Quantifying the Scattering Characteristics of Plasmonic Nanowires and Microwires using Characteristic Mode Analysis

Daniel S. Kiddle* (1), Ethan J. Wilcox (1), Ahmed M. Hassan (1), and Edward J. Garboczi (2)

(1) Computer Science Electrical Engineering Department, University of Missouri-Kansas City, Kansas City, MO 64110

(2) Applied Chemicals and Materials Division, National Institute of Standards and Technology, Boulder, CO 80305

The scattering characteristics of real conductive nanowires and microwires differ significantly from those of perfectly conducting wires of the same shape and size. These differences arise from the fact that wires of different materials have different distributed impedances, which alters the current distribution on the wire. In this work, we investigate the Characteristic Mode Analysis (CMA) for quantifying the effect of the nanowire's or microwire's material properties on its scattering characteristics. CMA decomposes the current of any scatterer into a set of fundamental modes that are calculated by solving a weighted eigenvalue problem. The current flowing through a scatterer at any frequency and due to any incident field excitation can be expressed as a weighted sum of these fundamental modes in a formalism similar to the classical Fourier series representation. However, unlike Fourier series, the contribution of each mode to the total current is weighed by two factors: (*i*) the Modal Significance MS_n and (*ii*) the Modal Excitation Coefficient (V_n), where n indicates the mode number. The Modal Significance MS_n expresses the relative importance of each mode at a certain frequency and depends only on the shape, size, material properties of the nanowire or microwire, and the material of its environment. By calculating the MS_n spectrum versus frequency, we can easily identify the frequencies where a desired mode has a high significance or the frequencies with a desired mixture of modes. The Modal Excitation Coefficient, V_n, is where the dependence on the incident electric field is encapsulated. Therefore, it gives an indication of the coupling of a certain mode with the incident electric field, which corresponds to how easily a certain electric field excitation can excite a specific mode n. The CMA of nanowires and microwires shows that the current modes are weakly dependent on the material. However, the Modal Significance, MS_n, and the Modal Excitation Coefficient, V_n, vary significantly with the material properties of the microwire or nanowire. In this talk, we will present MS_n and V_n results for noble metal nanowires, carbon nanotubes, and magnetic microwires. These results will facilitate the identification of the optimum material, with the desired scattering characteristics, for each plasmonic sensing application.