Planar waves that climb dielectric steps

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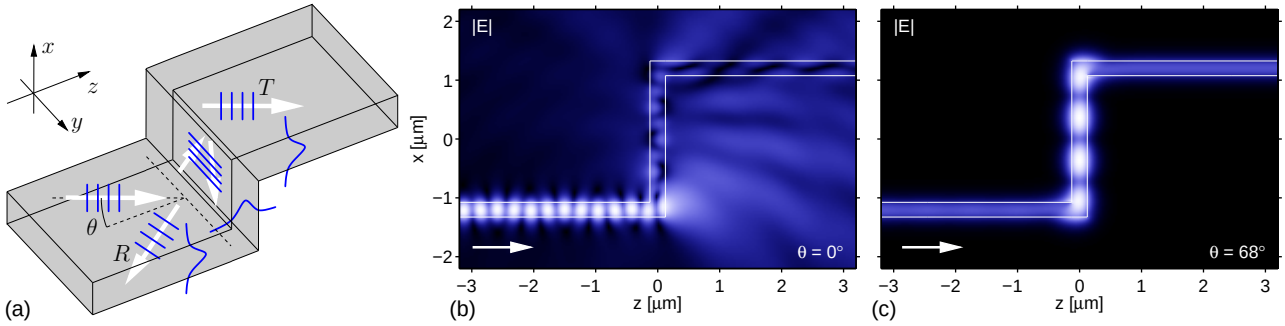
Oblique semi-guided light propagation across linear folds of slab waveguides is being considered. Exploiting a Fabry-Perot-like resonance effect, we observe virtually full transmission of laterally plane waves, and of laterally wide semi-guided beams, through step configurations consisting of two sharp 90° waveguide corners.

Incidence of semi-guided waves on folded slab waveguides at oblique angles

Sheets of slab waveguides with sharp corners are investigated. Referring to the schematic in part (a) of the figure, we consider the propagation of vertically (x) guided, laterally (y, z) unguided plane waves at oblique angles of incidence θ, relative to discontinuity along the y-axis. Following a line of arguments resembling Snell's law, one finds that radiation losses vanish beyond a certain critical angle of incidence. One can thus realize lossless propagation through 90° corner configurations, where the remaining guided waves are still subject to pronounced reflection and polarization conversion. For the Si / SiO_2-like parameters as given for the figure, simulations with a rigorous quasi-analytic solver [1] predict extremal levels of 74% transmittance and 26% reflectance for a 90° corner at $\theta = 41°$.

Full transmission across resonant step configurations

A system of two corners can be viewed as a structure akin to a Fabry-Perot-interferometer, where the corners work as partial reflectors. By adjusting the height of the vertical waveguide segment one identifies step-like configurations that transmit the semi-guided plane waves without radiation losses, and virtually without reflections, at specific angles of incidence. For the example shown in the figure, our simulations predict levels of transmittance $T = 1\%$ and reflectance $R = 12\%$ at normal incidence $\theta = 0°$ (b), and numerically perfect performance $T > 99\%$, $R < 1\%$ at $\theta = 68°$ (c).



Oblique incidence of semi-guided waves on a step configuration at angle θ, schematic (a), and cross-section views of the optical electric field (absolute value $|\boldsymbol{E}|$), for normal incidence (b), and at angle $\theta = 68°$ (c). Parameters: refractive indices 3.4 (cores) : 1.45 (cladding), slab thickness $0.25\,\mu$m, vertical slab distance $2.15\,\mu$m, incidence of TE polarized waves at vacuum wavelength $1.55\,\mu$m.

Semi-guided beams

Simulations of laterally confined wave bundles, with in-plane wide Gaussian profiles, show that the effect survives in a true 3-D framework. The vQUEP solver [1] has been extended accordingly.

References

[1] M. Hammer. Oblique incidence of semi-guided waves on rectangular slab waveguide discontinuities: A vectorial QUEP solver. *Optics Communications*, 338:447–456, 2015.