Studies on Some Optical Properties of Fibers Used in Optical Communication

A Thesis
Submitted in Partial Fulfillment of
the Requirements of the Degree of
Master of Science in Physics

By

Ola Ahmed Hussien Moshref
B.Sc. Physics Department,
American University in Cairo (1983)

To

Physics Department
Faculty of Science, Ain Shams University
Cairo, Egypt

1996

Ain Shams Univ.
Faculty of science

M.Sc. Thesis

Name : *Ola Ahmed Hussein Moshref*
: *Studies On Some Optical Properties Of Fibers Used In Optical Communication*
Degree : *Master of Science in Physics*

Supervisors

1) *Prof. Dr. N.Barakat*- Professor of Experimental Physics, Faculty of science, Ain Shams university.
2) *Prof. Dr. H. El-Hennawi*- Professor of Experimental Physics, Faculty of science, Ain Shams university
3) *Prof. Dr. M.M.Abdel Rahman*- Professor of Experimental Physics, Faculty of science, Ain Shams university

تاريخ البحث: \ \ ١٩

الدراسات العليا

ختم الإجازة: أجيزت الرسالة بتاريخ \ \ ١٩

موافقة مجلس الكلية \ \ ١٩

موافقة مجلس الجامعة \ \ ١٩

To

The memory of my father

and to

My mother

who taught me how to think and never lose faith.

Acknowledgement

I'd like to express my deep respect and gratitude to Prof. Dr. Nayel Barakat, Professor of Experimental Physics, Ain Shams University, who suggested the problem of investigation ,guided, encouraged, and supported – always with deep insight and faith.

I'm very grateful to Prof. Dr. Hatem El-Hennawi, Professor of Experimental Physics, Ain Shams University, for his valuable and continuous help in the experimental and theoretical work.

I also acknowledge the help and encouragement of Prof. Dr. Mohamed Medhat Abdel-Rahman, Professor of experimental Physics, Ain Shams University.

My appreciation of all the valuable discussions, help and advice offered by Dr. Fouad El-Diasti, Lecturer of Experimental Physics, Ain Shams University.

I'd like to thank all members of the National Institute for Standards for allowing me to use their laboratories and equipment.

Abstract

Moshref, Ola Ahmed. *Studies on Some Optical Properties of Fibers Used in Optical Communication*. Unpublished Master of Science dissertation, Ain-Shams University, Physics Department, 1996.

Multiple-beam Fizeau fringes across a step-index fiber immersed in a silvered liquid wedge have been studied in transmission and at reflection. Investigations of the factors affecting the multiple-beam fringe shape have been carried out with emphasis on the wedge angle of the interferometer, the refractive index difference between the liquid and clad, and the index gradient between the core and clad.

Modified expressions have been derived to investigate the effect of refraction at the liquid/clad and clad/core interfaces on the shape and magnitude of the fringe shift. The resulting corrections in the core and clad refractive indices are found to be 10^{-3} and 10^{-4} respectively when the refractive index difference between the liquid and clad is less than 10^{-3}. These expressions have been applied to the determination of the index-profile of monomode fibers from experimental measurements.

Keywords: Multiple-Beam Fizeau Fringes. Fiber Optics. Monomode Step-Index Fiber. Multimode Step-Index Fiber. Index Profile.

Summary

This thesis consists of five chapters. The first chapter is an introduction to the composition and characteristics of step and graded-index fibers. It outlines previous work in interferometric measurements of the refractive index of optical fibers.

In Chapter II, the modal equation for step-index fibers is derived starting from Maxwell's equations. Expressions for basic mode parameters such as normalized cutoff frequency and total number of modes are obtained. The impact of these parameters on the bandwidth, dispersion, and attenuation of optical waveguides is discussed.

Multiple-beam Fizeau fringes are studied in Chapter III, both in a parallel-plate interferometer and a silvered wedge. For the latter case, optimum conditions on the wedge angle and interferometric gap thickness for the formation of fringes are studied in detail. Expressions for determining the refractive index-profile of a step-index fiber immersed in a liquid wedge are derived. The effect of the refractive index difference between the liquid and clad, and between the core and clad on the fringe shape are thoroughly discussed. A novel method for determining the wedge angle from interferometric measurements is presented.

Chapter IV deals with the phenomenon of fringe discontinuity at the liquid/clad and clad/core interfaces. The variation of light intensity at different points on the fiber cross-section calculated from Fresnel equations are plotted to account for the drop of transmitted intensity at the interfaces. Hence, refraction at the interfaces is considered, new expressions describing multiple-beam Fizeau fringes across a step-index fiber immersed in a liquid wedge are derived, and the modification in the fringe shape is investigated.

Chapter V presents the experimental setup, procedure, and results. Applying the expressions of Chapters III and IV, index-profiles of monomode fiber samples immersed in liquids of different refractive indices are compared

showing a slight difference in behavior near the liquid/clad and clad/core interfaces when the correction in the clad and core refractive indices due to refraction effects is taken into consideration.

List of Figures

List of Tables

Contents