Photon Design®

Validation Report

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References	C. Manolatou et al High density Integrated Optics;, Journal of Lightwave technology vol 17 no 9 Sept 1999 p1682-1692
External Files	nanoptics

A comparison of high density resonant structures using OmniSim

Outline

This document demonstrates the use of the OmniSim design tool to model a range of integrated optic structures using the two dimensional finite difference time domain. The results are compared to a paper by C. Manolatou on high density integrated optics (ref 1). A set of waveguide structures are described based on a waveguide with refractive index of 3.2 and width of 0.2 um. These structures are all high index structures with wide angle propagation are ideal examples for simulation using the OmniSim design tool.

Three different structures have been studied as follows

1) 90 degree sharp bend
2) T junction
3) Waveguide crossing

90 Degree sharp bend

The basic sharp bend is shown below in figure 1

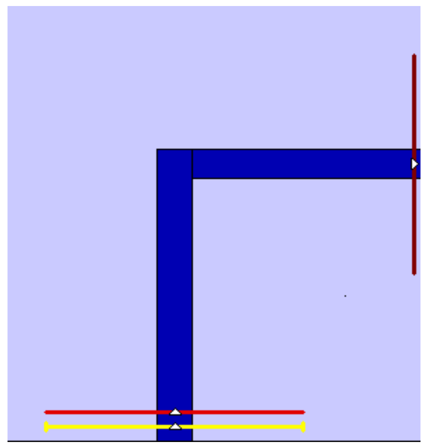
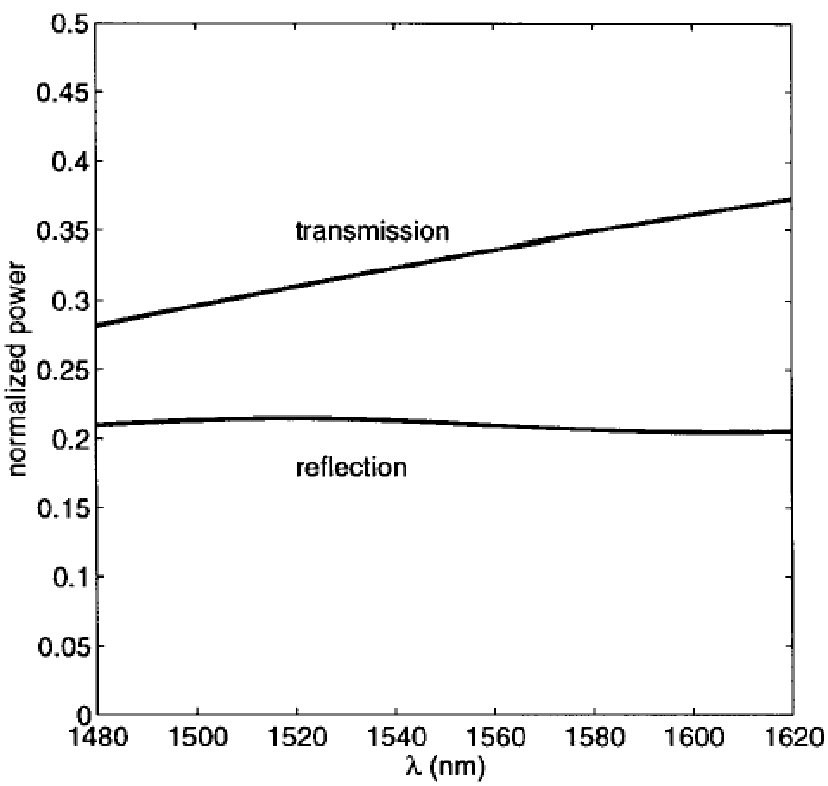


Figure 1: Basic right angle bend

This device has been simulated using the 2D FDTD engine, launching a sinusoidal pulse centred at 1.55 um with a spectral width of 0.1um. The transmission and reflection of the device are shown below in figure 2. The transmission results are in good agreement with those given in reference 1, although the reflection is slightly higher.



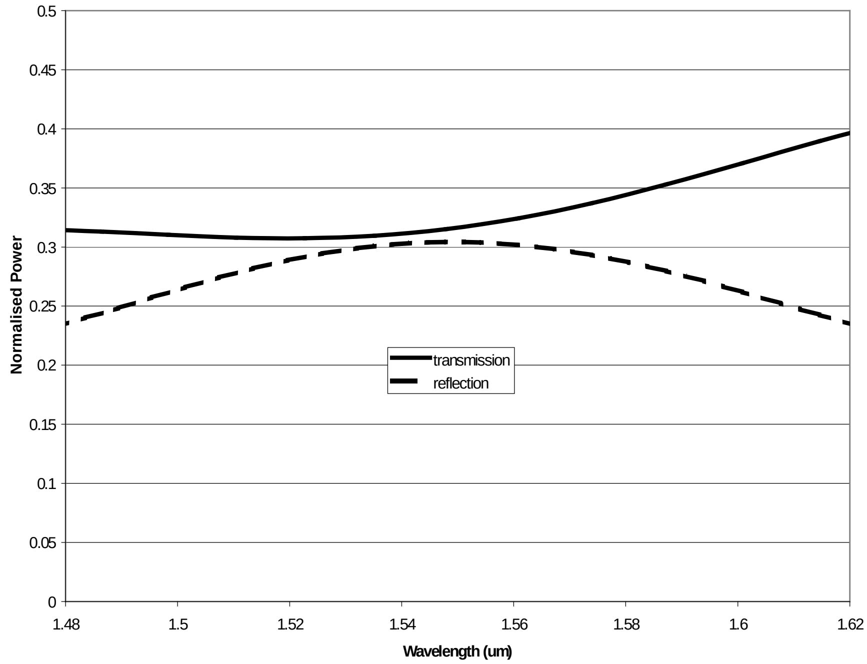


Figure 2: Transmission and reflection of basic right angle bend

To improve the transmission, it is possible to use a quarter circle resonant disc as shown in figure 3. The quarter circle has a radius of 0.68 um.

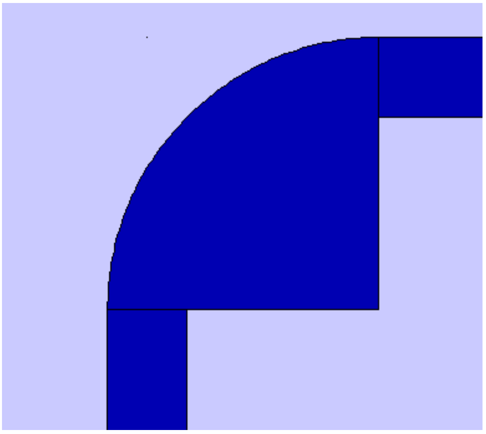


Figure 3: Quarter circle resonant bend

The quarter disc resonant cavity has increased the transmission to 97% which is close agreement to reference 1 which predicts 98%. The transmission and reflection results are shown below in figure 4.

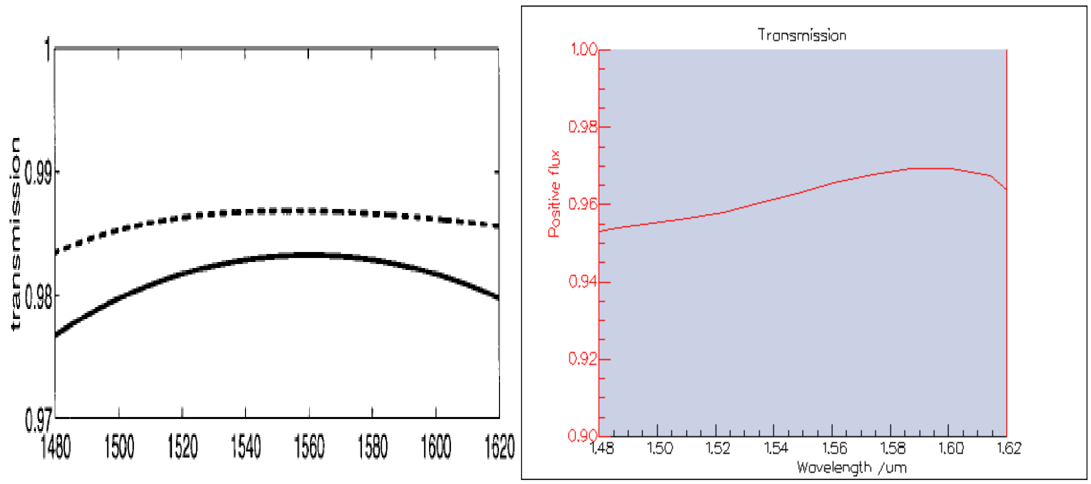


Figure 4a : Transmission results for quarter circle bend comparing ref [1] – solid line and OmniSim

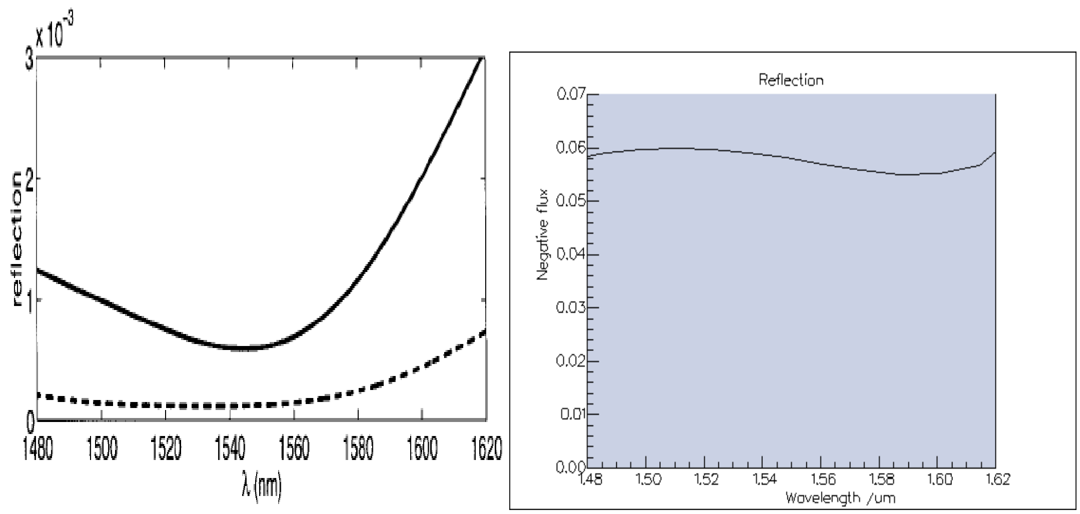


Figure 4b: Reflection results for quarter circle bend

A more practical method for easier fabrication is to use an angled corner reflection together with a square resonator, as shown below in figure 5. The red triangle represents an etched region with refractive index of 1 and has been created using the multiple mask feature of OmniSim.

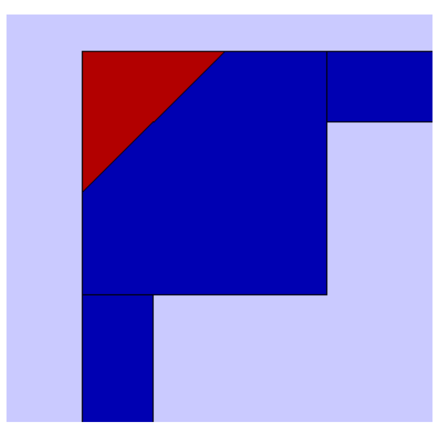


Figure 5: Corner reflector with resonant cavity

The efficiency of such a resonant structure is determined by the size of the square and the size of the triangle and many possible solutions exists. Hence this structure can ideally be optimised using the global optimiser in Kallistos. The results in figure 6 show the response of the design described in [1], together with results for the same design using OmniSim.

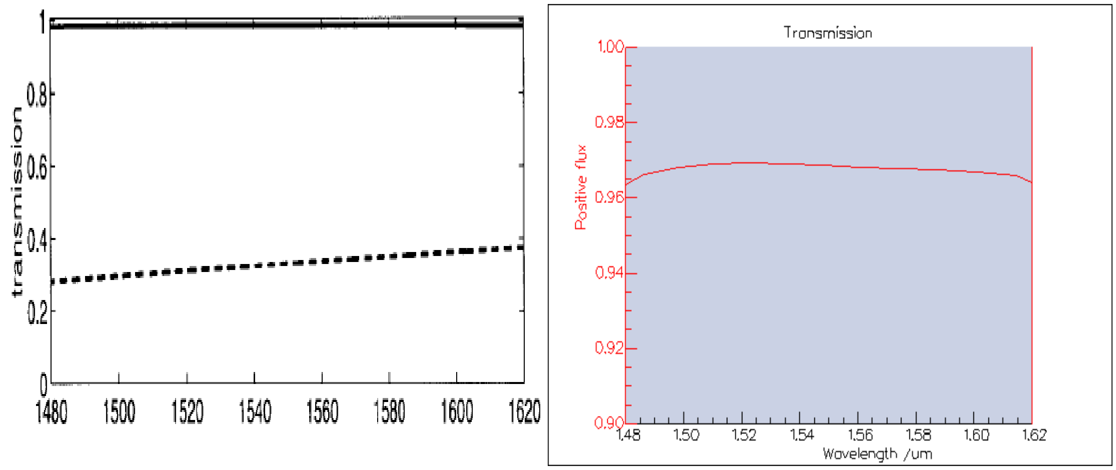


Figure 5a: Transmission results for square resonant corner reflector – solid line

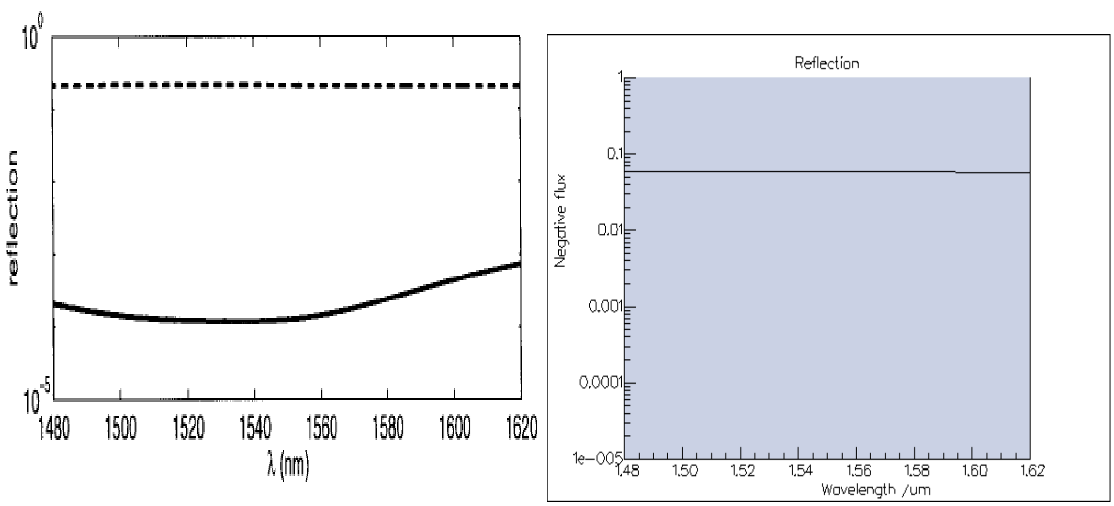


Figure 6: Transmission and reflection of square resonant corner reflector

Ref [1] shows that if the resonant cavity is increased in size then dips occur in the spectrum. Figure 7a below shows the response of a cavity 1 um wide (dotted line) and a 1.2 um cavity (dashed line). Those results have been reproduced using OmniSim in figure 7b. Agreement between the two sets of results is very good, with OmniSim reproducing the dips in transmission seen at 1.45 um and 1.6 um, for both cavities.

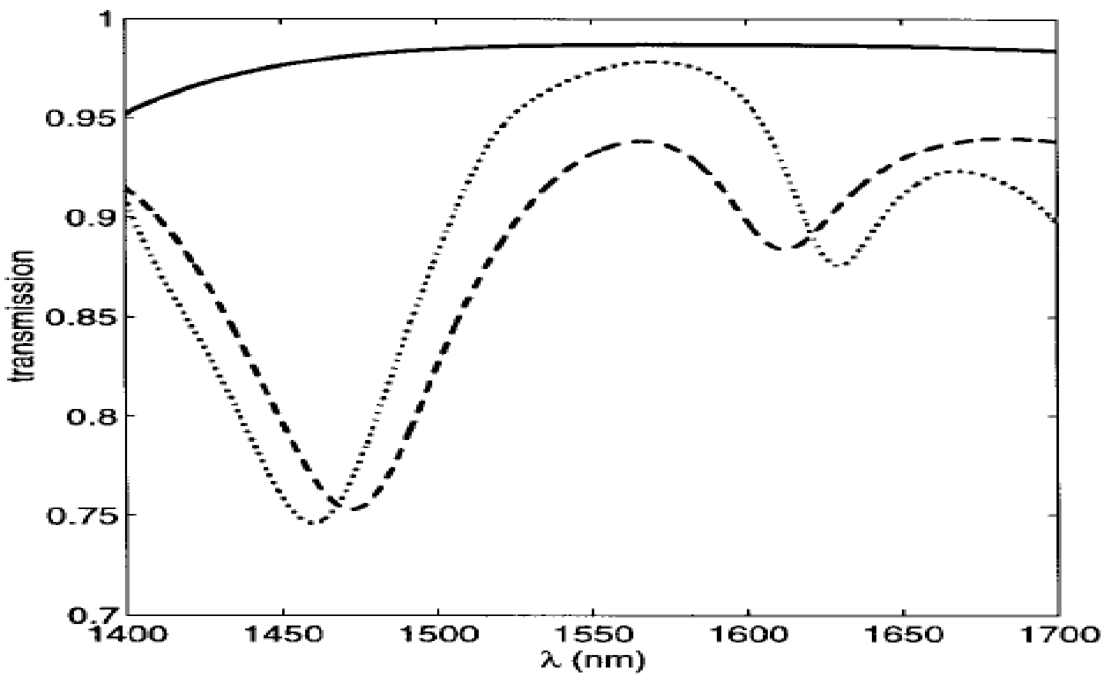


Figure 7a : transmission results for larger cavities

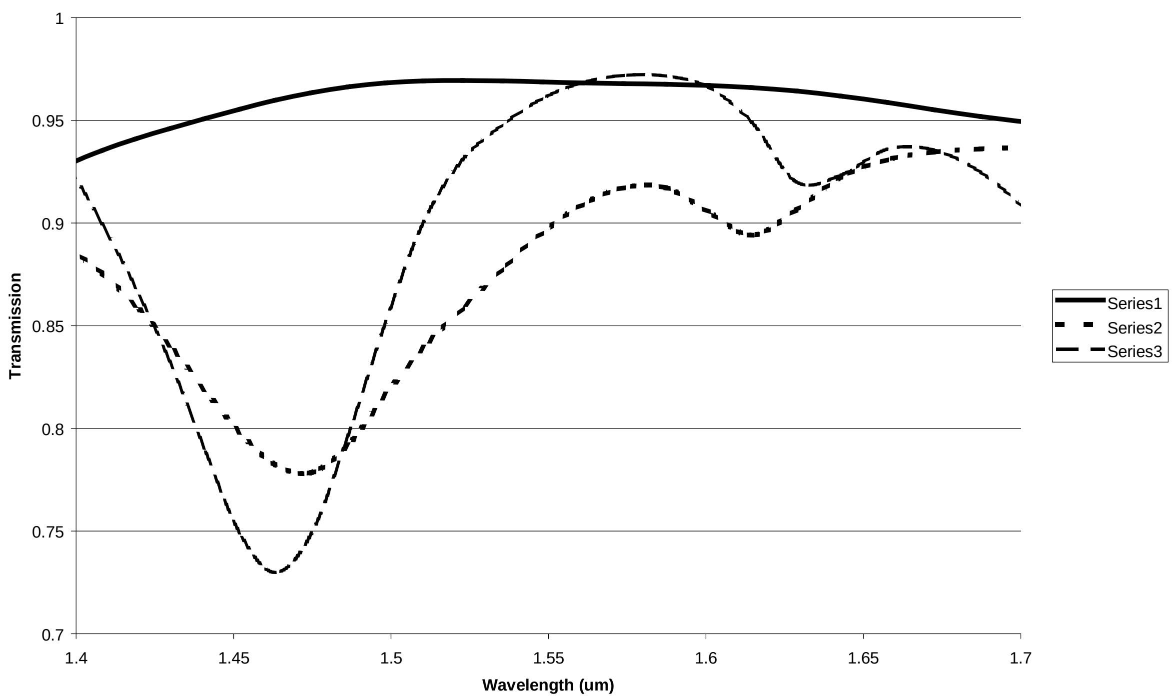


Figure 7b: OmniSim results for larger cavities

T junction

The second example in reference 1 is a T junction which is shown schematically below in figure 8.

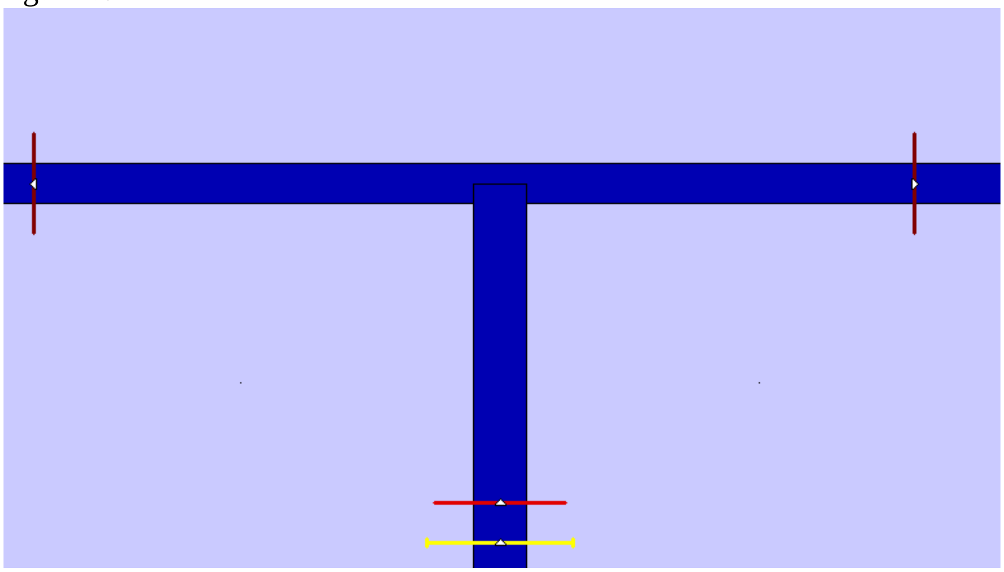


Figure 8: Basic T junction

In [1] this device is shown to have transmission of around 35% and reflection of about 25%. With OmniSim, very similar results were obtained for the transmission although the relcetion was slightly higher at about 30%. The results in ref [1] and OmniSim show very similar wavelength variations**.** The OmniSim transmission is plotted as the power through each arm, hence the total power is twice the value shown on the graph.

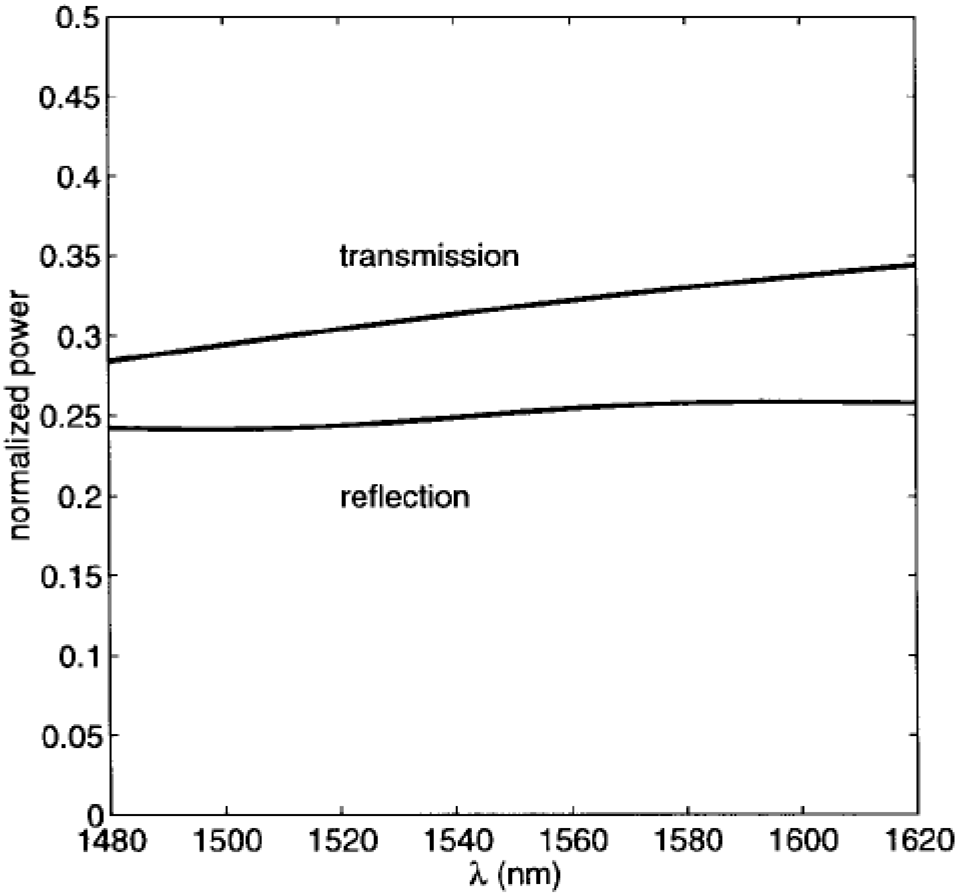


Figure 9a: Transmission and reflection for T junction from [1]

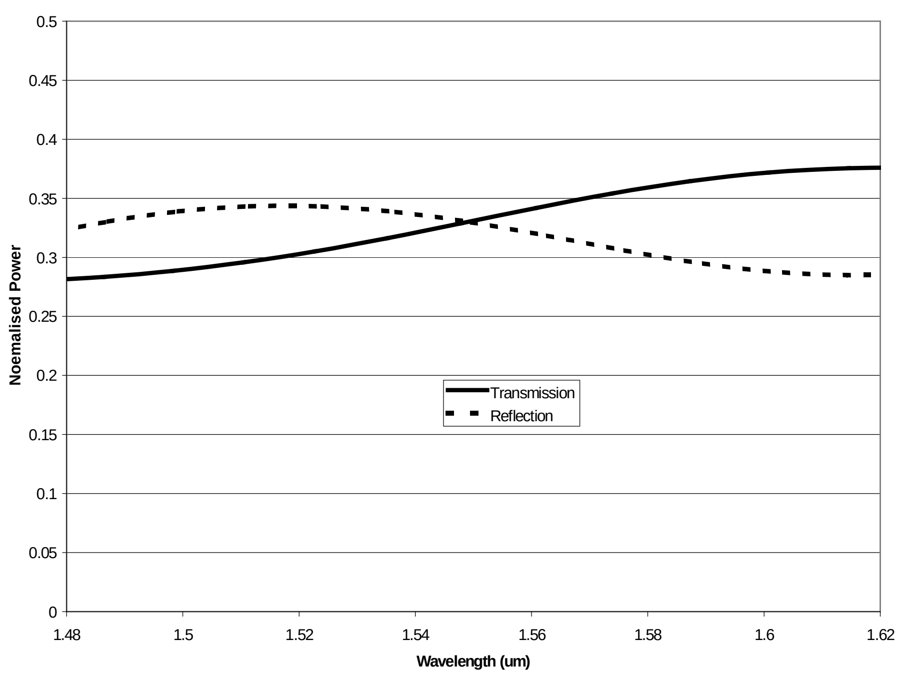


Figure 9b: Transmission and reflection for T junction using OmniSim

The transmission of the T junction can also be improved by the use of resonant cavities. Figure 10 below shows a schematic of the resonant cavity T junction device.

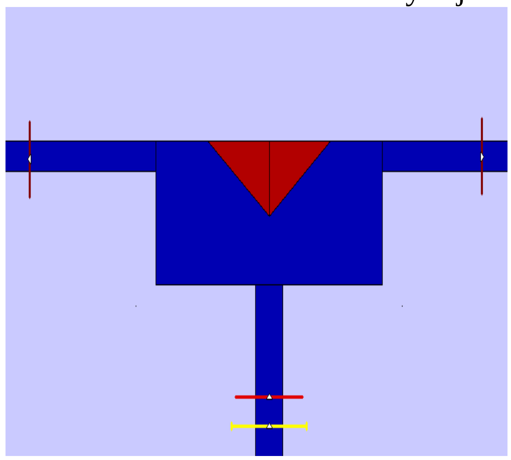


Figure 10: Schematic of T junction

Light is launched into the bottom of the device, a reference sensor is placed near the input and two output sensors are placed on the left and right arms. The design in reference [1] has a width of 1.44 um and a depth of 0.66 um. The results are shown below in figure 11

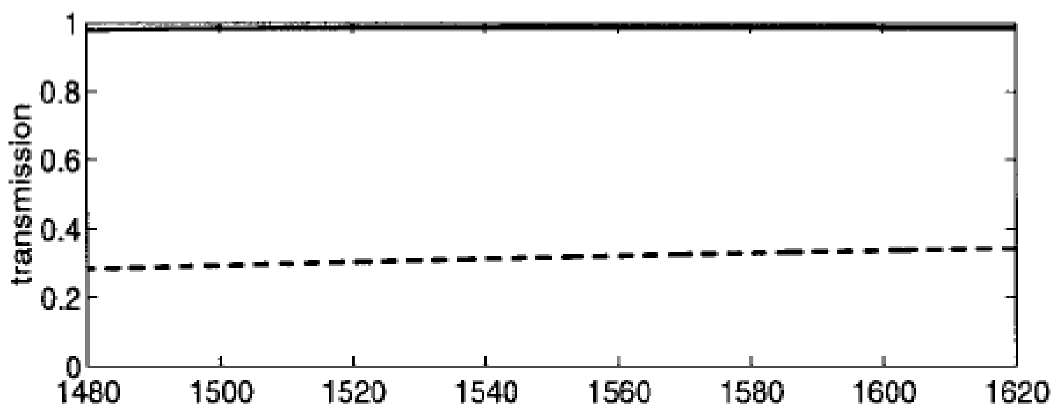


Figure 11a: transmission and reflection for resonant T junction

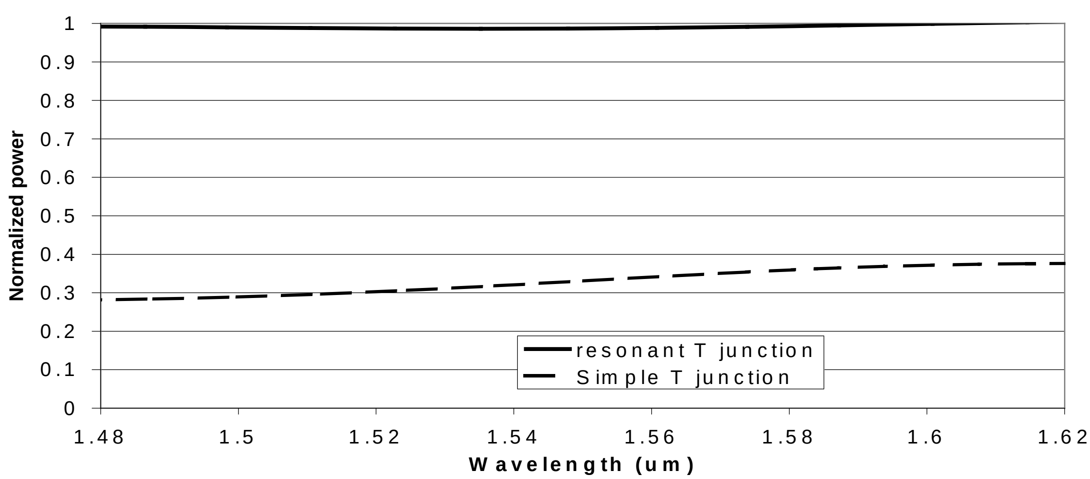


Figure 11b: OmniSim results for T junction

For this T junction OmniSim once again agrees very well with the transmission results in ref [1] but again gives higher reflection.

Ref [1] studies the effect of offsetting the input waveguide and shows that the output is asymmetric. Those results have been reproduced in figure 12 and 13 and again show very good agreement on the transmission but OmniSim predicts higher reflection.

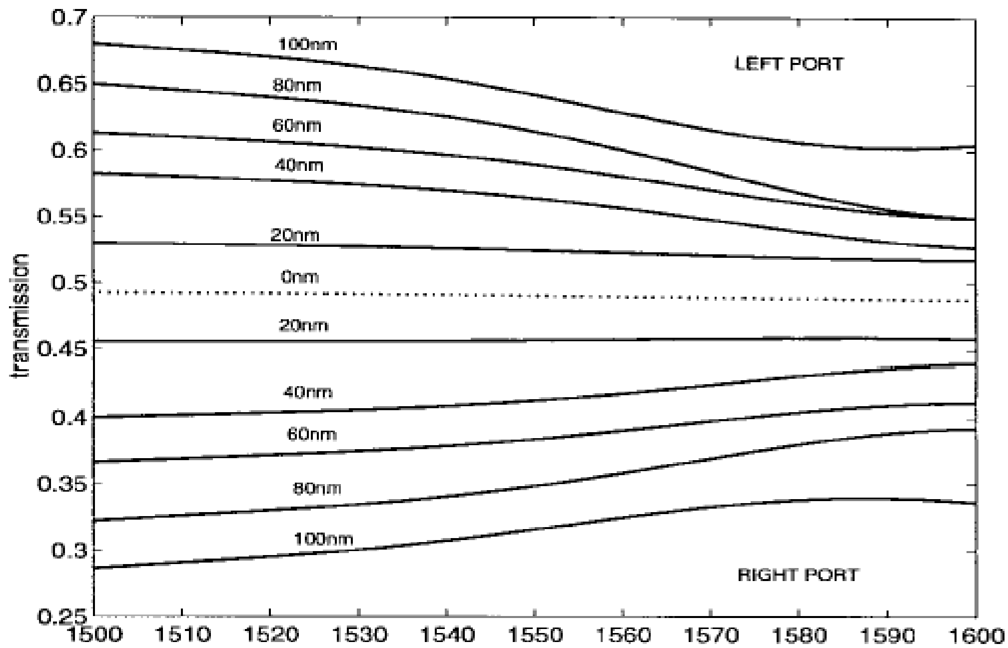


Figure 12a: Effect of offset input on transmission

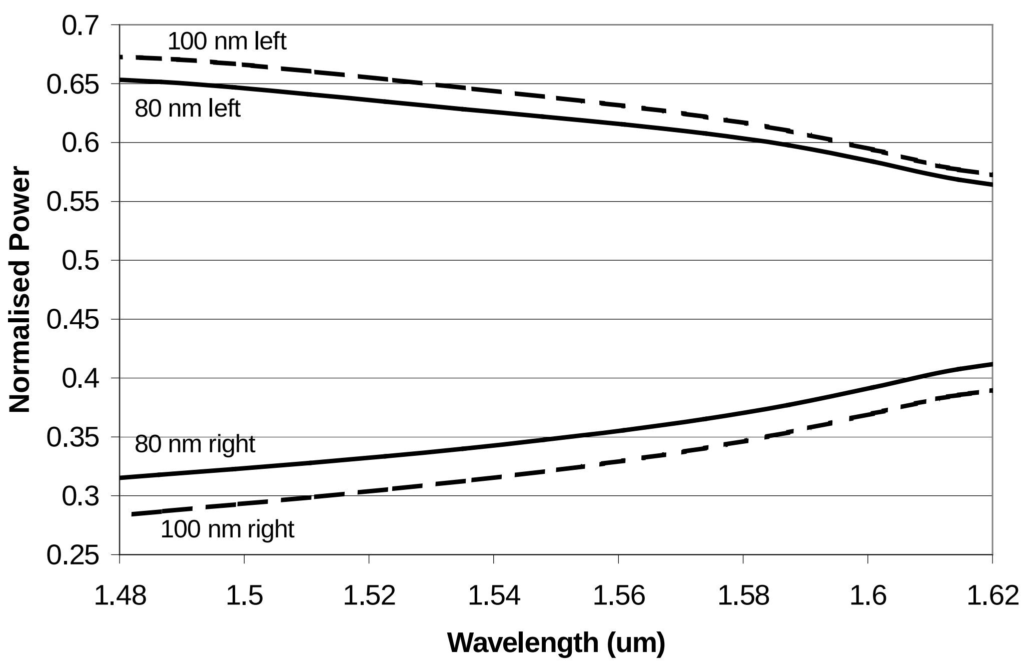


Figure 12b: OmniSim transmission results for offset input

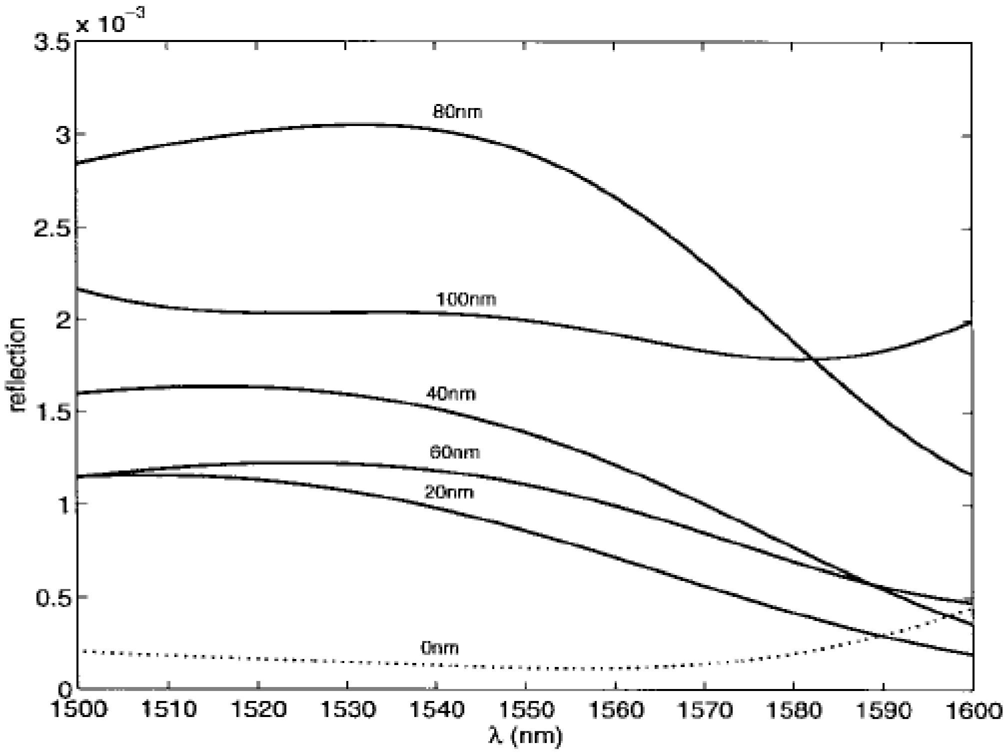


Figure 13a: Reflection results for offset input

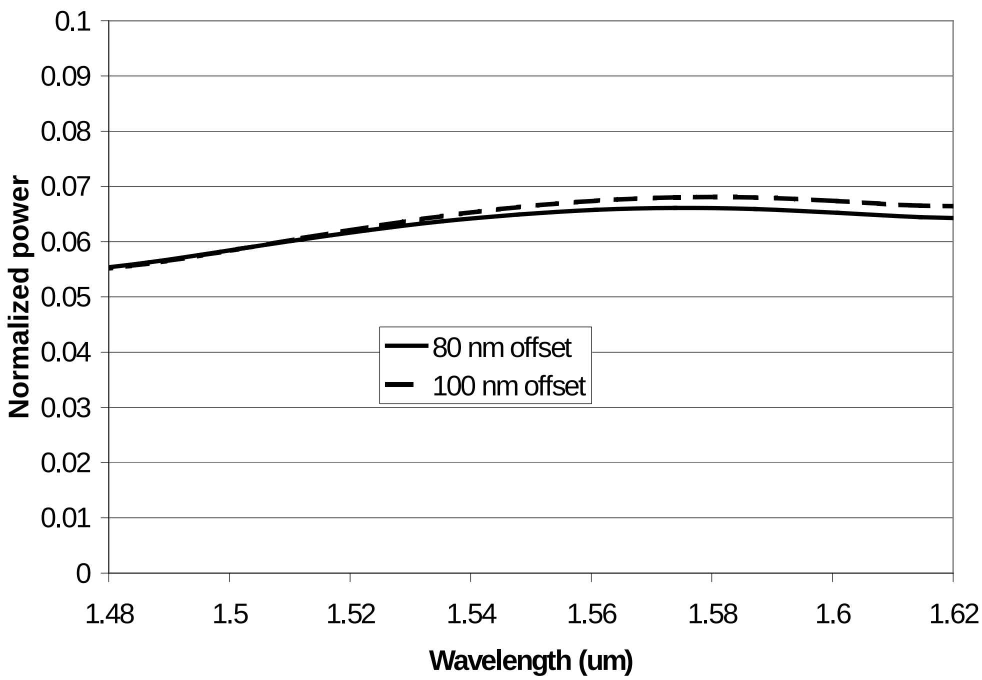


Figure 13b: OmniSim results for offset input

Crossing

The third device considered is a waveguide crossing. The results are shown for a simple waveguide crossing in figure 14. The results in reference [1] show a crosstalk of 0.08 and a transmission of 0.82, OmniSim gave virtually identical results.

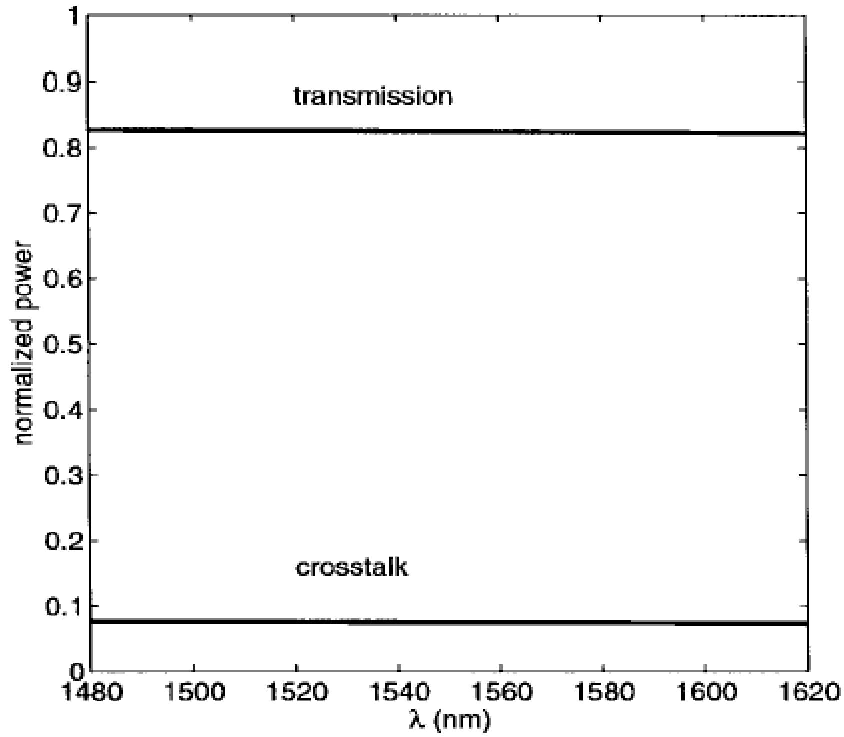


Figure 15a: Results from [1] for waveguide crossing

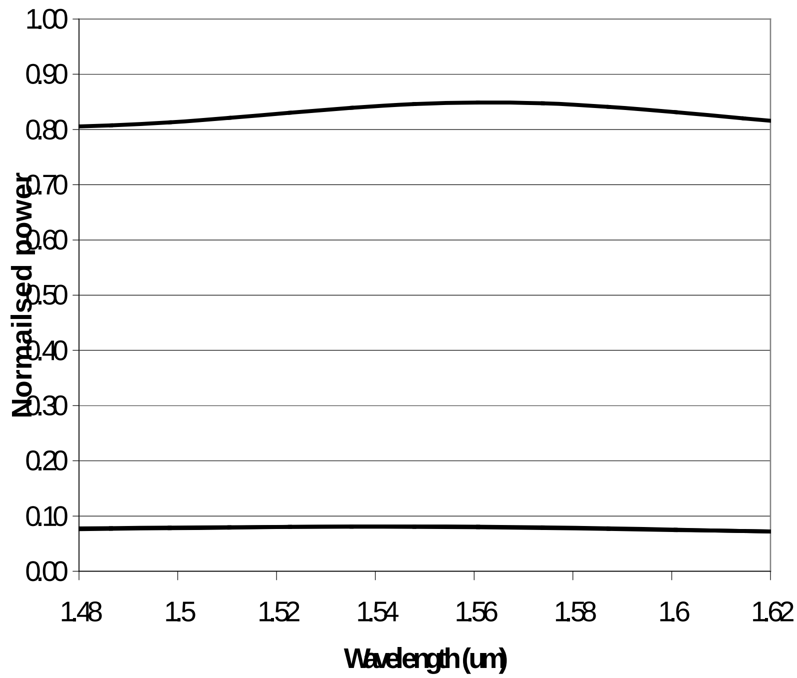


Figure 15b: Results from OmniSim for waveguide crossing

Conclusions

For a range of different devices the 2D FDTD engine in OmniSim has been shown to have very good agreement in transmission with published data in reference [1]. For reflection the agreement is not as good and OmniSim predicts higher reflection.

References

1) High density Integrated Optics; C. Manolatou et al, Journal of Lightwave technology vol 17 no 9 Sept 1999 p1682-1692