A Comparative Study of Resonant Effects in Two-Dimensional Active Coated Nano-Particles of Circular, Polygonal, and Elliptical Shapes

Mikkel B.- Jørgensen[(1)], Piotr M. Kaminski[(1)], Richard W. Ziolkowski[(2)], and Samel Arslanagić*[(1)]
(1) Technical University of Denmark, Department of Electrical Engineering
DK-2800 Kgs. Lyngby, Denmark, sar@elektro.dtu.dk
(2) Department of Electrical and Computer Engineering, University of Arizona
Tucson, AZ 85721, USA, ziolkowski@email.arizona.edu

The area of passive and active nano-antennas has recently attracted great attention due to their potentials in a large variety of applications. Numerous designs were proposed; both the traditional ones, inspired by their microwave counterparts, as well as those making extensive use of metamaterial and plasmonic structures. In regards to the latter, extensive analytical and numerical investigations were conducted on the theoretical designs of nano-antennas by use of passive and active coated nano-particles (CNPs) of various shapes and excitations. It was demonstrated that specifically designed active CNPs possess highly resonant properties making them useful candidates for a variety of nano-antenna designs.

Most attention in these works was devoted to spherically shaped active CNPs for plane wave excitations (J. A. Gordon and R. W. Ziolkowski, Opt. Exp., 15, 2622-2653, 2007), and for electric Hertzian dipole excitations (S. Arslanagić and R. W. Ziolkowski, J. Opt. A, 12, 2010). The gain medium was, in most cases, accounted for through a canonical, constant frequency gain model, but in recent works (S. D. Campbell and R. W. Ziolkowski, Advances in OptoElectronics, 368786, 2012) the effects of realistic quantum dot gain media on the performance of CNPs were investigated. The associated problem in two dimensions was studied for a magnetic line source excitation of the corresponding active cylindrical CNP configurations (S. Arslanagić, Y. Liu, R. Malureanu and R. W. Ziolkowski, Sensors, 11, 9109-9120, 2011), and recently for the more complicated stacked electric dipole excitation (S. Arslanagić, Proc. of META14, Singapore, 2014). The possibility of tailoring the directive properties of cylindrical and spherical active CNPs has likewise been explored (S. Arslanagić and R. W. Ziolkowski, Advanced Electromagnetics, 1, 2012).

The present work extends our previous studies of circularly cylindrical active CNPs to account for the resonant effects in the corresponding active CNPs of polygonal and elliptical shapes. This study not only provides insight into these new fundamental geometries, but also accounts on the influence of shape imperfections of cylindrical CNPs that are likely to occur in a manufacturing process. Particular attention will be devoted to the location of the resonances, as well as the amount of gain needed to achieve them in a great variety of these new CNP configurations.