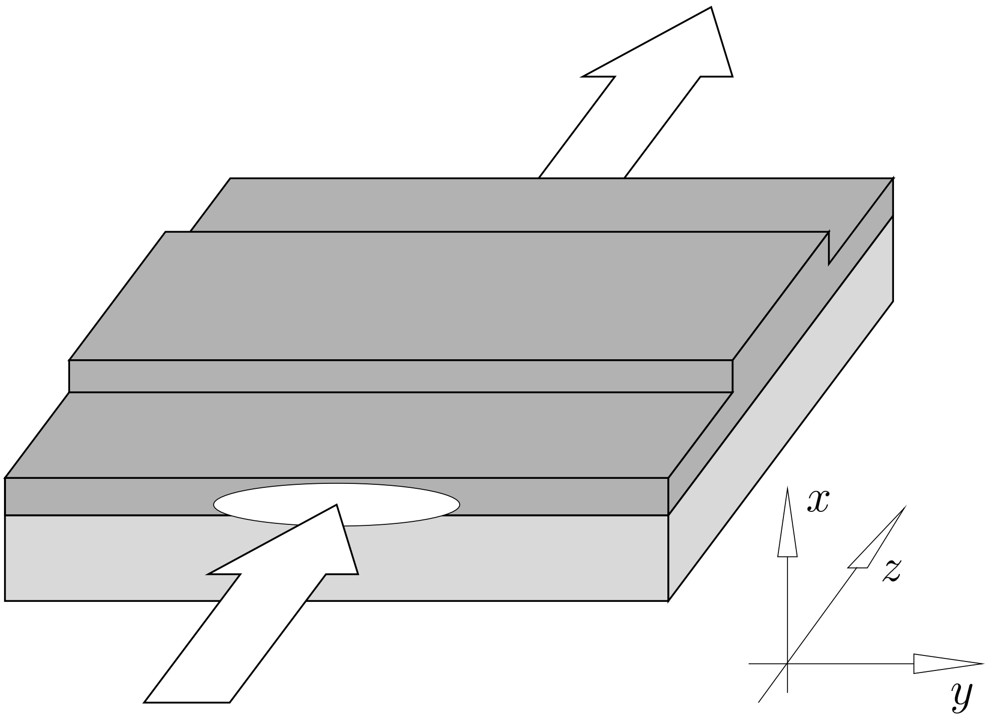
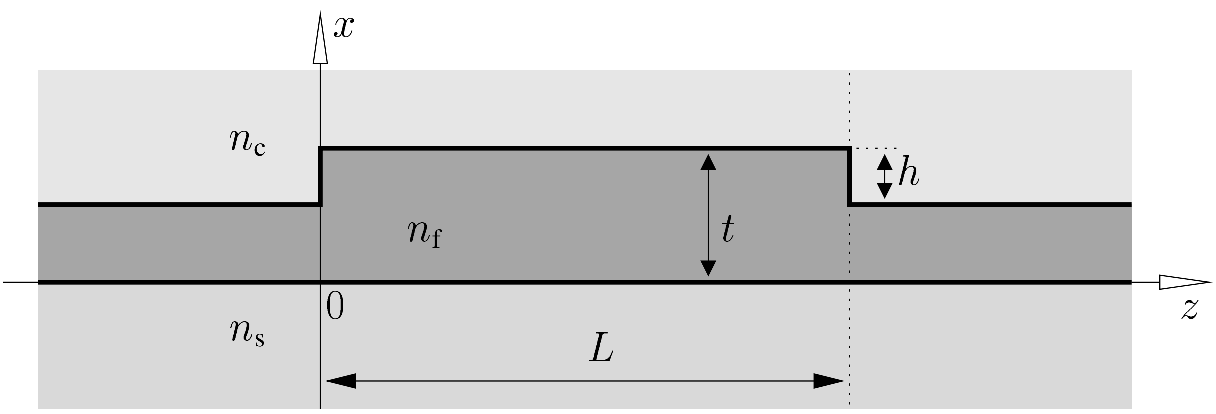
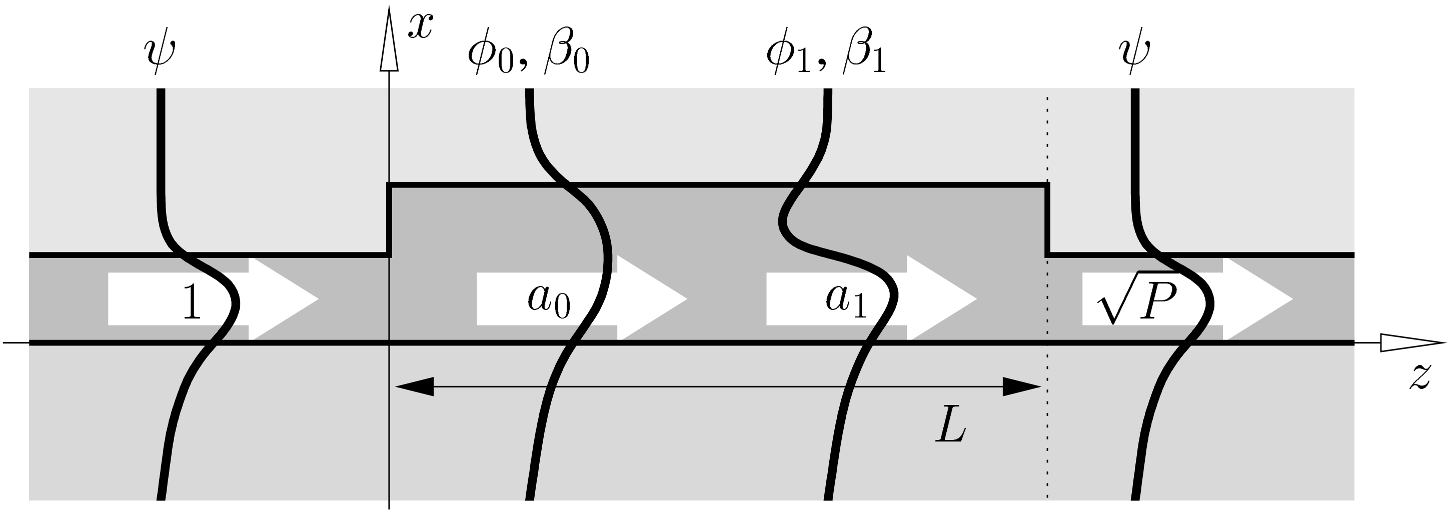
1 Cross strip interferometer

A bimodal segment of specific length and thickness between two single mode sections of a planar waveguide can serve as a simple interferometer. The configuration can be realized by etching a wide strip from a dielectric film and forcing a — vertically guided, laterally unguided — beam of light to traverse the strip perpendicularly. A TE-pass polarizer designed on the basis of this concept achieves more that 30dB polarization discrimination with a total length of only 5 micrometers, for air covered Silicon-Oxide/Nitride waveguides at a wavelength of 650 nanometers.





2 Overlap model



Ingredients:

ψ:	input / output mode field,
ϕ_0, ϕ_1:	fundamental and first order mode of the strip segment,
β_0, β_1:	the corresponding propagation constants,
$(\,.\,,\,.\,)$:	a suitable bilinear product.

Relative power transfer:

$$P(L) = w_0^2 + w_1^2 + 2w_0w_1\cos(\pi L/L_\mathrm{c})\,,$$

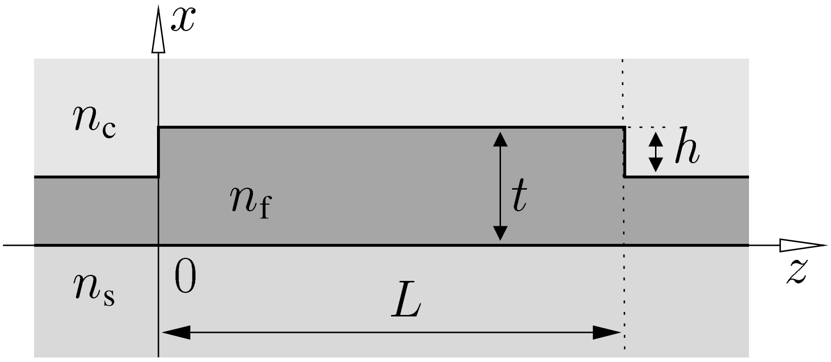
with $\quad a_j = (\psi, \phi_j)\,, \quad w_j = a_j^2\,, \quad L_\mathrm{c} = \dfrac{\pi}{\beta_0 - \beta_1}\,.$

L: the length of the thick section.

Modulation range of the transmission:

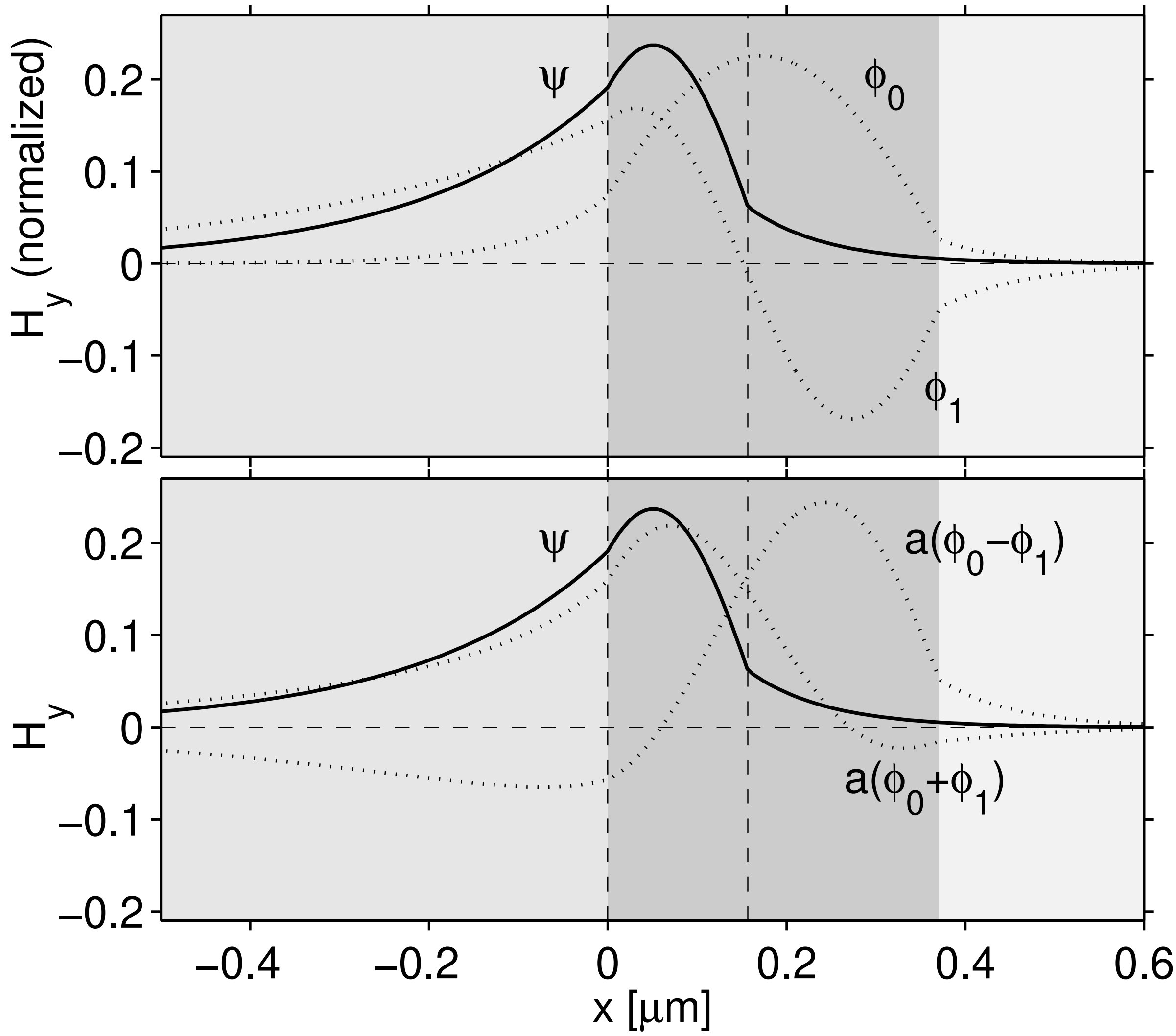
$$(w_0 - w_1)^2 \leq P \leq (w_0 + w_1)^2\,.$$

3 Mode shapes



$t = 0.371\,\mu$m, $h = 0.214\,\mu$m,
$\lambda = 650$ nm, $n_s = 1.465$,
$n_f = 2.01$, $n_c = 1.0$.

TM polarization, basic magnetic field component H_y:

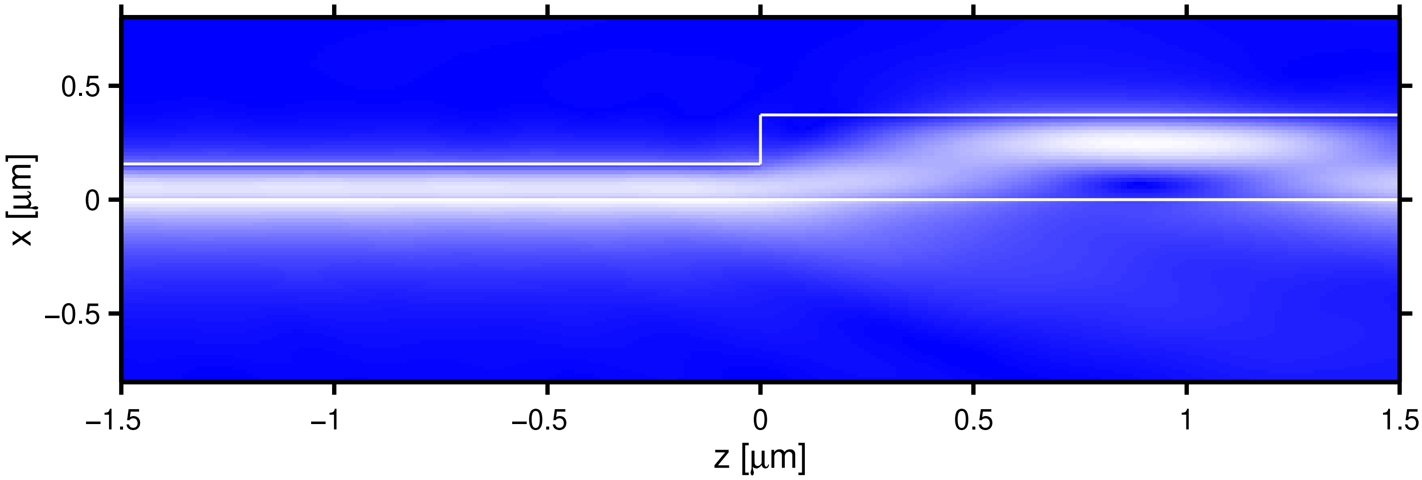


$(\phi_0 + \phi_1)/\sqrt{2} \approx \psi$, $\qquad (\phi_0 - \phi_1)/\sqrt{2} \perp \psi$.

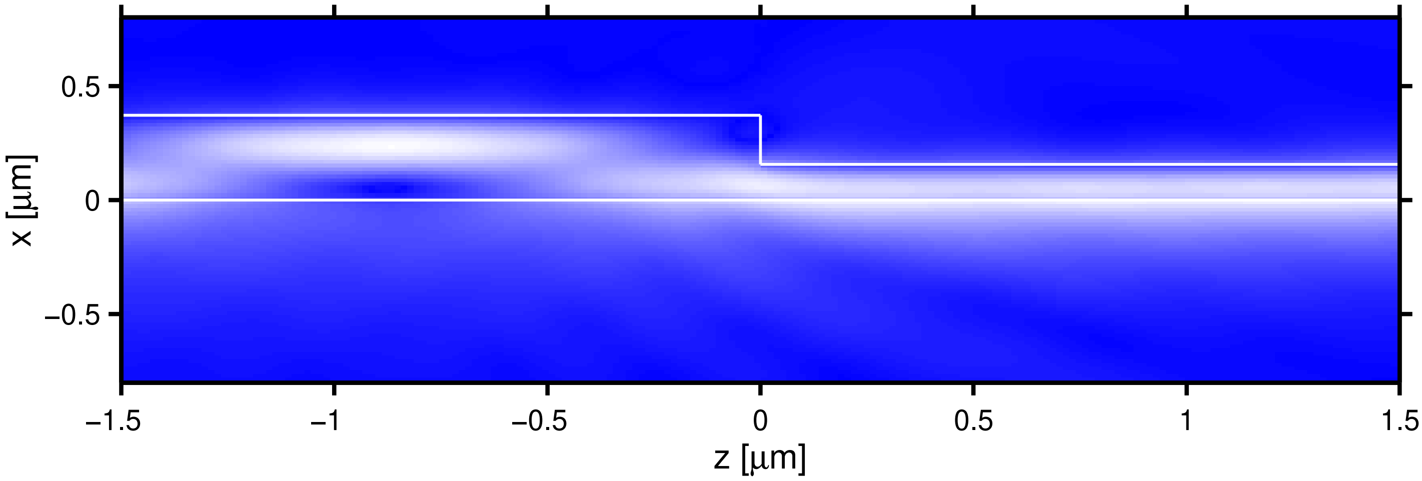
$a_j = 0.694$, $\;w_0 = w_1$, $\;(w_0 + w_1)^2 = 0.93$: $\qquad \min_L P = 0$, $\;\max_L P = 0.93$.

4 *Interferometer performance*

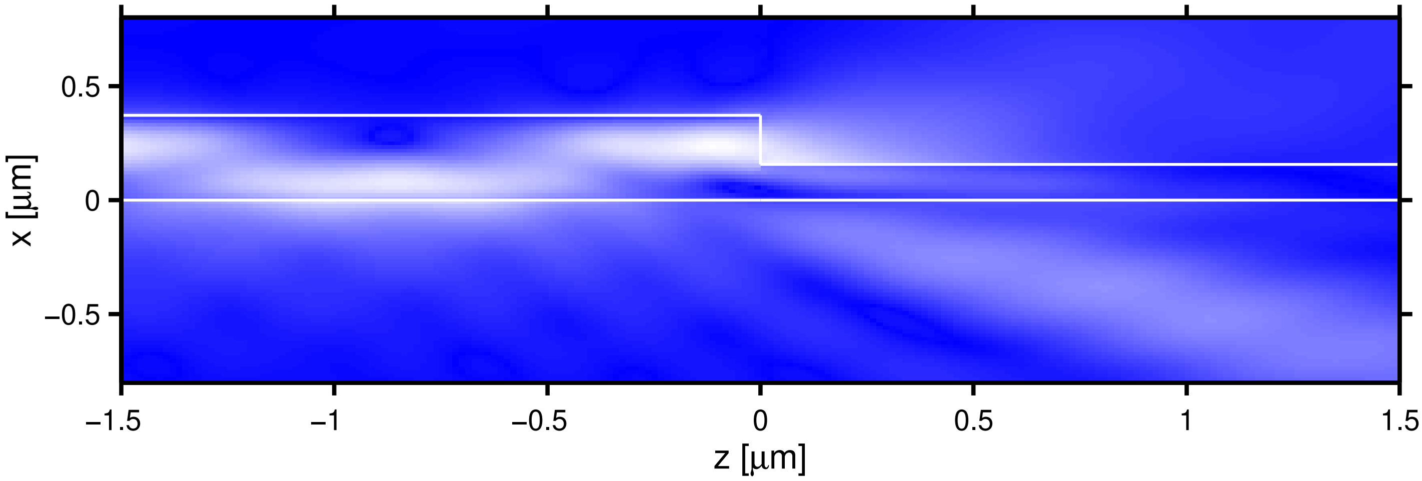
Low losses / reflections at the input junction:



Complete constructive . . .



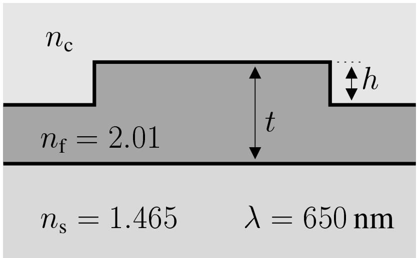
. . . or destructive interference at the output junction:

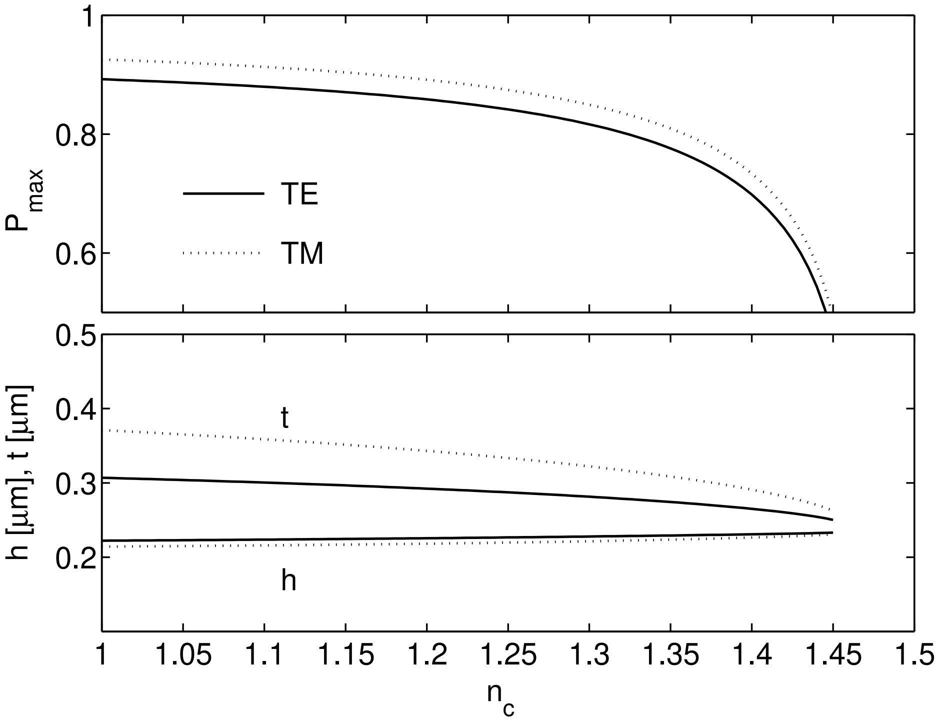


5 Optimized interferometer geometries I

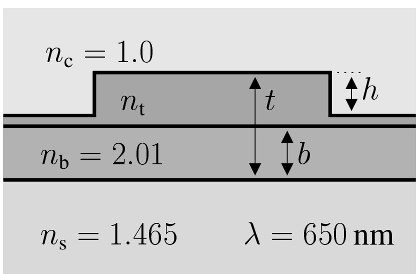
Parameters with $w_0 = w_1$ and optimum $P_{\mathrm{max}} = (w_0 + w_1)^2$:

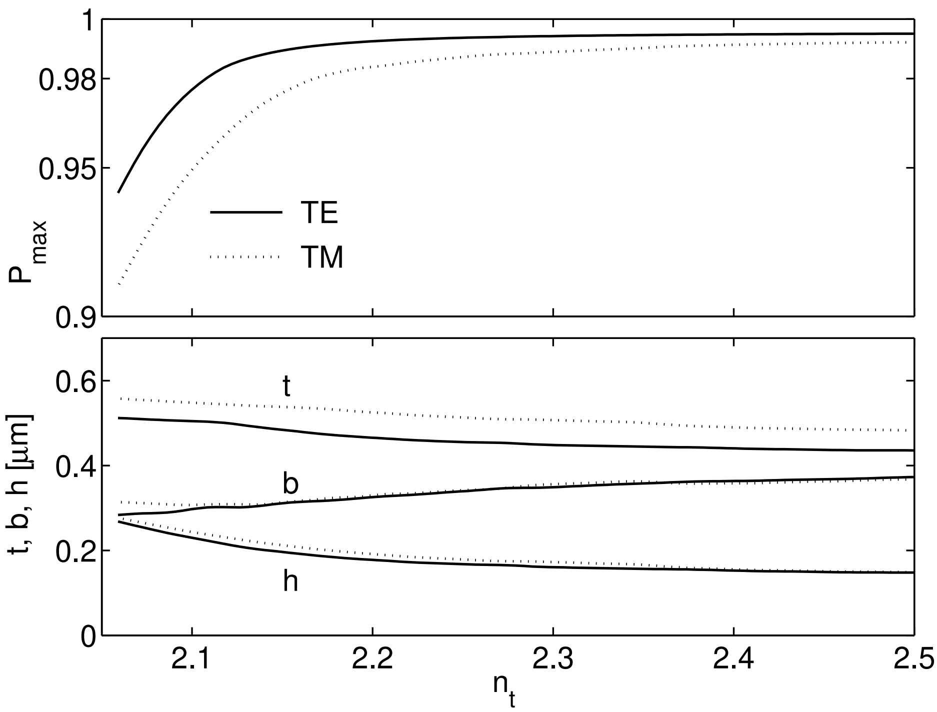
Single layer waveguide, variable cladding material





Double layer film, air cladding, variable top layer material

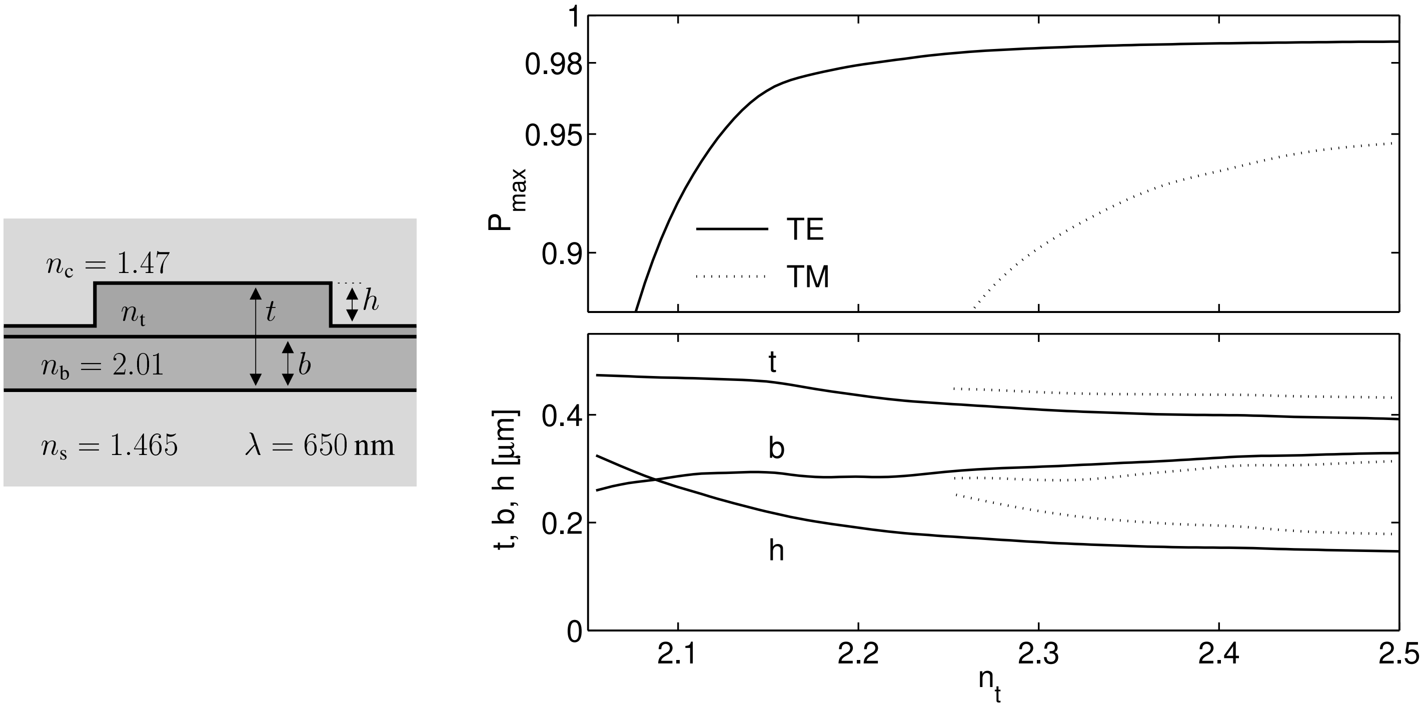




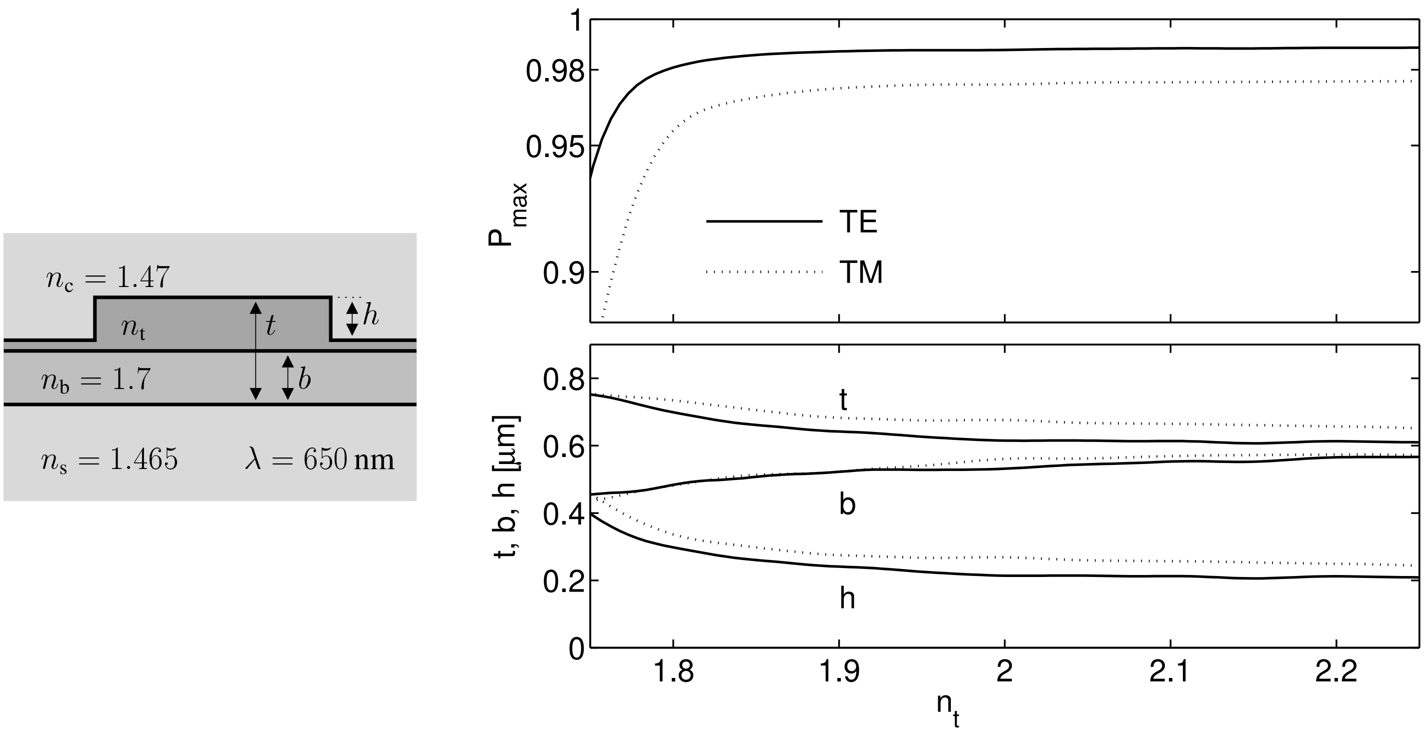
6 Optimized interferometer geometries II

Parameters with $w_0 = w_1$ and optimum $P_{\text{max}} = (w_0 + w_1)^2$:

Double layer high index film, cladding, variable top layer material



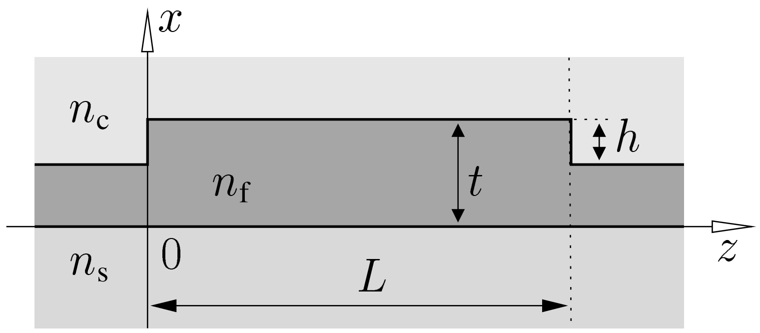
Double layer low index film, cladding, variable top layer material



7 Polarizer I

$L_c^{TE} \neq L_c^{TM}$: Adjust $L = 2m\, L_c^{TE} = (2m \pm 1) L_c^{TM}$ with natural m.

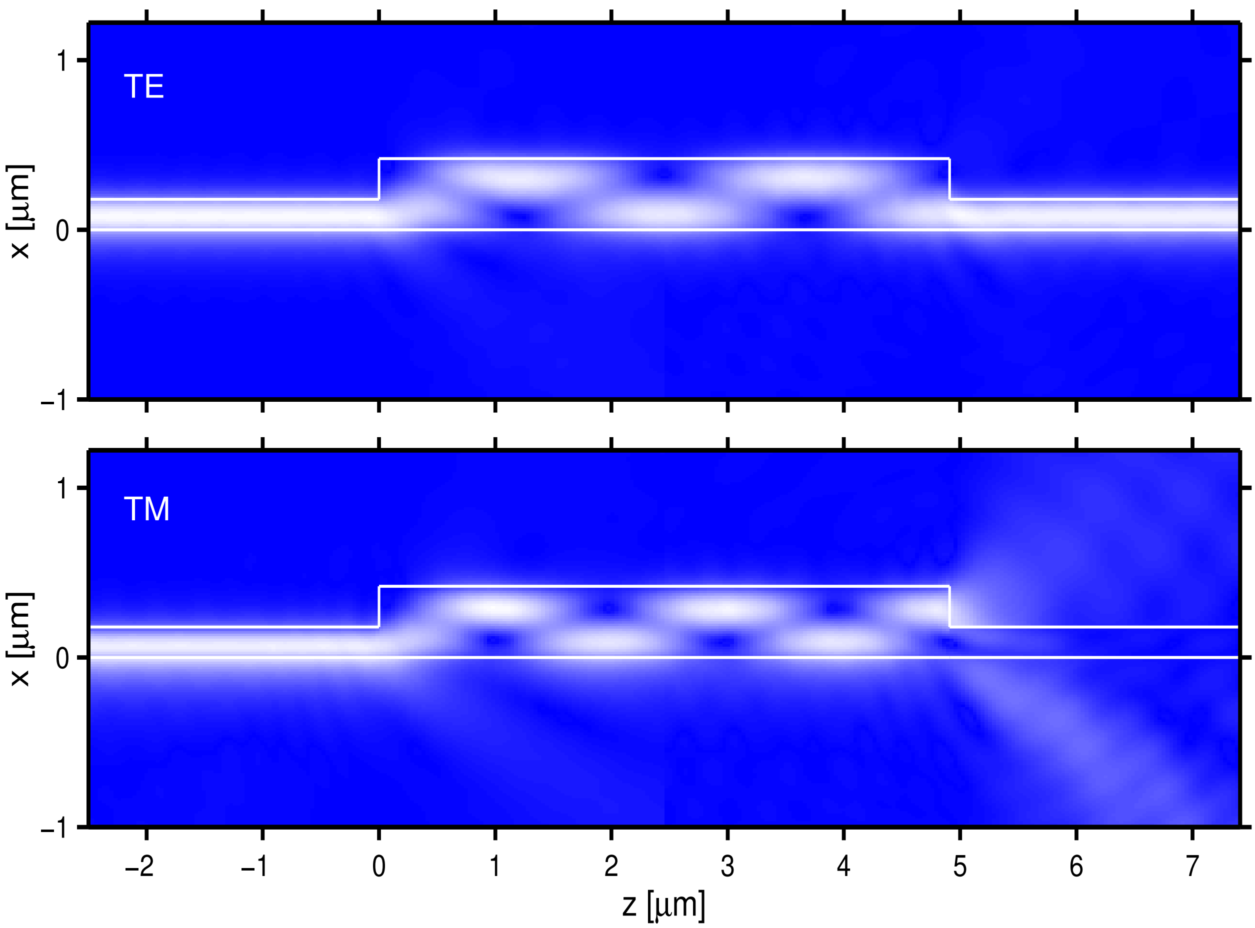
Single layer film



$\mathrm{ER} = 10 \log_{10} P^{TE}/P^{TM}$,
$\mathrm{LO} = -10 \log_{10} P^{TE}$,
$q_0 - \Delta q \leq q \leq q_0 + \Delta q$:
$\mathrm{ER} \geq 20\,\mathrm{dB}$, $\mathrm{LO} \leq 1\,\mathrm{dB}$.

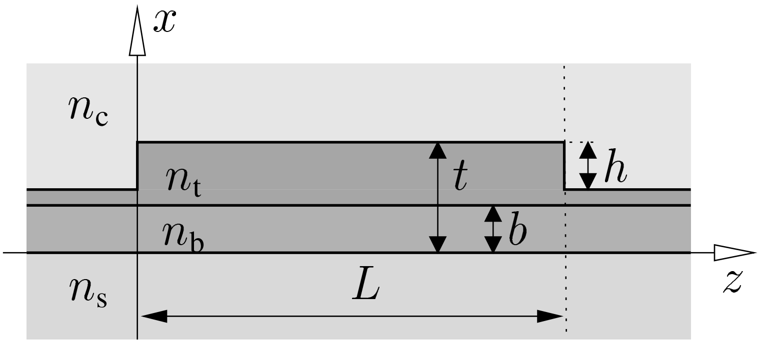
	t	h	L	λ	n_s	n_f	n_c
q_0	0.420 μm	0.240 μm	4.910 μm	650 nm	1.465	2.01	1.0
Δq	4 nm	15 nm	50 nm	24 nm	0.011	0.015	0.04

$P^{TE} = 94\%$, $P^{TM} = 0.01\%$, $\mathrm{ER} = 40\,\mathrm{dB}$, $\mathrm{LO} = 0.3\,\mathrm{dB}$,
$L_c^{TE} = 1.227\,\mu$m, $L_c^{TM} = 0.982\,\mu$m, $L = 4L_c^{TE} = 5L_c^{TM}$.



8 Polarizer II

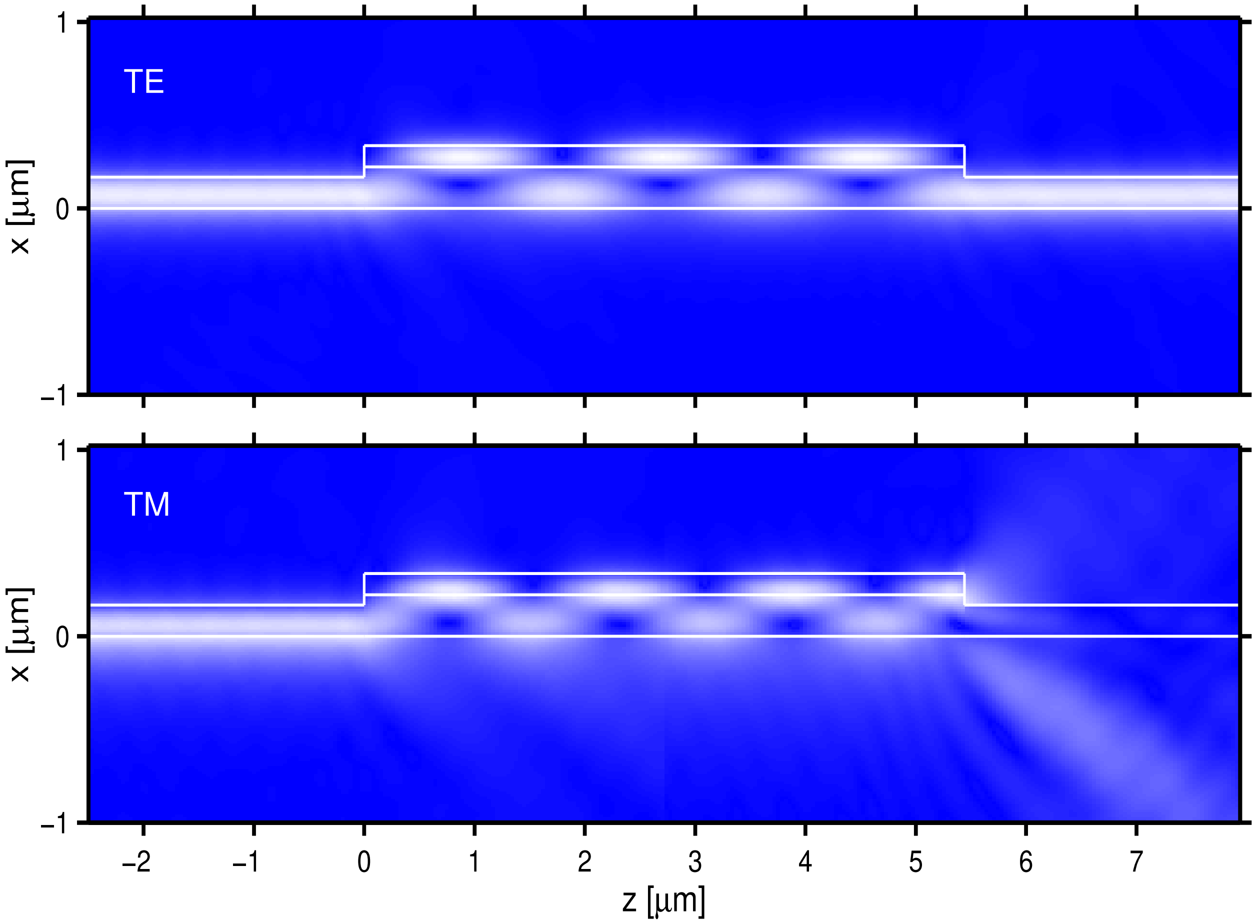
Double layer film, air cladding



$$\mathrm{ER} = 10\log_{10} P^{\mathrm{TE}}/P^{\mathrm{TM}},$$
$$\mathrm{LO} = -10\log_{10} P^{\mathrm{TE}},$$
$$q_0 - \Delta q \leq q \leq q_0 + \Delta q:$$
$$\mathrm{ER} \geq 20\,\mathrm{dB}, \quad \mathrm{LO} \leq 1\,\mathrm{dB}.$$

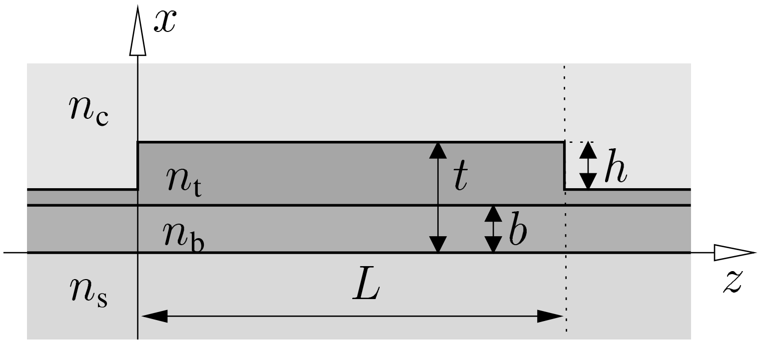
	t	b	h	L	λ	n_s	n_b	n_t	n_c
q_0	0.337 μm	0.222 μm	0.169 μm	5.441 μm	650 nm	1.465	2.01	2.3	1.0
Δq	14 nm	4 nm	10 nm	50 nm	11 nm	0.007	0.009	0.024	0.08

$P^{\mathrm{TE}} = 97\%$, $P^{\mathrm{TM}} = 0.06\%$, $\mathrm{ER} = 32\,\mathrm{dB}$, $\mathrm{LO} = 0.1\,\mathrm{dB}$,
$L_c^{\mathrm{TE}} = 0.907\,\mu\mathrm{m}$, $L_c^{\mathrm{TM}} = 0.777\,\mu\mathrm{m}$, $L = 6L_c^{\mathrm{TE}} = 7L_c^{\mathrm{TM}}$.



9 *Polarizer III*

Cladded double layer film



$$\mathrm{ER} = 10\log_{10} P^{\mathrm{TE}}/P^{\mathrm{TM}},$$
$$\mathrm{LO} = -10\log_{10} P^{\mathrm{TE}},$$
$$q_0 - \Delta q \leq q \leq q_0 + \Delta q:$$
$$\mathrm{ER} \geq 20\,\mathrm{dB}, \quad \mathrm{LO} \leq 1\,\mathrm{dB}.$$

	t	b	h	L	λ	n_s	n_b	n_t	n_c
q_0	0.566 μm	0.432 μm	0.263 μm	14.544 μm	650 nm	1.465	1.7	2.01	1.47
Δq	4 nm	2 nm	43 nm	130 nm	14 nm	0.008	0.015	0.007	0.035

$P^{\mathrm{TE}} = 96\%$, $P^{\mathrm{TM}} = 0.003\%$, ER = 46 dB, LO = 0.2 dB,
$L_c^{\mathrm{TE}} = 1.818\,\mu$m, $L_c^{\mathrm{TM}} = 2.078\,\mu$m, $L = 8L_c^{\mathrm{TE}} = 7L_c^{\mathrm{TM}}$.