Problem Set 12
Optical Waveguides and Fibers (OWF)

will be discussed in the tutorial on February 09, 2016

On January 29, 2016 a Lab tour will take place from 11:30 to 12:15. The meeting point is going to be the seminar room 3.41.

Problem 1: Multi-mode interference (MMI) coupler

Consider a multi-mode interference (MMI) coupler having two input ports and two output ports, see Fig. 1. The device should operate at a wavelength of 1550 nm. Assume that the waveguide core of the MMI coupler is made of silicon ($n_1 = 3.48$) having a thickness $h = 220$ nm, and that it is surrounded by silicon dioxide ($n_2 = 1.44$). The width of the MMI section is fixed to $w = 5\,\mu$m, and we need to adjust its length L, such that the power from a single input port is divided equally to the two output ports.

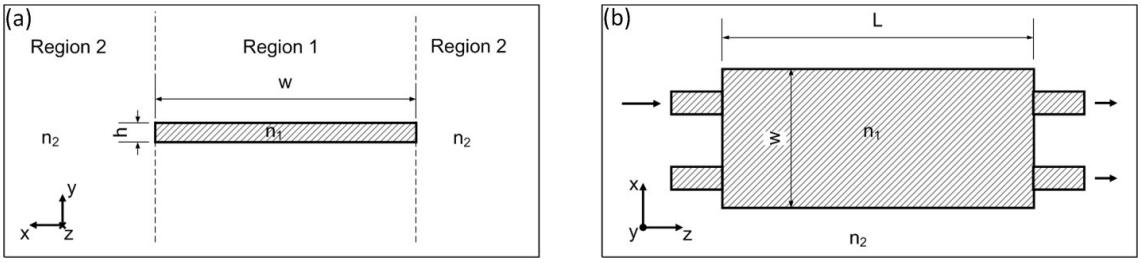

Figure 1: Multi-mode interference coupler: Definition of the geometry, (a) Cross-sectional view; (b) Top view of the structure.

a) Reduce the three-dimensional structure to a two-dimensional problem in the x-z plane by applying the effective-index method to the regions 1 and 2. Calculate the corresponding effective indices n_{1e} and n_{2e} for the fundamental TE slab modes (electric field parallel to the x- axis) using the Matlab code that you wrote for solving Problem Set 4, or the online solver available on the website http://www.computational-photonics.eu/oms.html. Note that the structure has a high index contrast. Nevertheless, the effective index method provides here a good estimation and a starting point for further numerical optimization.

b) Calculate the beat length which is defined by

$$L_\pi = \frac{4 n_{1e} w^2}{3\lambda}, \tag{1}$$

where n_{1e} represents the effective index of the fundamental TE mode of the 220 nm thick silicon slab waveguide in region 1. How long should the 2×2 MMI coupler be?

c) Which assumptions have been made in deriving the beat-length in Eq. (1)? Why does n_{2e} not play any role?

d) Apply again the effective-index method to the slab waveguide defined by n_{1e} and n_{2e} for calculating the quantity $\beta_0 - \beta_1$. Compare the result with the value given by the equation

$$\beta_0 - \beta_m = \frac{m(m+2)\pi}{3 L_\pi}, \tag{2}$$

which has been assumed in deriving the imaging properties of the MMI based on the beat-length L_π.

e) Which value of w should you insert in Eq. (2) in order to get a perfect agreement with the value of $\beta_0 - \beta_1$ calculated by means of the effective-index method?

Questions and Comments:

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