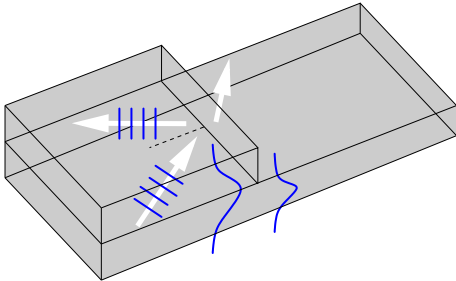


Reflection of semi-guided optical beams at thin film transitions – scalar 3-D model

Candidate: — requested —

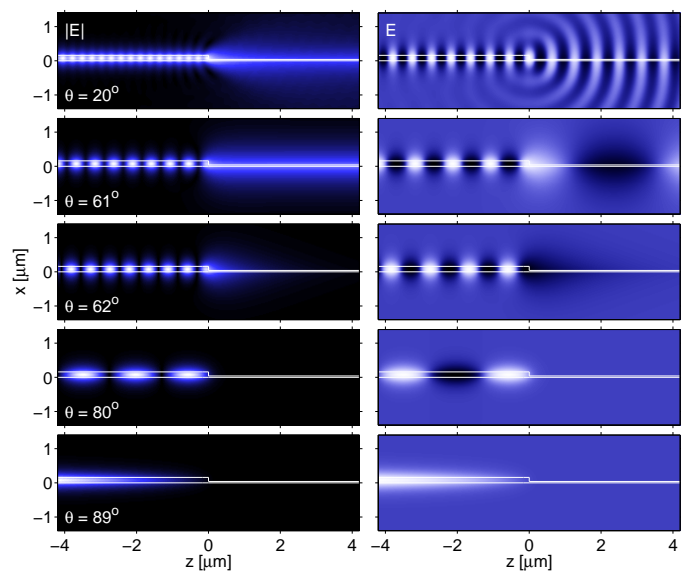
Supervisors: Manfred Hammer, Jens Förstner

Embedding: Theoretical Electrical Engineering (TET)



Classical concepts for integrated optical components like lenses, mirrors, prisms, but also for complex lens-systems, or for entire spectrometers rely on the effects that a transition between regions with different layering has on thin-film guided, in-plane unguided light. Specifically this concerns tapered or step-like transitions between regions with different core thicknesses. Results for the reflection and refraction at such a discontinuity may form the basis for a description of the in-plane propagation by geometrical optics.

We've recently reconsidered [1]. this early problem of integrated optics, with a view to applying nowadays readily available computational tools. Accepting the scalar approximation, using an ansatz of harmonic field dependence on the position along the interface, the 3-D problem reduces to a 2-D Helmholtz problem, with an effective permittivity that depends on the incidence angle. The plots show absolute values and time snapshots of the time-harmonic scalar field E associated with the effective problem for different angles of incidence θ . Regimes with partial reflection and radiative losses, with lossless partial reflection, and with lossless total reflection of the guided waves can be identified.



So far this is a mere 2-D model of the actual 3-D problem. Hence we would like to see what happens if a lateral localized beam hits the interface, for perpendicular as well as for angled incidence.

Tentative program, certainly negotiable and to be adapted according to the progress of the work:

- Make yourself familiar with the theoretical background of the problem in question.
- Repeat some of the simulations of Ref. [1] with the 2-D Helmholtz solver (QUEP) of the Metric program collection.
- Formalize a model for the propagation of vertically guided, laterally localized beams in the structure (scalar approximation; starting point: an expansion like Eqn. (20) section 3.2, of Ref. [1]).
- Implement the model, using the QUEP solver of the Metric library.
- Run a series of 3-D simulations, for a series of interesting configurations, for steps up and steps down, also with multimode stacks, perhaps a sequence of parallel steps . . .

If you think that you could be interested in the concepts of optical waveguides, if you are aware that a computer can be programmed (and you are not afraid to do so; a little knowledge of C/C++ and Matlab would certainly help), and if you might like a theoretical task in between Applied Physics, Applied Mathematics, and Electrical Engineering, then don't hesitate to contact us!

[1] F. Civitci, M. Hammer, H.J.W.M. Hoekstra, *Semi-guided plane wave reflection by thin-film transitions for angled incidence*, Optial and Quantum Electronics (available online, 2013)