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An asymptotic model based on matching far and near field expansions for thin gratings problems. (English) Zbl 1477.65235

Summary: In this paper, we devise an asymptotic model for calculating electromagnetic diffraction and absorption in planar multilayered structures with a shallow surface-relief grating. Far from the grating, we assume that the solution can be written as a power series in terms of the grating thickness \( \delta \), the coefficients of this expansion being smooth up to the grating. However, the expansion approximates the solution only sufficiently far from the grating (far field approximation). Near the grating, we assume that there exists another expansion in powers of \( \delta \) (near field approximation). Moreover, there is an overlapping zone where both expansion are valid. The proposed model is based on matching the two expansions on this overlapping domain. Then, by truncating terms of order \( \delta^2 \) or higher, we obtain explicitly the equations satisfied by the lowest order terms in the power series. Under appropriate assumptions, we prove second order convergence of the error with respect to \( \delta \). Finally, an alternative form, more convenient for implementation, is derived and discretized with finite elements to perform some numerical tests.

MSC:
65N30 Finite element, Rayleigh-Ritz and Galerkin methods for boundary value problems involving PDEs
65N12 Stability and convergence of numerical methods for boundary value problems involving PDEs
65N15 Error bounds for boundary value problems involving PDEs
78A45 Diffraction, scattering
78A48 Composite media; random media in optics and electromagnetic theory
35B40 Asymptotic behavior of solutions to PDEs
30B10 Power series (including lacunary series) in one complex variable
78M10 Finite element, Galerkin and related methods applied to problems in optics and electromagnetic theory
35Q60 PDEs in connection with optics and electromagnetic theory

Keywords:
diffraction grating; thin layers; asymptotic analysis; finite element method

Full Text: DOI

References:


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