

Abstract

All-optical processing components have been introduced for signal processing in high speed communication systems to fulfill the enormous demand of transmission capacity of present day's communication systems. All-optical control of device components has become essential for faster operation of the integrated optic devices. Miniaturization of optical components has become another matter of concern to achieve large scale integration of integrated optic waveguide devices. In this direction, two-mode interference (TMI) coupler has become strong candidate for future integrated optic devices due to its many desirable properties such as compactness, large fabrication tolerance and polarization insensitivity in comparison to other components. On the other hand, miniaturization is achieved in surface plasmon polariton (SPP) based waveguide devices due to confinement of the electromagnetic energy in the metal-dielectric interface in a direction perpendicular to the interface separating the two media. In this research, we have studied two-mode interference coupling in surface plasmonic waveguide to explore the possibility of designing compact optical processor device components by using SPP propagation in TMI couplers. This thesis is intended to make important contributions to the development of compact and high speed optical processor device components such as all-optical logic gates and tunable power splitter. Contributions made in this thesis can be categorized to address three main issues.

Firstly, the previous works on planar optical waveguide components such as directional coupler, multimode interference coupler and two-mode interference coupler and their theoretical background have been reviewed. It is seen that two-mode interference waveguide structure is simpler and more compact than other structures. Some previous works on SPP waveguides used for integrated optical processors and related theory are also studied in this thesis. The KCl:Tl⁰(1) pulsed laser has been discussed for optical control of these SPP waveguides.

In the first endeavor, we have introduced an ultra-compact surface plasmonic two-mode interference (SPTMI) waveguide as a basic component for integrated

optical processor devices. The main objective of this thesis is to reduce the dimensions of devices and operating time of the components used in integrated optical processor devices. The SPTMI waveguide coupler introduced in this work has been able to fulfill both of these goals. The optical pulse controlled operation of the SPTMI waveguide couplers ensures a high operating speed of the order of picoseconds. The proposed device is found to be more compact than few recently reported works on optical pulse controlled device components for integrated optical processor devices, and the power consumption is found to be lower than that in the reported works.

High performance all-optical logic gates have become key components in optical computing and networking systems to perform optical signal processing functions such as binary addition, parity checking, header reorganization, all-optical label swapping and data encryption. We have implemented all-optical NOT, AND and OR logic operation with reduced device size, faster operating speed and low power consumption for applications in optical integrated processor devices. The selection of the logic operation performed by using the same basic device is made by the high and low states of the properly selected control and input signals. We have also implemented all-optical XOR gate as well as all-optical universal NOR and NAND logic gates which are the basic building blocks of a large number of integrated optical processor devices. This is our second contribution made in the thesis.

Optical power splitter is another important component of integrated optic waveguide processor. Tunable optical power splitters are useful for dynamical redistribution and efficient management of optical power in various optical devices. In our third contribution, we have designed a compact 3dB optical power splitter with optical pulse controlled power splitting ratio. The power splitting ratio of the proposed tunable optical power splitter can be dynamically tuned in a wide range by varying the energy of optical pulse applied to the nonlinear cladding area. Depending on the energy of pulse, any desired value of power splitting ratio can be achieved.

Keywords: All-optical logic gate, Integrated optical processor, Surface plasmon polariton (SPP), Surface plasmonic two-mode interference (SPTMI), Tunable optical power splitter, Two-mode interference (TMI) coupler,