A Variational Vectorial Mode Solver

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A variational method for the fully vectorial mode analysis of lossless dielectric waveguides with piecewise constant rectangular refractive index distributions is proposed.

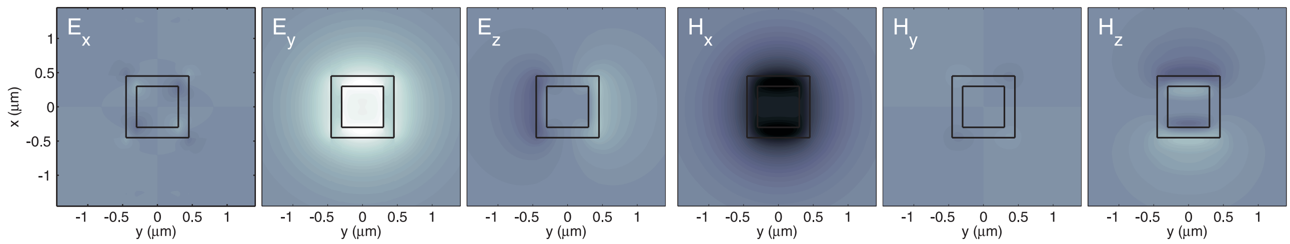
Summary

An extension of the scalar Mode Expansion Mode Solver [1] to fully vectorial simulations is discussed. The method uses a six component variational formulation of the Maxwell equations [2] together with approximations of each component of the vector field by specific superpositions of some given basis functions, depending on one of the coordinates, times unknown coefficient functions that are defined on the entire second coordinate axis. In principle there is some freedom in choosing the basis functions; we use the vector field components of modes of the constituting vertical slices of the waveguide.

It turns out that with our field template the problem of finding the unknown lateral coefficient-functions reduces to finding those, which correspond to only two field components; the computational effort becomes comparable to the scalar case [1] or the Film Mode Matching method [3].

Just like the scalar approach this method can be used with only a few terms in the expansion for rough approximations; the technique can then be compared to a semi-vectorial Effective Index Method. With a suitable choice of basis fields a reasonable approximation can be achieved with a relatively low number of terms. On the other hand, higher order expansions lead to rigorous simulations. Both limits are discussed.

The present method can also be seen as a step towards solving the scattering problem in 3D using a similar approach.



Vectorial field profile of the fundamental mode of the box-shaped waveguide from [4]. The Si_3N_4 (n=1.99) shell around the $0.6 \times 0.6\,\mu m^2$ SiO_2 (n=1.4456) core is 150 nm thick and surrounded by SiO_2; the wavelength is 1.55 μm. The effective index is 1.52436.

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References

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