SCATTERING AND ABSORPTION OF LIGHT BY NANO-THICKNESS NEGATIVE-DIELECTRIC STRIP GRATINGS.

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In the innovative optoelectronics, "negative-dielectrics" (ND) are considered as promising materials. Metals, like silver and gold, are ND in visible light and near-infrared range. The goal of the present paper is to study the problems of the plane wave scattering of light by a thin flat grating made of penetrable ND strips or of impenetrable strips covered with ND from one or both sides. Strip gratings have been used in wide range of applications. Several techniques have been devised for building the numerical solutions to perfectly conducting strip gratings and also to penetrable imperfect ones, like resistive and thin dielectric strip gratings: the spectral Galerkin moment method [1], the Fourier transformation method [2], the singular integral equation method with projection to orthogonal polynomials [3], and the method of analytical regularization of dual series equations [4].

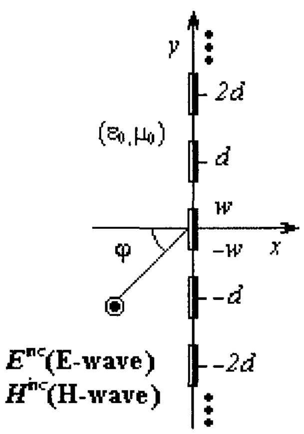


Fig. 1. Geometry of the Problem

The problem formulation involves a set of generalized boundary conditions, relating tangential fields to effective electric and magnetic currents. The strip coatings are characterized by two surface impedances $Z^{\pm}$ on corresponding sides. Notations can be seen in Fig.1. Accurate numerical solution is based on the Floquet-Rayleigh field expansions, which lead to the coupled pair of the dual-series equations for the series coefficients. To determine the unknown coefficients a_n and b_n, we use two dual sets of boundary conditions that hold on the complimentary subintervals (the strip and the slot) of the elementary period. Further, we make an extraction and analytical inversion of the static part of the full-wave dual-series equations that needs combined application of the Riemann-Hilbert problem (RHP) technique and inverse Fourier transform depending on the equation features. This procedure leads to the simultaneous linear equations:

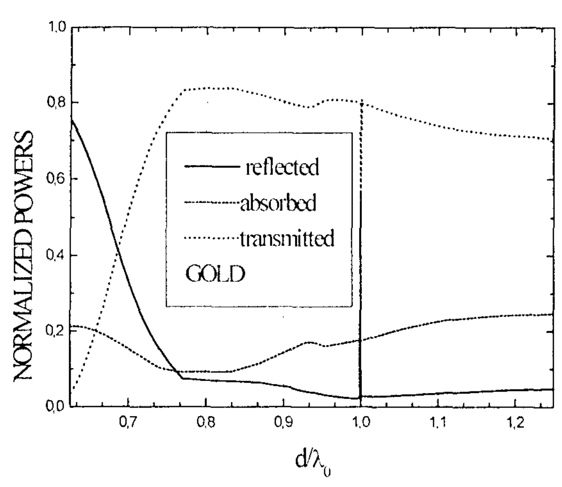
$$\begin{cases} \sum\limits_{n=-\infty}^{\infty}\left[\left(\delta_{mn} + A^{11}_{E(H),mn}\right)x_n + A^{12}_{E(H),mn} d_n\right] = B^1_{E(H),m} \\ \sum\limits_{n=-\infty}^{\infty}\left[A^{21}_{E(H),mn} x_n + \left(\delta_{mn} + A^{22}_{E(H),mn}\right) d_n\right] = B^2_{E(H),m} \end{cases} \tag{1}$$

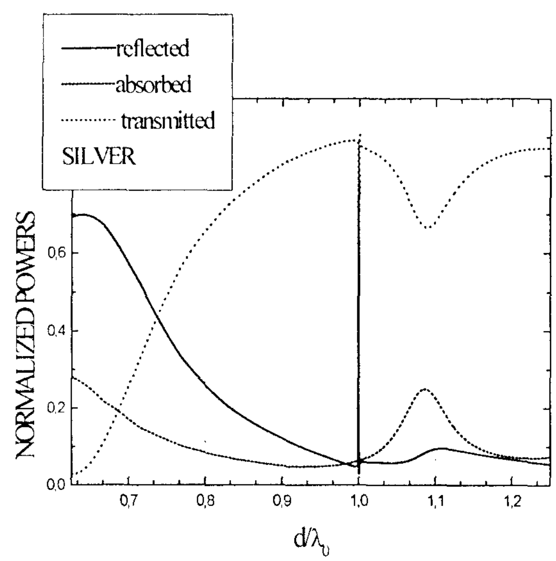
With the matrix and right-hand-part elements:

$$\begin{cases} A^{11}_{E,mn} = \dfrac{1}{2(R/\zeta_0)g_n} S_{mn}(\theta) \\ A^{12}_{E,mn} = -\dfrac{W}{(R/\zeta_0)} S_{mn}(\theta) \\ B^{1}_{E,m} = -\dfrac{1}{(R/\zeta_0)} S_{m0}(\theta) \\ A^{21}_{E,mn} = 2j\kappa\, W\, T_{mn}(\theta) \\ A^{22}_{E,mn} = \left(2j\kappa(Q\zeta_0) - r_n\right) T_{mn}(\theta) \\ B^{2}_{E,m} = 2r_0\, T_{m0}(\theta) \end{cases} \qquad \begin{cases} A^{11}_{H,mn} = \dfrac{1}{2(Q\zeta_0)g_n} S_{mn}(\theta) \\ A^{12}_{H,mn} = -\dfrac{W}{(Q\zeta_0)} S_{mn}(\theta) \\ B^{1}_{H,m} = -\dfrac{1}{(Q\zeta_0)} S_{m0}(\theta) \\ A^{21}_{H,mn} = -2j\kappa\, W\, T_{mn}(\theta) \\ A^{22}_{H,mn} = \left(2j\kappa(R/\zeta_0) - r_n\right) T_{mn}(\theta) \\ B^{2}_{H,m} = 2r_0\, T_{m0}(\theta) \end{cases} \tag{2}$$

where $T_{mn}(\theta)$ and $S_{mn}(\theta)$ can be found in [4], $g_n=(1-(\sin\varphi+l/\kappa)^2)^{1/2}$, $r_n=|n|-jg_n\kappa$, $\kappa=d/\lambda_0$, and $\theta=2\pi w/d$. The unknown coefficients are $x_n=c_n g_n$, $c_n=a_n+b_n$, d_n a_n-b_n. It can be shown that (1) is a Fredholm second kind equation and therefore yields stable and accurate numerical solution with accuracy controlled by the truncation number N of each block. According to [5], three complex parameters, R, Q, and W, are electric, magnetic, and cross resistivities. W is responsible for different properties of the two faces and vanishes for a surface with two identical face impedances and for a penetrable ND strip grating.

Numerical computations have been carried out for the reflected, transmitted, and absorbed power fractions as a function of the electrical and material parameters of the ND grating. In Fig.2. we present several samples of plots of the reflected, transmitted , and absorbed powers versus the normalized period of the gratings made of gold, silver, and platinum for the H-wave case. These gratings are penetrable and W=0 in this case. One can see that for the gratings made of gold and silver the reflected power prevails over transmitted and absorbed ones in the frequency range $0.6< d/\lambda_0 < 0.7$ whereas the . transmitted power prevails over the reflected and absorbed powers for most of optical





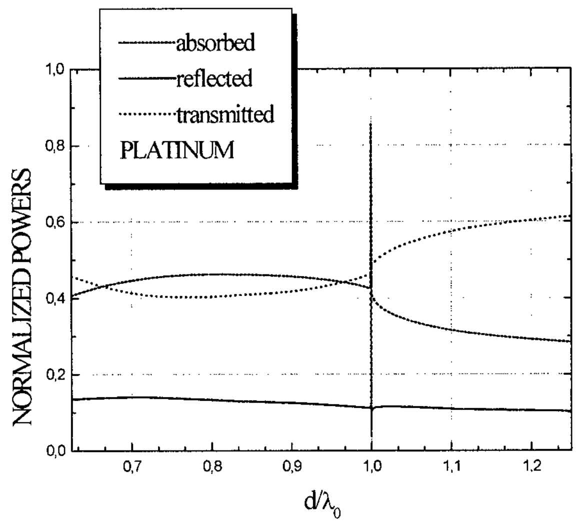


Fig.2. Normalized powers for H-wave scattering by strip gratings versus the electrical period. $2w/d=0.5$, $\varphi=0^0$, $h/d=0.02$, $d=5*10^{-7}$m.

range starting with 0.7 d/λ_0. The values of transmission are quite comparable and run up to 0.9. The absorption by the grating made of platinum exceeds the transmission and reflection in the frequency range $0.65< d/\lambda_0< 1$ and transmission prevails over absorption and reflection for the rest of optical range. The reflection stays low over all optical range. Fig.2 demonstrates a deep drop of transmission for all gratings and a rise of absorption for a grating made of platinum near the ± first Wood's anomaly ($\kappa=1$, for the normal incidence).

We have developed accurate numerical solutions to the scattering problems concerning the ND strip gratings in free space. The computations have been carried out for the reflected, transmitted, and absorbed power fractions as a function of the electrical and material parameters of the grating.

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