STUDIES ON OPTICAL WAVEGUIDE FIBER CHARACTERISTICS

THESIS

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By

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بسم الله الرحمن الرحيم

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SUMMARY

The present thesis comprises four chapters. Chapter I describes the present state of art and development of the main optical communication system components namely the transmitter which includes a light source, a receiver which includes a detector, and low-loss optical fibers as the communication media. Light sources used are either light emitting diodes or injection lasers while detectors are either PIN photo diodes or avalauche photo diodes. The advantages of optical communication are given. The main types of optical fibers namely step-index, graded-index, monomode and multimode fibers are described. Also the fiber characteristics including attenuation, modal and material dispersion are presented.

Chapter II is concerned with the application of Maxwell's equations to the propagation of electromagnetic waves inside cylindrical wave guides. Deduction of wave guide equations and modal equation provide the main characteristics of mode propagation in step-index and graded index fibers. These include the shape and number of modes in both fibers. Leaky modes in graded-index fibers are also described.

Chapter III deals with the determinations of the two important parameters of multimode graded index optical fibers,

namely the index profile parameter α and Δn, the difference in refractive indices between core and cladding. Application of the mathematical expression for the shape of multiple-beam Fizeau fringes crossing a graded-index optical fiber when inserted in a silvered liquid wedge has been extended. The effect of using the enclosed liquid of different refractive indices on the shape of the multiple-beam fringes crossing the fiber, in core, clad and liquid regions has been dealt with theoretically and experimentally verified. Using the minimum variance technique, formulae are utilized for calculating both α and Δn from fringe shifts. Experimental results have been obtained from microinterferograms with liquid refractive index close and in between refractive indices of clad and core. The consistency of the values of α and Δn found experimentally and calculated theoretically for different n_L is a proof of the reliability of the multiple-beam interference method developed for determining accurately the two previously mentioned parameters of multimode graded index optical fibers.

Chapter IV deals with the process of fiber splicing. A new method based on utilizing two-beam interference formed by a Zeiss-Linnik interference microscope has been presented and applied to examine the topography of the fiber surface around the region of splicing. The interference fringes revealed the existence of two bucklings on both sides of the point of splicing. Their heights have been determined interferometrically and the corresponding losses due to their existence measured. It is concluded that the dimensions of such buckling which result from the process of fusion splicing should be less than one micron so that no detectable loss is introduced.

A block diagram of the optical communication system used in the measurement of the loss due to splicing, and erected at Ain Shams University, Faculty of Science, Laser Lab. is presented as well as the apparatus used in the present work.

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CHAPTER I

CHARACTERISTICS OF OPTICAL WAVEGUIDE FIBERS WITH EMPHASIS ON MULTIMODE FIBERS

I.1 HISTORICAL ACCOUNT AND THE PRESENT STATE OF ART OF OPTICAL COMMUNICATION SYSTEM COMPONENTS

Inspite of the potential advantages of optical fibers in optical communication, it was not until 1966 that their use in this field was proposed [1]. The reason was that the attenuation exhibited by glass fibers available at that time was in the range of thousands of dB/Km. This allowed transmission only over short distances. In addition light sources and detectors were not at all compatible in size and ruggedness with optical fibers. In 1966, Kao and Hockman pointed out [2] that the attenuation found in glasses employed for optical fibers was not a basic property of the material, but produced by the impurities present, mainly metallic ions. Since the intrinsic material loss, essentially determined by Rayleigh scattering, which decreases as the fourth power of the wavelength, is very low, getting rid of the impurity content would allow achieving much lower losses. It was also recognized that an attenuation of 20 dB/Km for glass fibers was the limit, i.e. the maximum value acceptable for practical application to long distance transmission. In 1970 Corining glass works succeeded in fabricating monomode fibers, hundreds of meters long with attenuation under 20 dB/Km [3]. The technique was based on depositing a thin layer of very pure, doped silica material inside a fused silica tube. This was a real breakthrough which