SCATTERING ANALYSIS OF DIELECTRIC PERIODIC STRUCTURES BY AN OBLIQUE INCIDENCE*

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Abstract

The scattering of dielectric periodic structures by a plane wave incident in the direction oblique to the periodic grooves is analyzed by a method which combines the multimode network theory with the rigorous mode matching method. Combining the TE and TM characteristic mode functions determined in the corresponding 2-D scattering problem resulting from a TE or TM wave incident along the principal-plane of the same structure, and using a simple mathematical transformation, the 3-D scattering problem by an oblique incidence is rigorously solved.

Introduction

Dielectric periodic structures have been widely using in the millimeter wave and optical-integrated circuits, such as different kinds of filters, reflectors, couplers, and traveling-wave, leaky wave

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antennas\textsuperscript{[11]. The scattering of dielectric periodic structures by principal-plane incidence has been deeply studied\textsuperscript{[12-3]}, while a further investigation shows when the incident wave runs from the special case of principal-plane incidence to the general case of oblique incidence, the original 2-D boundary-value problems turn into more complicated 3-D boundary-value problems; meanwhile, new wave phenomena occur, such as the simultaneously exciting of the polarization mode (TM or TE mode) contrary to the incident polarization mode (TE or TM mode), the coupling of two polarization modes (TE and TM modes) and the more complex frequency selective characteristics, which may be utilized to design new devices or may deteriorate the performance of existing devices\textsuperscript{[1,6]. Therefore, the analysis of the scattering of dielectric periodic structures by an oblique incidence is of greatly theoretical and practical interests.

The 2-D boundary-value problems of scattering by the principal-plane incidence have been systematically analyzed by the method which combines the multi-mode network theory with the rigorous mode matching method\textsuperscript{[3-5]. In the case where TE or TM polarization plane wave incidence, only the same polarization mode will be excited in the structure. It means that the scattering problem for a pure TE or TM mode incidence can be separately analyzed in terms of a scalar boundary problem. However, in the case of oblique incidence, the boundary condition that the tangential components of electromagnetic fields are continuous can be satisfied only when TE and TM modes are simultaneously excited; therefore, it turns to be a vector boundary problem. Actually, after a further study, it is obvious that using the same method as that used to treat 2-D boundary problems, the 3-D boundary-value problems can be solved rigorously by combining the TE and TM mode functions determined respectively in the corresponding 2-D problems.

\textbf{Theoretical Analysis}

The scattering of a dielectric periodic structure by an oblique incident plane wave is shown in Fig.1(a), and the related structure