STUDIES ON THE PROPAGATION CHARACTERISTICS OF POLARIZATION MAINTAINING OPTICAL WAVEGUIDES

A thesis submitted in fulfilment
of the requirements of the degree of
DOCTOR OF PHILOSOPHY

by

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TO
MY PARENTS

C E R T I F I C A T E

This is to certify that this thesis entitled THE PROPAGATION CHARACTERISTICS OF POLARIZATION MAINTAINING OPTICAL WAVEGUIDES, being submitted by Ravendra Kumar Varshney, to the Indian Institute of Technology, Delhi, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements, which to my knowledge, have 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 the award of any degree or diploma.

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ABSTRACT

Birefringent optical waveguides find use in a large number of applications such as coherent optical communication systems, interferometric fiber optic sensors, and polarization sensitive integrated optical devices. These waveguides include various polarization-maintaining optical fibers such as elliptical core fibers, bow tie fibers, and side tunnel fibers and integrated optical waveguides such as planar and strip waveguides. The present thesis is devoted to the study of the propagation characteristics of some of the polarization maintaining optical fibers and integrated optical waveguides.

We first present a simple first order perturbation approach to study the various propagation characteristics of highly elliptical core fibers. The unperturbed waveguide is taken to be a pseudo-rectangular-core waveguide whose refractive index distribution is separable in the (transverse) x and y coordinates. Results obtained by the perturbation approach agree very well with those reported by using accurate numerical techniques. We have then proposed an equivalent rectangular core waveguide for studying the birefringent properties of elliptical core fibers. We have shown that, in the useful single mode region, the birefringent properties of elliptical-core fibers can be determined quite accurately by considering an equivalent rectangular-core waveguide having the same core area, aspect ratio and

core-cladding refractive indices, and whose properties can be obtained by solving simple transcendental equations using a pocket calculator. We have also extended the perturbation approach to study the propagation characteristics of double clad elliptical core waveguides. We have shown that by introducing an appropriate depressed inner cladding, one can achieve larger birefringence, larger core-size and zero polarization mode dispersion in the single mode region of elliptical core fiber. Applicability of the equivalent rectangular core waveguide model, for practical elliptical core fibers, is also shown by measuring birefringence of two different elliptical core fibers and comparing the experimental values with corresponding theoretical values obtained by the present rectangular core waveguide model; the two values are found to be in an excellent agreement. We have also extended our rectangular core waveguide model to study the propagation characteristics of side-tunnel fibers and have shown that the polarization characteristics of a side-tunnel fiber can be obtained to a good approximation by using the proposed perturbation approach.

Integrated optical waveguides such as planar, channel, rib and strip loaded, waveguides, are the basic component of integrated optical devices. Strip loaded and rib-waveguides are more promising because in these waveguides,

lack of edge-smoothness in the loading strip does not cause significant scattering losses. We have developed a simple first order perturbation approach to study the propagation characteristics of such waveguides. A comparision of the results obtained by the present analysis with those obtained by using numerical techniques shows an excellent agreement. Finally, we have presented a study on the intensity dependent propagation characteristics of a planar waveguide having an inhomogeneous film and a self-focusing nonlinear cover medium. For the profile considered, viz., an exponential index profile, the analysis is exact, and the results show that the threshold power requirements are considerably relaxed in comparison to those in the case of homogeneous film waveguides. Empirical relations are also established to obtain the values of minimum threshold power and minimum diffusion depth required for observing the optical bistable behaviour in the lowest order mode of a given waveguide.

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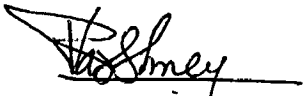

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