A Source-Model Technique for Analysis of Scattering by a Periodic Array of Penetrable Cylinders Partially Buried in a Penetrable Substrate

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***Abstract*— A computational technique for analysis of scattering by an array of penetrable cylinders with smooth arbitrary cross section is described, for cylinders that are partially buried in a penetrable half-space substrate. In fabricated devices, cylinders may be partially buried due to side effects of the fabrication process, or anchored intentionally for some applications. Our suggested method is a rigorous full-wave frequency-domain source-model technique. The cornerlike intersections of the cylinders with the substrate and superstrate cause computational difficulty, owing to rapid spatial variations of the fields in their vicinity. They are addressed with particular care, by intricately locating properly modulated fictitious sources using a novel algorithm. We show that expanding the scattered fields with the fields of these sources satisfies all boundary conditions and energy conservation requirements within very low error thresholds. The respective software tool is robust to the choice of materials, geometric parameters, and incident excitation. Sample results are presented for circular and trianglelike cylinders. These examples demonstrate the importance of precise geometric modeling for analyzing partially buried arrays. For instance, as a larger portion of the array is buried, quantities such as scattered and dissipated power change rapidly but not necessarily monotonously as a function of the burial depth.**

***Index Terms*— Buried structures, computational electromagnetics (EMs), EM scattering, frequency-domain analysis, periodic structures, source-model technique (SMT).**

technique (SMT) [6] for analysis of 2-D scattering from linear periodic arrays of penetrable cylinders that are partially buried in a penetrable substrate. Special attention is lent to the numerical modeling of the intersection of the cylinders, substrate, and superstrate.

Early works analyzed plane-wave scattering from arrays of perfectly conducting [7], [8] or penetrable cylinders [9], [10] in free space. Scattering from an array of dielectric cylinders fully buried in a dielectric slab was analyzed in [11] using the T-matrix method, yet only for the far-fields and not including the fields near the cylinders. A finite-element method was proposed for full wave analysis of an array of dielectric cylinders resting on a substrate in [12]. However, if the cylinders are partially buried and the depth of burial is of the scale of the wavelength or of a typical dimension of the geometry, this feature cannot be overlooked in the analysis. Recent experiments report the effect of burial-depth on the scattered spectra [1], [5], [13], [14].

A large body of work has brought forth analytical and numerical methods for analyses of *single* 2-D [15]–[18], [20], [21] and 3-D particles [22]–[27], either perfectly conducting or dielectric, buried in a ground plane or a dielectric half-space, or straddling several layers against a multilayered background