Measurement of Nano-Antenna Array Active Impedance Using Scattered Fields

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Modern nanotechnology allows us to fabricate nano-antenna arrays operating at optical frequencies. Due to the fabrication tolerances, inhomogeneity of the materials, and complex behavior of metals at optical frequencies there is a need to measure the nano-antennas' properties. Optical nano-antennas are characterized, like in the RF regime, by the fundamental parameters of antennas such as: directivity, gain, input impedance, polarization, etc. Parameters such as directivity and polarization can be measured by using near-field imaging methods (R. Esteban, R. Vogelgesang, J. Dorfmuller, A. Dmitriev, C. Rockstuhl, C. Etrich, and K. Kern, Nano Letters, 8, 3155-3159, 2008) or by an even more efficient far-field measurement scheme, using coherent scattering from nano-antenna arrays as has been demonstrated experimentally in (Y. Yifat, Z. Iluz, M. Eitan, I. Friedler, Y. Hanein, A. Boag, and J. Scheuer, Appl. Phys. Lett. 100, 111113 (1-4), 2012). Nevertheless, the above measurement techniques cannot measure nano-antenna impedances, which are required for the integration between antennas and loads. Due to the extremely small dimensions, it is impossible to measure the nano-antenna impedance directly by connecting probes or transmission lines to the antenna terminals. For this purpose, we propose a different approach, based on external illumination of an antenna array and measurements of the scattered fields. This technique can be further extended to characterize unknown nano-load properties for new optical sensor applications.

Several experimental papers dealing with the determination of the antenna impedance by measuring the scattered fields have been published (T.J. Mayhan, A.R. Dion, and A.J. Simmons, IEEE Trans. Antennas Propagat., 42, 526-533, 1994; E. Heidrich, and W. Wiesbeck, IEEE Trans. Antennas Propagat., 46, 341-350, 1998). These papers demonstrated the technique on a single antenna, terminated with three different loads (open-circuit, short-circuit, and matched load to a reference impedance). However, the array configuration was not studied. In an array configuration the return loss changes both with frequency and illumination/scanning angle for scattering/radiating array (D.M. Pozar IEEE Trans. Antennas Propagat., 51, 2486-2489, 2003).

In this paper, the theoretical formulation, followed by simulations and measurements demonstrate the advantages and limitations of this technique.