PREFACE

World today is undergoing a technological revolution, the revolution of information, leading the world into an age of information. The transition to and life in this new age is being made possible by a thin fiber of glass not more than the diameter of human hair carrying tremendous amount of information in the form of light signals. However, with the evolution, of optical fiber communication systems, many branches of it also evolved. Based on the principal of waveguiding, many devices (both active and passive) were designed, sometimes using fibers as a part of it, or sometimes with different geometrical shapes of the wave guide other than the circular cylindrical structure. Thus, we come across a growing study of waveguides having, planar, rectangular, elliptical, triangular and other non-circular cross-sections, which confine electromagnetic energy in the transverse direction of the guiding structure and propagating in one direction.

The study of such waveguides gave birth to many interesting and useful devices and they become a major part of the emerging field of integrated optics. The field of integrated optics is primary based on the fact that light can be guided and confined in very thin films (with dimension of the order of wavelength of light) of transparent material on suitable substrates. By a proper choice of substrates and films and a proper configuration of the waveguides, one can perform a wide range of operations like modulation, switching, multiplexing, filtering or generation of optical waves.
The emergence of fiber optics and integrated optics revolutionized the technology of the twentieth century. Telephone channels are now able to carry all kinds of information such as TV signals, data, etc., using optical fibers. On the other hand with the development of integrated optics, all optical appliances and even optical computer are not simple dream any more. Thus the twenty first century, as many great scientists view it, will be the age of integrated optics.

While studying the existing literature on multilayered optical waveguides, it was found that whereas both experimental work and theoretical studies based on numerical methods have been extensively reported, the more rigorous analytical approach to the study of such multilayered waveguide has been relatively less emphasized. The motivation behind the present investigation was to take up a rigorous and detailed study of the multilayered fibers of various refractive index profiles and of the multilayered planar waveguides in respect of their propagation and attenuation characteristics.

The present thesis reports some fairly rigorous analytical studies on light propagation through multilayered optical waveguides. The aim is to give a physical insight into the manner of propagation of electromagnetic waves through multilayered structures of different types of symmetry i.e., rectangular and circular particularly in the case when these guides can support only a single mode or a small number of modes. It is important to investigate the feasibility of mode separation so that the conditions of monomode operation can be achieved. Hence
various properties of lower order modes are considered in detail. Obviously, the rigorous way is to start with the Maxwell’s equations taking into account the different boundary conditions and then proceed to find the characteristic equations which provide information about the propagation constants of the guided modes from which other relevant characteristic properties may be obtained. Using this method and other related methods, the present thesis reports some fairly rigorous analytical studies on light propagation through multilayered optical waveguides. The various aspects dealt with are the attenuation properties, the power confinement factors and the power coupling between adjacent layers in some Distributed Feedback (DFB) lasers in which multilayered structures are involved.

The thesis begins with an introduction giving the background of the research in the field of wave propagation through optical fibers and planar waveguides. The details of the investigator’s own findings can be seen in the central portion of the thesis, (chapters 2 to 4) give the details of a study of multilayered planar waveguides of step, semi-parabolic and refractive index profiles. Waveguides with metal coatings are also considered. The main emphasis in this part of the work is on attenuation and propagation characteristics. The perturbation technique has been used for such studies. Besides this, the field confinement factors have also been calculated for different types of multilayered planar waveguides. The power coupling in adjacent layers in DFB lasers is also briefly studied.
Chapter One presents the introductory material necessary for understanding the context of the thesis. A review, both in the historical perspective and in the logical sequence of the development of the subject, has been presented.

In chapter two, the propagation of electromagnetic waves through various types of four-layer metal-clad slab waveguides is studied. A general and unified characteristic equation, valid both for the TE and the TM modes is reported for such a waveguide, when the guiding layer has a truncated semi-parabolic refractive index profile. Using the perturbation method, simple analytical expressions for attenuation parameters for these modes are obtained corresponding to two special types of four-layer structures, viz., the semi-parabolically graded slab waveguide (SPSW) and the step-index slab waveguide (SSW).

In chapter three the propagation constants of various types of four-layer waveguides without any metal coating are estimated. Using the same technique as that in chapter two, the change in the effective refractive index of a three-layer guide due to the addition of a fourth layer is derived analytically. A comparative study for two special types of waveguides i.e., SPSW and SSW, is made with respect to changes in the effective refractive index and the attenuation parameters. Later in the chapter, a characteristic equation of a five-layer slab waveguide is developed and the effect of an additional layer on the four-layer SSW structure in respect of propagation and attenuation of electromagnetic waves are determined.
In chapter four, the field intensity distribution in different layers of three different types of structures i.e., the SSW, the SPSW and the parabolic-index slab waveguide (PSW) have been studied. Analytical expressions have also been found for the relative power confinement factors in different layers. The applicability of the constants for factors to the computation of the coupling constants for different DFB lasers is also briefly shown.

In chapter five, a summary of the work is presented and the main conclusions have been outlined. The scope for further extension of the work has also been briefly discussed.