arbitrarily polarized light wave excitations. Optical antenna is one of the most important optical nano-devices. In analogy to its radio-frequency (RF) and microwave counterparts, the optical nano-antenna is defined as a device designed to efficiently convert free-propagating optical radiation to highly localized energy. Since its invention, based on different photophysical processes, optical antennas have been used in light-emitting devices, photovoltaics, and spectroscopy, leading to applications such as surface enhanced Raman scattering (SERS), light-emitting diode (LED), and solar cells.

The conventional optical nano-antennas can only operate at single fixed frequency. This has highlighted the need to search for optical antennas covering wide frequency band. Several broadband optical antennas have been proposed recently [E. S. Unlu et al., Opt. Express, 19, 1000-1006, 2011; M. Navarro-Cia et al., ACS Nano, 6, 3537-3544, 2012]. However, the performance of all these designs will be affected by the polarizations of incident waves. Circular polarization is required in order to achieve the best performance. This has limited their applications in practical systems. To address this issue, new broadband optical antennas are proposed in this paper. We will first study broadband electrical optical antennas, which can exhibit good performance under arbitrarily polarized light waves. Full wave electromagnetic simulations are carried out. It is found that strong electrical field enhancement can be achieved using the proposed devices under different polarizations including linear, elliptical and circular waves. Furthermore, based on the Babinet's principle, we will investigate the design of magnetic broadband optical antenna with robust performance. Strong magnetic field enhancement over broad bandwidths can be achieved using such devices. Moreover, different designs of the proposed broadband optical antennas will be investigated to provide optimal performance.