A Source-Model Technique for Analysis of Scattering by, and Waveguiding across, Chains of Cylinders Partially Buried in a Half-Space Medium

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The interaction of EM radiation with arrays of cylinders has been studied for decades. The motivation lies in many different applications that incorporate arrays of elongated 2D-like objects, such as wires, strips, or rods. Mature applications include frequency selective surfaces, absorbing structures and polarizers which operate in the microwave and radio frequency range. In more recent applications, arrays of nanometer-scale cylinders have been used in the optical regime as frequency selective surfaces, reflection or transmission gratings, biological and chemical sensors, and are still considered as potential elements in nanometer-scale integrated optical circuits.

This work presents a computational technique for EM analysis of chains of penetrable cylinders with arbitrary, smooth cross-sections, when these are partially buried in a supporting penetrable substrate layer. This type of anchoring of the arrays of cylinders into a background layer may be a side-effect of the fabrication process, or a desirable feature that increases the mechanical robustness in certain applications. However, the semi-infinite media are terminated sharply at their intersection with the cylinders, which renders rapid spatial variations of the EM fields near the meeting points of the three media. Even though the analytical behavior of the fields near 3-media wedges can be found at the quasi-static limit for some composites, e.g., a composite of three dielectric materials, it is difficult to provide a convergent analytical formulation in the general electrodynamic case.

The solution scheme we suggest is a rigorous full-wave frequency-domain method based on the Source-Model Technique, which includes a novel algorithm for intricately representing the fields near the 3-media intersections, and thus provides a numerical remedy for the field divergence problem there. Our method enables the calculation and demonstration of yet-unseen dynamics of physical values as a function of the relative depth of burial of the array in the layered background, such as the the modal wave number and mode profile of an un-excited structure. We demonstrate the importance of careful geometrical modeling and full-wave simulations of the array and background media, which have been made possible with our general, robust, and computationally efficient technique.