Beam Steering by an optical antenna

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Routing visible light at a desired direction is a fundamental issue for photonic applications. Here we demonstrate a multiple slot based optical Yagi-Uda antenna for beam steering of visible light. Yagi-Uda antenna usually refers to an array of rods working as an electric dipole feed, a reflector, and many directors.[1] Our antenna structure consists of multiple subwavelength-size slots, which is a Babinet-inverted type. As a result, our optical antenna has a magnetic dipole feed with auxiliary reflector and director slots.[2, 3] Unlike other optical nanoantennas on a high refractive index substrate, our structure does not suffer from the directivity limit arising from a natural tendency to radiate into high-refractive-index medium.

In this work, we have identified the magnetic dipole induction of a resonantly excited slot by finite-difference time-domain (FDTD) simulation and far-field Fourier space imaging measurement.[4] In order to compare the simulation with the measured far-field pattern, near-to-far field (NTFF) transformation developed for stratified media has been performed. We also examined resonant condition of the excited 'feed' slot and found out a linear relation of the resonance wavelength with respect to the slot length. The feed slot excites other auxiliary slots with plasmonic interactions to make far-field radiation with high degree of directionality. Various geometrical factors including slot lengths and inter-distances are investigated by comprehensive FDTD simulations and NTFF transformations for optical antenna structure. With polarization selectivity, we have investigated two different types – type A and type B – of Yagi-Uda antennas as shown in Fig. 1. We found out that increasing auxiliary slots helps to enhance the front-to-back (FB) ratio, which is a measure of directionality, up to 9.2 dB.

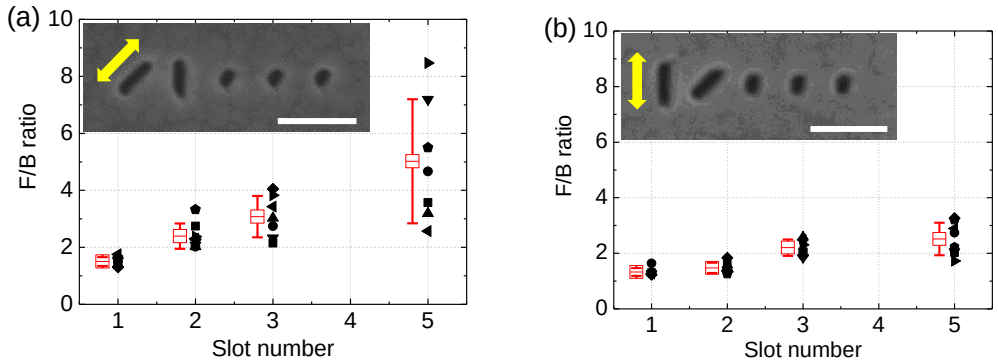

Fig. 1. Measured front-to-back ratios of various nanoantennas.
(a) Measured FB ratios of the type-A antennas as a function of the number of slots. (b) Measured FB ratios of the type-B antennas (complementary structure of the previously reported Yagi–Uda antenna). Secondary Eelectron Microscope images of each type of antenna are shown in the insets (scale bars: 200 nm).

Acknowledgment

References

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