Chapter 4 Conclusion

By using the plane wave expansion (PWE) method, we present an analysis of photon transport in the 2-D triangular lattice photonic crystal waveguides. In both reduced rods and void rods situations, we found the phenomenon of energy localization inside of them. It was much more concentrated inside the reduced rods. With an ultra-low propagation speed of EM waves, it indicates that a PhC waveguide acts like a cavity. The energy hops from one defect rod to another due to the overlapping of their evanescent waves. We therefore apply the tight bind approximation (TB) in solid state physics to describe the band structure of our photonic crystal waveguides. All reasons indicate that the energy transit in the PhC waveguides is a hopping (or tunneling) mechanism.

The defect mode of two closely parallel PhC waveguides includes an even and odd mode, which is split from one defect band of a single PhC waveguide. These two modes have a crossing point where even and odd modes are degenerate. In the crossing point, the light would continuously travel along single waveguide without coupling to the neighbor one, so we also called that a decoupled point. With using different PhC waveguides and the design to the coupling region, we presented two different optical communication devices. One is dual wavelength demultiplexing, and another is optical bidirectional module.

By employing the decoupling at the crossing-point at wavelength of 1.3 μm and ultra-short coupling length of 5 lattice constants at 1.55 μm, we designed a dual-wavelength demultiplexer with output power as high as 15 dB. During our dual wavelength demultiplexing design process, we use a novel hexagonal loop to feed the photon-leakage back to the output port therefore the performance can be highly improved. A constructive interference at the merging point of the loop is necessary to have the maximum power transfer. We believe the performance, for example, output power ratios, can be further improved by fine tune of the geometrical features. Furthermore, in order to reach a bidirectional transmission, we design a simple structure of optical bidirectional module (BIDI) similar to half a directional coupler by using reduced rod PCWs. Due to its ultra-localized field distribution and the obvious cavity-like property, the coupling efficiency can highly raise. Both cases are simulated by FDTD method and their power ratios are all maintained in good dB values.