Simulate Photonic bandgap micro-cavity in optical waveguide

Original problem

PBG in optical waveguide was first studied by MIT in 1997; the work was published in the "*Letter to Nature*". The Original layout is shown in Figure 1[1]. It is a high contrast ridge waveguide with PBG air holes drilled in the waveguide, the PBG has s defect in the center which will lead to resonate through the wave propagation.
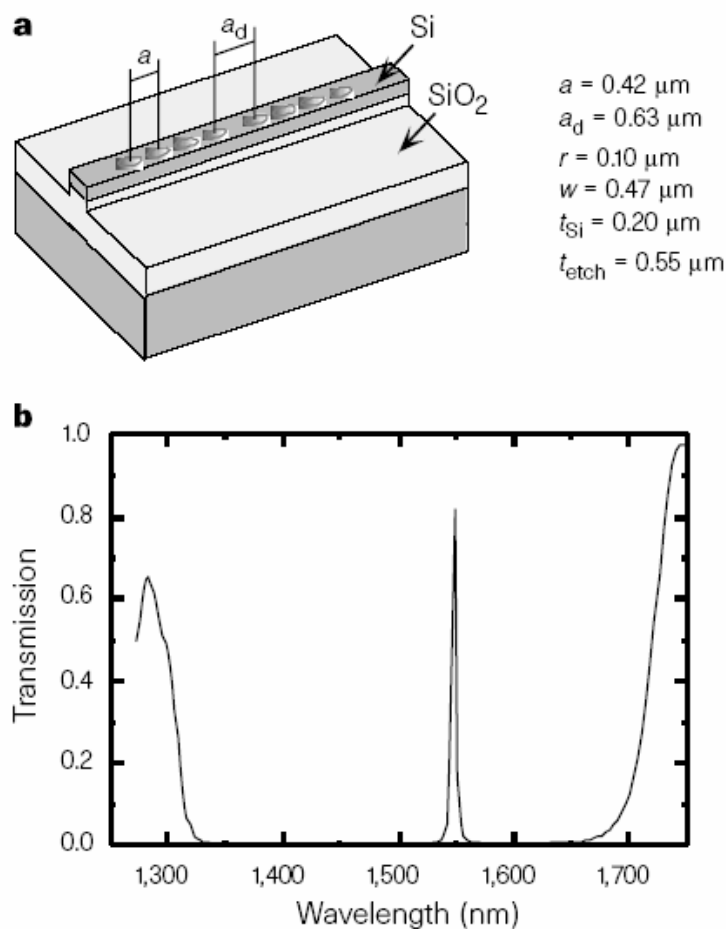

Figure 1 PBG cavity in ridge waveguide and transmission function.

[1] J.S. Foresi, et al. "Photonic bandgap micro-cavity in optical waveguides", *Letter to Nature*, VOl. 390, 13, 1997, pp.143.
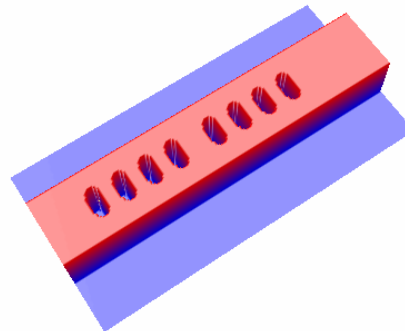
Project in OptiFDTD

Figure 2 is the layout information in OptiFDTD. Using the OptiFDTD integrated mode solver, the waveguide mode can be solved and being launched for the FDTD simulation. The time domain beam form is a Gaussian modulated continues wave which cover relative broad band information.
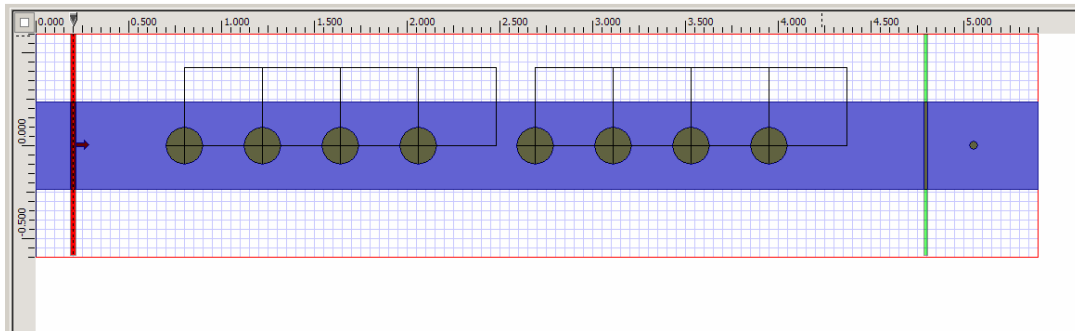
(a)
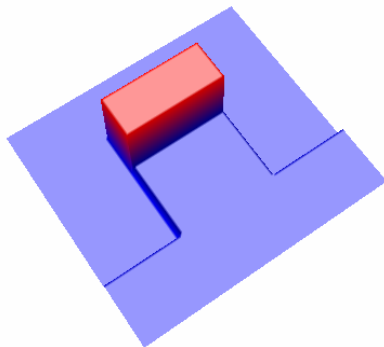
(b)   (c)

Figure 2   Layout in OptiFDTD

Simulation

For resonant layout, simulation usually needs longer iteration, if we are not sure how long the iteration it should be, we can always select "simulation until user stop" in OptiFDTD, in this case we can check the response in the point detector to determine if the response is convergent or not. Figure 3 is the time domain response in the point detector and the corresponding normalized spectrum. Blue curve shows the simulation run 18,000 time iteration steps, while green curve is

for the 48,000 steps. It can be seen that both curves has the same resonant point but to get the accuracy Q-value, the simulation need longer iteration.
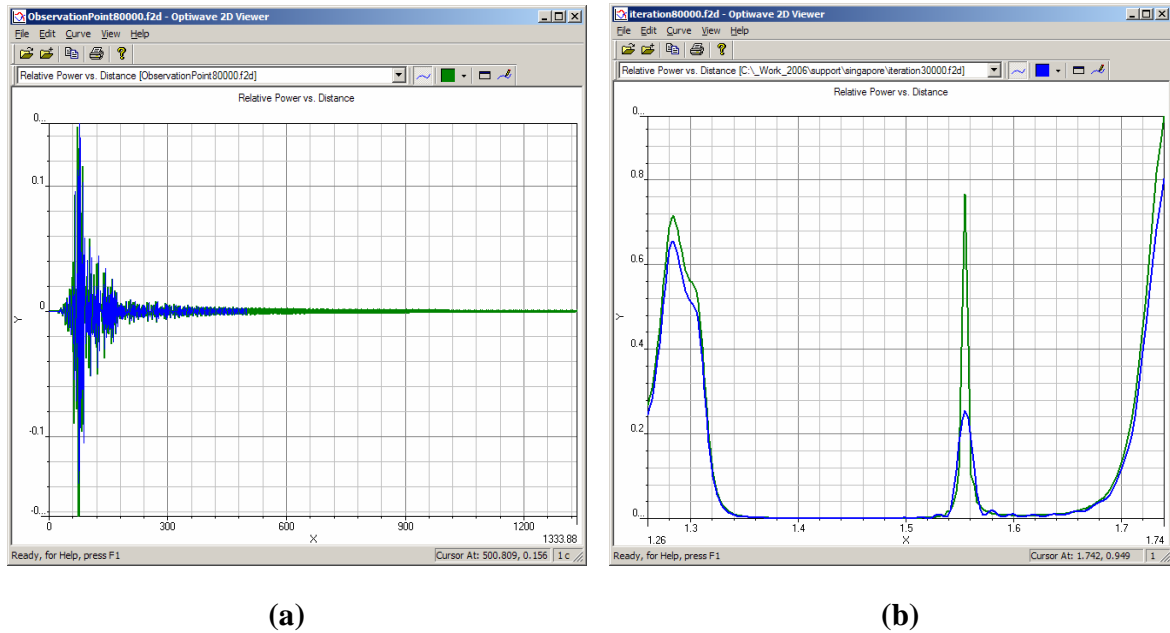

(a)   (b)

Figure 3, (a) time domain field response in point, (b) normalized spectrum

Transmission function

Please compared the power transmission spectrum in Figure 4 (b) with the published paper in figure 1, they are agreed very well. Both the point detector and Area detector can extract the transmission function. However point detector will just compared the input amplitude; this asked the point should be put in the waveguide position where the peak value happens. Area detector will detect the power through the observation plane, SO the transmission from Observation area will more accurate than that come from the point.
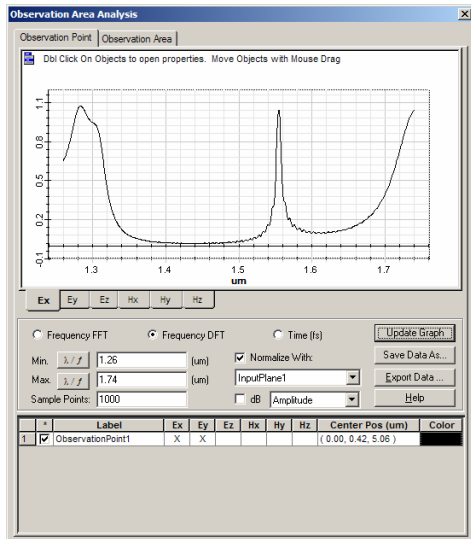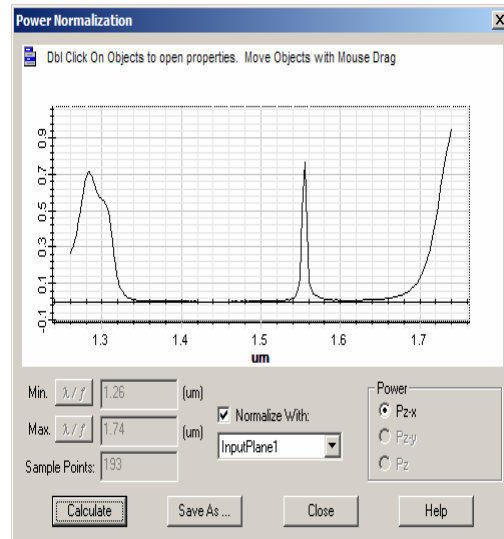
(a)   (b)

Figure 4 (a) Transmission spectrum from Point, (b) transmission spectrum from Area

Calculate the Quality value (Q-value)

From the power transmission spectrum graph, the resonant wavelength and the bandwidth can be measured in OptiFDTD by using the graph tools, and then Q-value can be evaluated as shown in figure 5 and the following equation

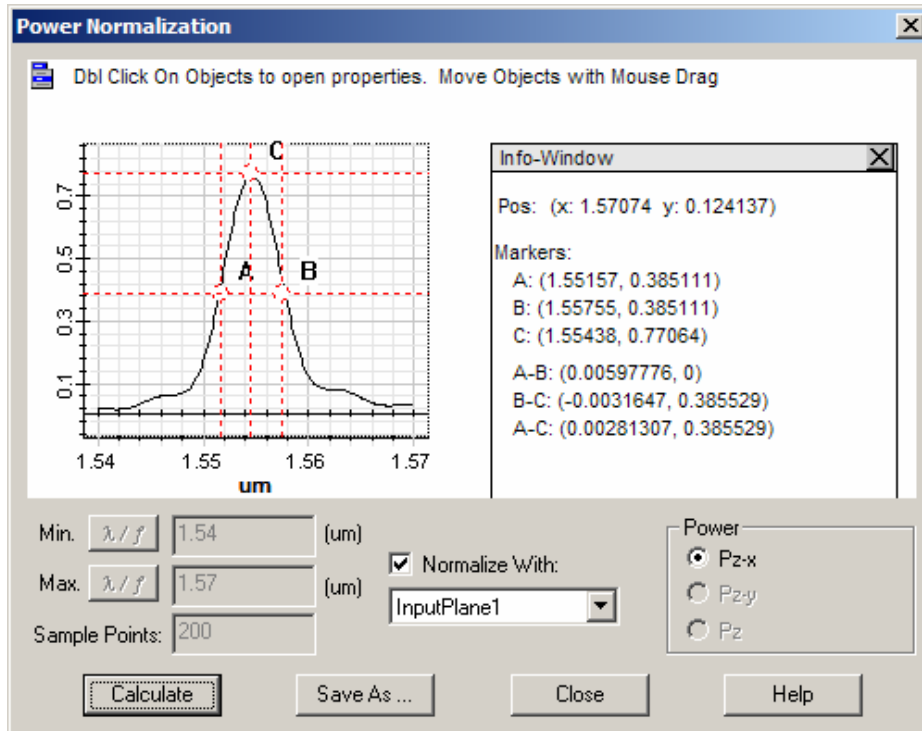$$Q = \frac{f_0}{f_2 - f_1} = \frac{1.55438}{0.00597776} = 260.02$$

Figure 5   Calculate the Q-value

Observe the guided field mode for different input wavelength

Observation area will al record the field pattern for each sampling wavelength as shown in figure 6

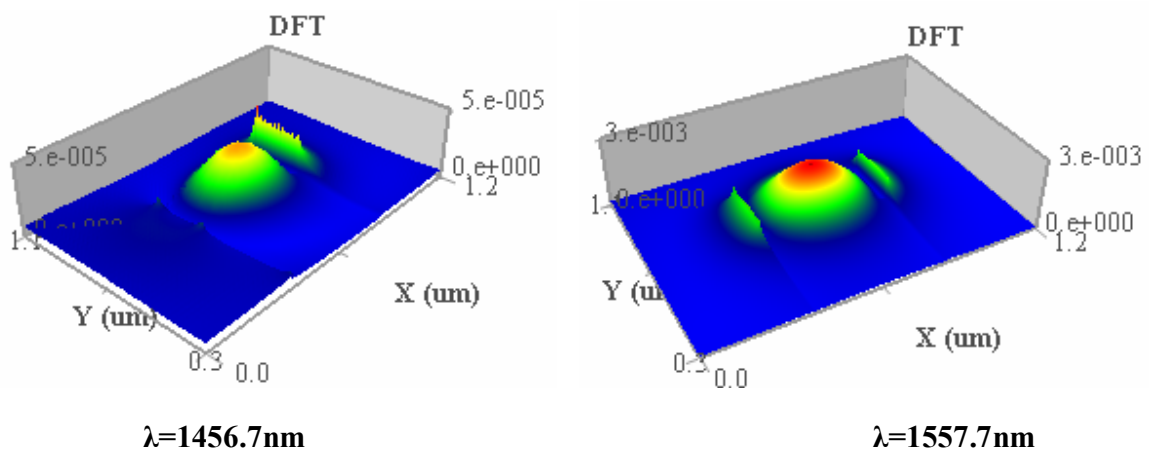

λ=1456.7nm   λ=1557.7nm

Figure 6 Transmitted field pattern for different wavelength