DESIGN AND ANALYSIS OF FIBER AND INTEGRATED OPTIC POLARIZATION DEVICES

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DOCTOR OF PHILOSOPHY

by

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to my parents, and

Sumita and Suhas

CERTIFICATE

This is to certify that this thesis entitled DESIGN AND ANALYSIS OF FIBER AND INTEGRATED OPTIC POLARIZATION DEVICES by Supriya N. Diggavi is a record of bonafide research work carried out by her. She has worked under our guidance and supervision and has fulfilled the requirements, which to our knowledge has reached the requisite standard for the submission of this thesis. The results contained in this thesis have not been submitted in part or full to any other University or Institute for any degree or diploma.

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ABSTRACT

Polarization components like polarizers and polarization splitters find important applications in coherent optical systems and in interferometric fiber optic sensors. In the present thesis we propose the design and analysis of different types of waveguide polarizers and polarization splitters.

We begin with an analysis of four-layered leaky structures and obtain analytical expressions for the propagation constant and leakage loss for such structures. We show that the analysis can be extended to structures with inhomogeneous waveguiding layers and also demonstrate the applicability of the method to structures with absorbing layers. Using this method, we have carried out a detailed study of polarizers having birefringent overlays.

Waveguide polarizers based on interaction between the guided mode and plasmon modes supported by thin metal films have been recently demonstrated. The method used for the analysis of such structures does not take into account the waveguiding layer and hence cannot predict the performance of the devices in terms of its various parameters. We have analysed such structures using a recently developed matrix method. Our study has yielded important

characteristics of the device like throughput loss and polarization extinction ratio. Comparison of predicted extinction ratios and throughput loss is made with available experimental results.

The polarizing device discussed above is based on the interaction with metal layers and hence is limited by the absorption loss of the metal. This can be overcome if one can have an all-dielectric structure. We have proposed such an all dielectric structure based on the phenomenon of resonant tunneling. Numerical calculations carried out through the use of the matrix method show that it is possible to obtain extremely high differential attenuations between the TE and TM modes with typical attenuations values greater than 80 dB/mm for the TM mode in contrast to about 0.5 dB/mm for the TE mode. We have shown that with such a structure it is possible to obtain a TM pass polarizer which is not generally possible with metal-clad polarizers. The proposed resonant tunneling principle can be used for obtaining various other novel waveguide devices such as polarization splitters etc.

In polarizing structures, one of the undesired orthogonal polarizations is almost completely lost. It is however sometimes useful to have access to both the orthogonal polarization components. This is achieved in a polarization splitter. In the present thesis, we propose two designs of polarization splitting directional coupler, one based on a fiber optic directional coupler and the other on a channel waveguide directional coupler.

The fiber optic polarization splitter consists of two interacting optical fibers with a thin layer of metal in between. We have developed an analysis based on the perturbation method for the study of such structures and have carried out a detailed study of the tolerence requirement of the device.

The polarization splitter based on a channel waveguide directional coupler is an integrated optic device which consists of thin layers of metal of different thickneses deposited on the two waveguides with a dielectric overlay on top of the metal layers. We have used a combination of th matrix method and the effective index method to analyse such a structure. We have shown that with such a structure it is possible to obtain extinction ratios better than -20 dB with a throughput loss less than 1.0 dB.

CONTENTS