2021

Microphotonics

CAD-LAB: WAVEGUIDES

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Contents

1 Reducing the 3D structure to 2D: the effective index method

1.1

By simulating the slab waveguide modes, we get the fundamental TE-mode with,

$$n_{core} = 2.855119 \tag{1}$$

Comparing those modes, we find the least transmission when

$$n_{cladding} = 1.527117 \tag{2}$$

1.2

From the bent_coupler we get $\beta = 2.60528$

1.3 Observation

Fundamental mode: As Figure 1 shown, the results are almost the same in the center of the core. But the boudary shows the different effects. The actual TE-mode exists one small peak each side, but the slab-mode not.

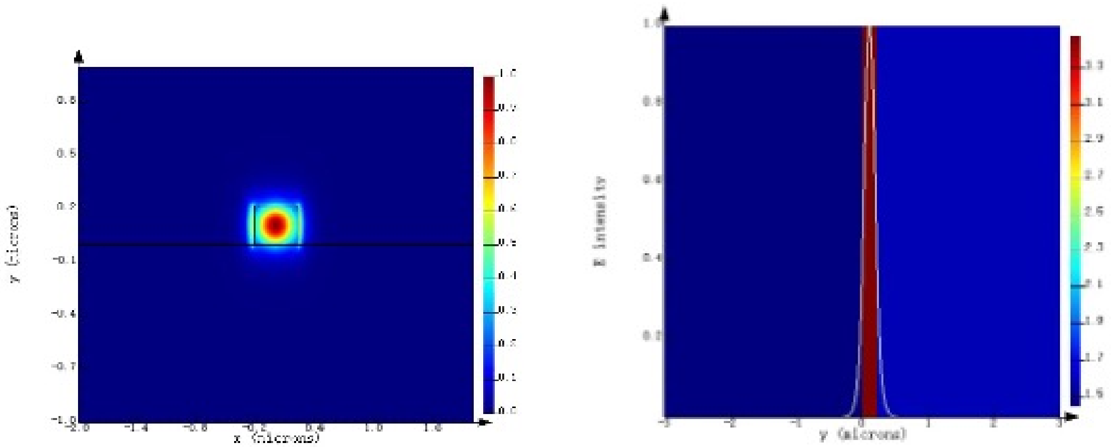

Figure 1: Fundamental mode: actual TE-mode (left); 2D slab TE-mode (right)

Modes on the two interface: They show a quite similar results in Fig 2.

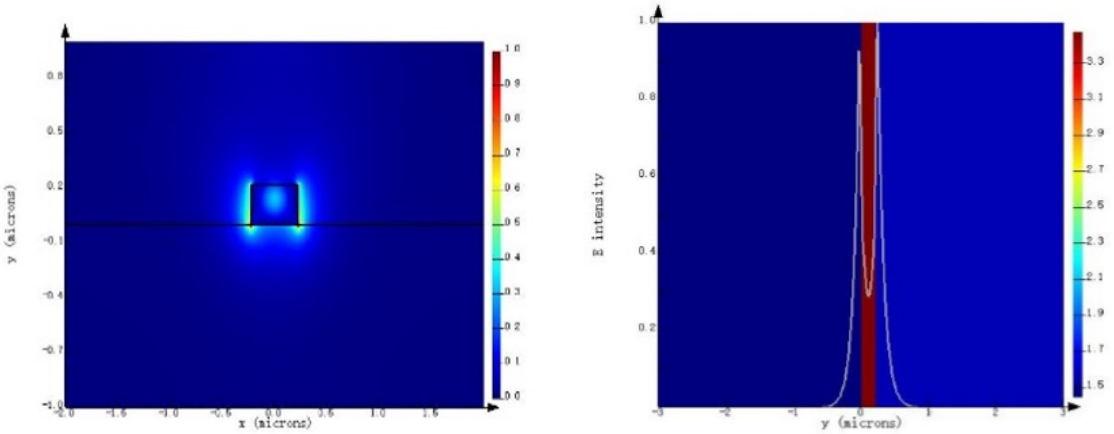

Figure 2: Mode on interface: actual TE-mode (left); 2D slab TE-mode (right)

Other modes: It is difficult to find some similarities among them.

The validity of the effective index method: It is available when studying the fundamental mode of the center (or ignoring the boundary effect), or studying the interface mode.

2 Waveguide-ring coupler

2.1

The Fig 3 shows how the light propagates through the coupler and partly couples to the bent waveguide.

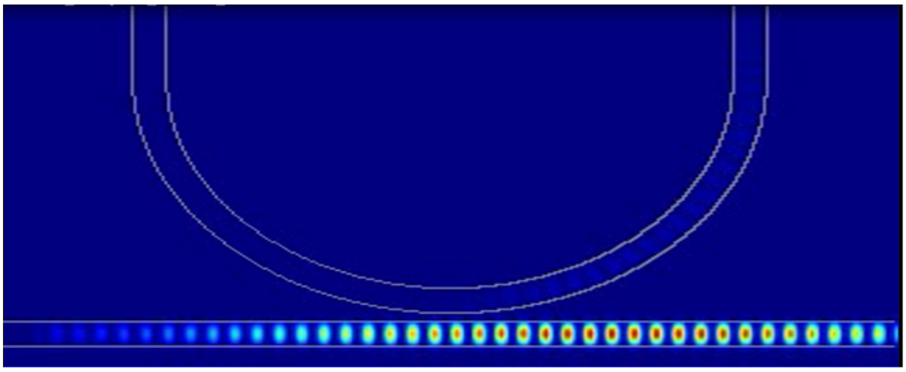

Figure 3: Propagation of a pulse through the system

2.2

With a continuous wave input, the behavior of the splitter is shown in figure 4. The upper row is linear, and the lower row is logarithmic. It is obvious that the coupler is not very wavelength-dependent.

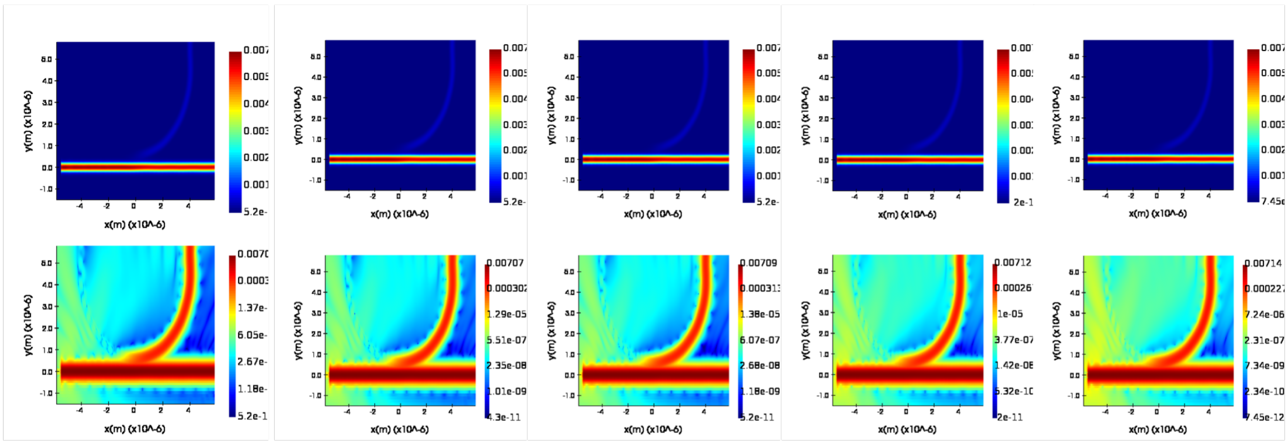

Figure 4: P of Field Monitor-object at 5 different wavelength: linear(upper); logarithmic (lower)

2.3

Fig 5 shows the trasmission factor r, rises at three different ring-radius as the gap distance increases. The changing trend of them are similar as r and gap distance is positively correlated. It can be seen that r and gap-distance is linear positive correlation.

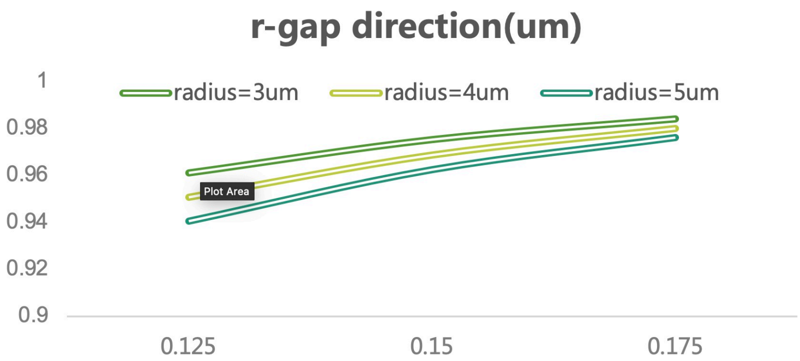

Figure 5: The relationship between r and gap distance

3 Add-drop filter

3.1

There is three λ_{res}, $1569.32\mathrm{nm}$, $1538.01\mathrm{nm}$ and $1507.83\mathrm{nm}$, which is related to the T distribution of dft_wg_output. The average FSR of two initial FSR is $30.745\mathrm{nm}$, with

$$\mathrm{FSR} = \frac{\lambda^2}{n_g L}, n_g = 3.109 \tag{3}$$

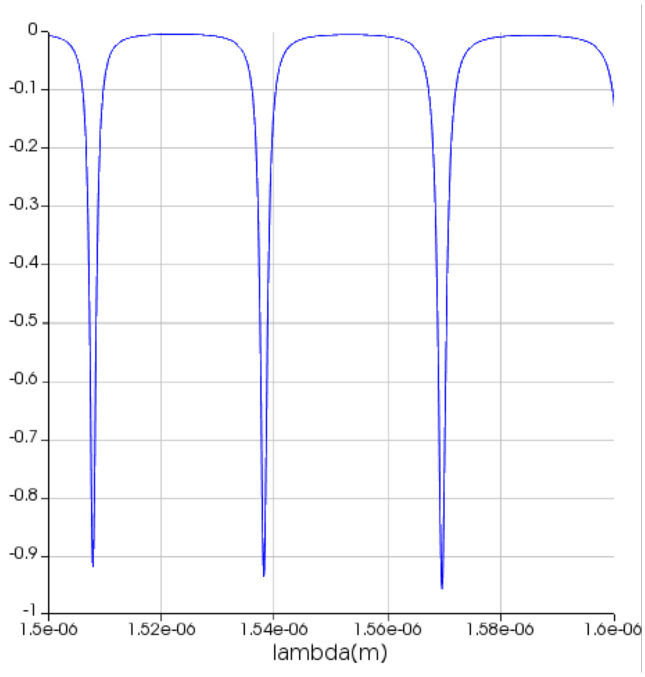

Figure 6: T distribution of dft_wg_output

3.2

When reducing the waveguide range to $[1530\mathrm{nm}, 1550\mathrm{nm}]$, T distribution of dft_wg_output is shown in Fig 7, $\lambda_{res} = 1538.03\mathrm{nm}$. T of dft_wg_output in bend_coupler.fsp at λ_{res} is 0.905347. For $n_g = 3.109$, the FWHM can be calculated by

$$\mathrm{FWHM} = \frac{\left(1 - r^2\right) \lambda^2 res}{\pi ngLr} \tag{4}$$

and finally we get $\mathrm{FWHM} = 958.6\mathrm{nm}$.

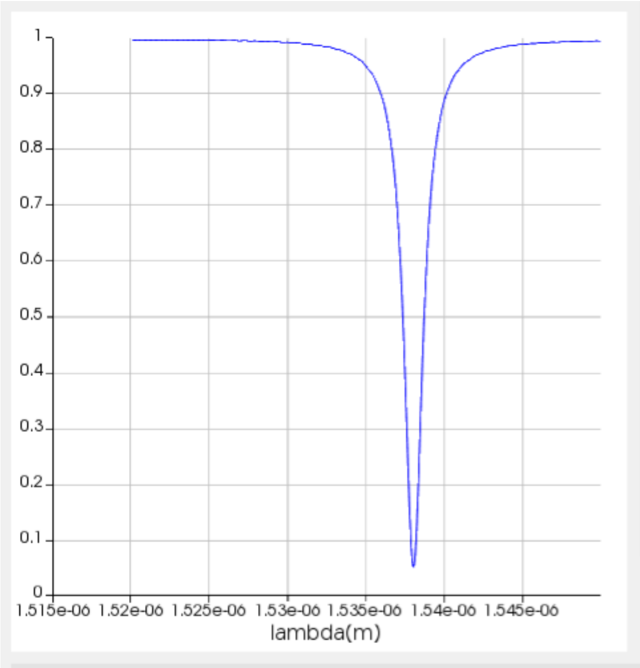

Figure 7: T distribution of dft_wg_output with a limited wavelength range

3.3

From text we know

$$\mathrm{FSR} = \frac{\lambda^2}{n_g L} \tag{5}$$

$$\mathrm{FWHM} = \frac{\left(1 - r^2 a\right) \lambda_{res}^2}{\pi n_g L r \sqrt{a}} \tag{6}$$

Change ring-radius first. As it increasing, one of the λ_{res} should be at about $1530\mathrm{nm}$, FSR should be larger than 27nm, and FWHM may decrease. Find a suitable ring-radius, then increase the gap distance to make the FWHM lower to about 90pm.

After trying different ring-radius, finally we found $\mathrm{ring-radius} = 4.26$ is siutable, because one of the λ_{res} is $1.53172\mathrm{nm}$, and FSR is $29.32\mathrm{nm}$. Then open bend_coupler.fsp to find an applicable gap distance, which can decrease FWHM to about $90\mathrm{pm}$. As gap distance becomes larger, T become larger, and FWHM will be smaller. When gap distance= $0.26\mathrm{um}$, $r^2 = 0.990881$ at λ_{res}, and FWHM=$83.5\mathrm{pm}$.To calculate FWHM, we use

$$\mathrm{FWHM} = \frac{\mathrm{FSR}\left(1 - \mathrm{r}^2\right) \lambda^2 \mathrm{res}}{\pi \mathrm{r} \lambda^2} \tag{7}$$

to avoid calculating n_g.

Go back to the ring_add_drop.fsp, simulate with $\mathrm{gap} = 0.26\mathrm{um}$, $\mathrm{ring} - \mathrm{radius} = 4.26\mathrm{um}$. Comparing to the situation at $\mathrm{gap} = 0.125\mathrm{um}$ and $\mathrm{ring} - \mathrm{radius} = 4.26\mathrm{um}$, there is no apparent difference at λ_{res}, which is shown in Fig 8. The red curve is $\mathrm{gap} = 0.26\mathrm{um}$ and $\mathrm{ring} - \mathrm{radius} = 4.26\mathrm{um}$, and the green curve is $\mathrm{gap} = 0.125\mathrm{um}$ and $\mathrm{ring} - \mathrm{radius} = 4.26\mathrm{um}$

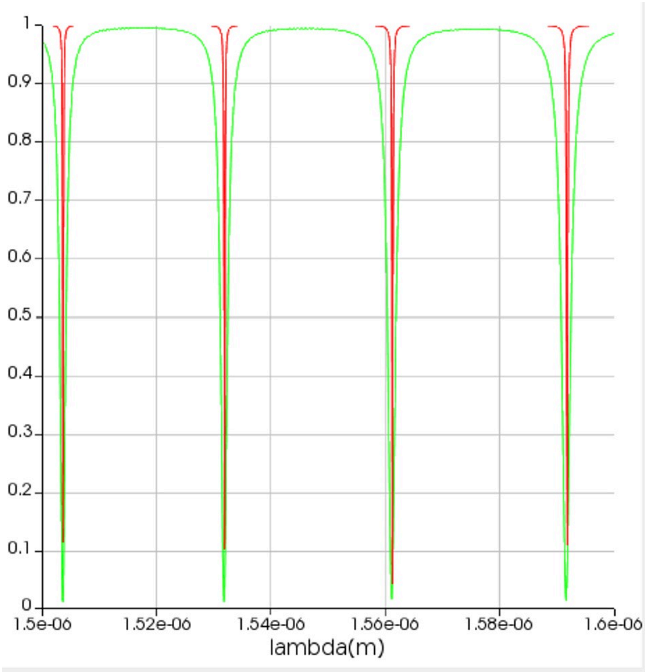

Figure 8: T distribution of dft_wg_output at $\mathrm{gap} = 0.125\mathrm{um}$

In conclusion, when $\mathrm{gap} = 0.125\mathrm{um}$ and $\mathrm{ring} - \mathrm{radius} = 4.26\mathrm{um}$, the add-drop ring resonator meets the above conditions.