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Electromagnetic Scattering, Guidance and Radiation in Cylindrical Periodic and Bandgap Structures

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In this review work a semi-analytical approach for electromagnetic scattering and guidance by cylindrical arrays composed of circular rods periodically distributed along concentrically or eccentrically layered circular rings is presented. The rods can be dielectrics, perfect conductor, air-holes or metals. The method uses the T-matrix of a circular rod in isolation, the reflection and transmission matrices of a cylindrical array based on the cylindrical harmonics expansion, and the generalized reflection and transmission matrices for a cylindrically layered structure. The formulation is rigorous. The proposed approach introduces a cylindrical layer model to the array, extracts the reflection and transmission matrices of a cylindrically periodic layer, and then obtains the characteristics of the whole layered structure by using a recursive formula for the generalized reflection transmission matrices [1, 2]. The recursive formula is based on a simple matrix multiplication, which guarantees a very short computation time for arbitrary number of the layers. The reflection and transmission matrices are expressed in terms of a block circulant matrix characterizing the periodic arrangement of the rods. Their inverse matrices can be calculated using the eigenvalues and eigenvectors of the circulant matrix, which simplifies the calculation procedure. The proposed approach could be applied to various configurations of the layered cylindrical arrays with different types and locations of the excitation sources.

Firstly, the method is applied to the modal analysis of guided waves in a specific microstructured optical fiber. In this case without any initial excitation, we could assume a unique symmetric property of the mode field distribution inherent to the periodicity of the circular rods. Such kind of structure represents a new class of optical fiber that allows greater freedom in fiber design than could be achieved by use of conventional materials. The results of the normalized propagation constant are compared with those obtained by a variational method and a very good agreement with the present rigorous method is observed.

Next, the proposed formulation is used to analyze the radiation characteristics of a localized source located inside the multilayered cylindrical structures – cylindrical bandgap structure. Three different configurations of the cylindrical bandgap structures are studied and the rods are taken as perfect conductors. We discuss in detail the relations between the transmission spectra of the cylindrical harmonic waves and the directivity of radiation by the exciting source. Radiation patterns in both principle *H*-plane and *E*-plane are analyzed. Discussions about the relation between the resonance and stopband characteristics of the transmission spectra and the radiation patterns of the localized source are given from the viewpoint of the flexible design and control of the multibeam and directive beam forming characteristics.

Finally, we investigate the light scattering by metal-coated dielectric nanocylinders periodically distributed along a cylindrical surface. The spectral responses of the scattering and absorption cross sections and the near field distributions are analyzed. Various resonances observed in the spectral responses are discussed and unique features of the near field distributions related to the surface plasmons resonances are brought out for the metallic nanocylinders structure.

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