PREFACE

The invention of Laser has given birth to many new diversified fields in Physics like Non linear Optics, Fiber Optics and Integrated Optics. The field of Integrated Optics deals with the guidance of light waves confined to a very thin (of a few microns thickness and a few cm^2 area) dielectric transparent layers (thin films) which are sandwitched between substrates and superstrates of appropriate materials. Integrated Optics involves the intrinsically two-dimensional integrated optical circuits (IOCs) which use thin films (planar optical waveguides) as their key elements.

The waveguiding region of thin films consists of either homogeneous or inhomogeneous materials. In terms of the material properties (or the refractive index profiles along various axes) the waveguiding structures are grouped as various combinations like stepwise uniform/ graded refractive index, isotropic/ anisotropic, invariant/ linear/ nonlinear with respect to external fields etc. Research and Development in IOCs have led to practical applications in communication sensing and signal processing, variety of single components and multiple components, IORF spectrum analysers, photonic switching, time integrating correlator etc. Theoretical studies of IOCs are carried out by various mathematical tools such as Geometrical Optics, Direct application and solutions of wave equations and boundary conditions, WKB approximation and Reciprocity, variational principles, Coupled Mode Theory and Numerical Simulations.

In general the waveguiding region has a multilayer structure. The periodic stratified structure in particular influences the optical guiding properties and leads to many interesting applications like Bragg-Wave type couplers and nonlinear coherent couplers. The recently introduced multiquantumwell structures (MQW) have been incorporated into various high-speed devices such as semiconductor lasers, modulators and optical switches. The propagation of light waves through such guiding structures is associated both with linear and nonlinear optical phenomena e.g. self focusing effects have been predicted theoretically and also observed experimentally. Guided-wave dispersion relations have been derived from the nonlinear wave equation. The propagation of nonlinear single interface and thin-film guided waves has also been investigated by many research workers. Further the studies on s- and p- polarized nonlinear surface polaritons have attracted wide attention.

In the present work we have carried out a detailed modal analysis of a two dimensional waveguide having a distorted parabolic index profile. We have mainly studied the variation of the fields for TE modes in such waveguiding structures by incorporating the effects due to distortion in the profile, thickness of the waveguide and the wavelength of a given mode.

The topic of surface waves at interfaces separating linear and nonlinear media is of current interest in the nonlinear integrated optics. We have therefore analysed the surface waves by considering the nonlinear media having positive and negative nonlinearities in their dielectric constants. For this purpose we have modelled a waveguide structure which consists of a thin layer of linear medium sandwitched between two semi-infinite nonlinear media, one with positive nonlinearity and the other with negative nonlinearity.

In Chapter-1, the importance of light guidance through thin optical films has been elaborated in the beginning. The structure of thin films is explained and the role of optical coatings in the fabrication of beam splitters, polarisers, band pass filters etc. has been brought out. Next we have studied the ray paths in planar optical waveguides by considering the variants and establishing the requisite ray equation. In particular the ray paths in a square law medium have been examined in terms of periodic length. Finally the condition for guided rays in the film has been given.

At the outset of Chapter-2, we have briefly summarised the essentials of electromagnetic theory. The characteristic features of electromagnetic waves propagating in free space and dielectric are described. This is followed by the meanings of plane polarised waves and Poynting vector. The reflection of an electromagnetic wave at a plane interface also forms a topic of discussion. The modal analysis of inhomogeneous planar waveguides has been given in somewhat details. The wave equations for **E** and **H** fields are established. These are solved to obtain the TE mode solutions in a symmetric step index planar waveguide. The symmetric and antisymmetric modes are clearly distinguished from the nature of these solutions. The physical meanings of these modes has been described at length by means of field distribution graphs. The concept of cut-off of a mode is easily understood from this description.

In Chapter - 3, we have presented our studies on modal analysis of an inhomogeneous waveguide with a parabolilc refractive index profile having a flat continuation near the waveguide axis. To start with we have summarised the electromagnetic mode treatment of a truely parabolic index planar waveguide. The relevant scalar wave-equation for the electric field is established. Its TE mode solutions are obtained in terms of Hermite Gaussian functions. Next we have considered a parabolic index waveguide having a flat continuation in its profile near the waveguide axis. The expression for the refractive index distribution for such a structure is simplified to a form which is suitable in the electromagnetic mode analysis. This is utilised to solve the relevant wave equation for the TE modes. The solutions are once again in terms of the Hermite Gaussian functions. However, these involve the 'effective beam waist', particularly defined in the present work. This beam waist incorporates the terms which take care of the relative distortion in the refractive index profile. These expressions are utilised to evaluate the field distributions of different orders of TE modes. The effects of the relative distortion in the profile, the thickness of the waveguide and the wavelength of the wave have been taken into account in these calculations for a number of TE modes. The results have been reported in a number of tables and figures.

In the last Chapter – 4 of this dissertation we have examined the problem of nonlinear surface waves at the interfaces in a planar optical waveguide which consists of a thin layer of linear medium sandwitched between two nonlinear media with positive and negative nonlinearity. For this purpose we have utilized Tomlinson's method. In the beginning we have considered a linear-positive nonlinear medium combination. We have used Tomlinson's functional forms for the electric fields of the surface waves in the two media. The scalar wave equation has been simplified and the expressions for the requisite parameters k_x, k_{1z} and k_{2z} of the surface wave are obtained in terms of a single parameter D_1. Also the expression for the position of the peak intensity z_0 is established. The expression for the critical power of the surface wave has been obtained for this case. It differs from Tomlinson's expression in that it involves the thickness of the linear medium d. By letting d tending to 0, we can obtain Tomlinson's expression for the critical power of the surface wave.

In the second case the relevant expression for the parameters and the critical power are obtained by considering the interface between a linear medium and the negative nonlinear medium. These expressions also involve the thickness d, although they slightly differ from those in the earlier case. As such we have carried out the numerical estimates of the field amplitude and critical power only for the first case.

Our study on the behaviour of field amplitude during the propagation of the surface wave at the interface brings out the following features :

1. For $D_l = 0$, the amplitude remains constant in the linear medium, but decreases monotonically in the nonlinear media.
2. As D_l increases, the intensity of the surface wave is more and more sharply peaked with nonlinear medium while it remains constant at the interface. Further the intensity peak shifts more and more into the nonlinear medium. It reaches a maximum distance when D_l is equal to 2.277. However for larger D_l values, the peak shifts back towards the interface.