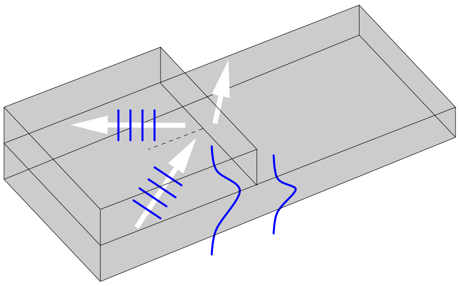
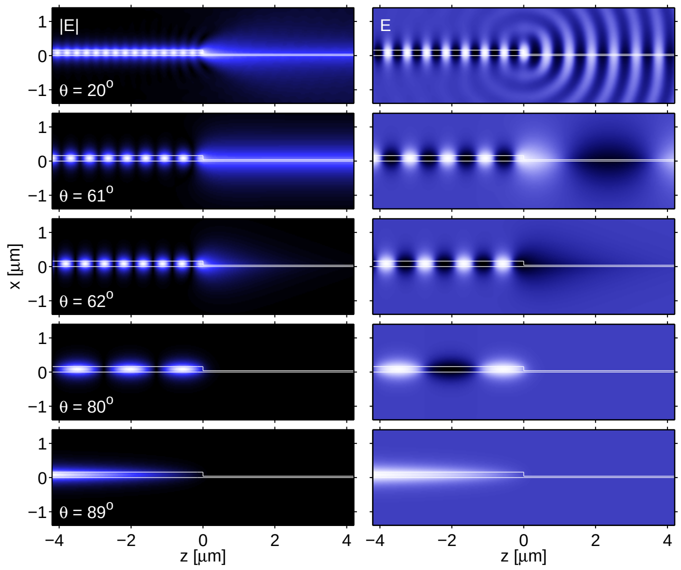
Reflection of semi-guided optical beams at thin film transitions – scalar 3-D model

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 relection 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 vertially guided, laterally loalized 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* , Optical and Quantum Electronics (available online, 2013)