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Light Transmission and Reflection on Corrugated Dielectric Film

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We have applied the Lippmann-Schwinger equation to a corrugated dielectric film used as a scatterer. It was shown that the transmission and reflection spectra have sharp variations, when the wavelength corresponds to the excitation of the guided modes. The resonance line width is strongly increased with the corrugation. Double resonance is observed when only one film side is modulated.

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I. INTRODUCTION

Materials that possess a periodic modulation of their refractive index on the scale of the wavelength of light have been attracting much interest in their optical properties [1]. The interaction between light and such materials can lead to a photonic band gap (in a certain frequency region the light propagation is blocked). One of the 2-D photonic crystals is a slab with a periodicity in the dielectric function of the film plane. There is much interest in such films. It was found that oblique metal films containing periodic holes show enhanced light transmission, as compared to that predicted for a subwavelength aperture [2]. This surprising phenomenon was theoretically explained by the excitation of surface plasmons, which leads to light tunneling through the metal films [3, 4]. Dielectric films have also resonance properties. Thin-film dielectric waveguides incorporating periodic elements exhibit sharp variations of the externally propagating fields at certain values of the wavelength [5, 6]. This resonance effect is observed under variations of the grating parameters such as the wavelength, the film thickness, and the angle of incidence. Such films can be used as very narrow spectral filters [7–9].

The aim of this paper is to study the resonance properties (line width, frequency value) of corrugated dielectric films at various values of the amplitude of the corrugation. Taking into account that any periodical function can be expanded as the sum of harmonic functions, it is naturally to study this problem for such simple modulation laws. We have applied the Lippmann-Schwinger equation to the corrugated film used as a scatterer. This method allows one to study the problem at low values of the modulation amplitude. It is clear that the finite-difference time-domain numerical method, used often in numerical electrodynamics, cannot be applied at very low values of the modulation amplitude. The Lippman-Schwinger equation has been used for studying the diffraction of atoms from a solid surface [10]. A similar approach, based on the Green function method and the extinction theorem, was used for studying light diffraction and reflection from a metallic grating

