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PREFACE

With the publication of the fortieth volume of Progress in Optics, a significant milestone has been reached. The first volume was published in 1961, a year after the invention of the laser, an event which triggered a wealth of new and exciting developments. Many of them have been reported in the 228 review articles published in this series since its inception.

The present volume contains six review articles on a variety of subjects of current research interests. The first, by T.R. Woliński, is concerned with polarimetric optical fibers and sensors. These devices have created a novel generation of powerful sensory-oriented techniques. The article reviews the main efforts and achievements in this field within the last two decades. It discusses the physical origin of polarization phenomena in birefringent fibers, both at the fundamental and the applied levels, and various deformation effects due to pressure, strain, twist and temperature on propagation of the lowest-order mode in fibers.

The second article, by J. Tanida and Y. Ichioka, presents a review of recent researches on digital optical computing. After introducing the basic concepts needed for understanding the developments in this field, some feasibility experiments as well as software studies are discussed.

The article by V. Peřinová and A. Lukš which follows, deals largely with photodetection from the standpoint of the theory of open systems, bordering on novel techniques for testing irreversibility via quantum trajectories. Both destructive and non-destructive models of the process of photodetection are discussed.

The fourth article, by Z. Zalevsky, D. Mendlovic and A.W. Lohmann, presents an account of modern theories of resolution in optical systems, based on the concepts of communication theory.

The next article, by J. Turunen, M. Kuittinen and F. Wyrowski, is concerned with the design of microstructured optical elements by the use of electromagnetic diffraction theory. Such an approach is required when the paraxial approximation is inadequate to describe their performance, or when it becomes necessary to take into account the state of polarization of the light. Diffractive elements based on linear or modulated gratings which operate in zero-order, first-order and multi-order modes are discussed.

The concluding article by Z. Ficek and H.S. Freedhoff deals with the theory underlying the interaction of an atom with an intense polychromatic driving field, with particular reference to certain experiments. Several different systems which have been studied to date are discussed, including subharmonic resonances in the absorption spectrum of a strong probe, the fluorescence, near-resonance absorption and the Autler–Townes absorption by the entangled driven systems.

In publishing this fortieth volume it is appropriate to acknowledge the substantial help which I have received over the years. There are too many persons to acknowledge individually. Three of them, however, deserve special mention: Mr. Jeroen Soutberg, director of ISYS Prepress Services in the Netherlands, is largely responsible for the production of these volumes. He must be credited for consistently maintaining the highest possible standards. I wish to thank Dr. M. Suhail Zubairy, one of my former students and now Professor at a University in Islamabad, Pakistan for preparing, for many years, the subject indexes for these volumes. I also wish to express my appreciation to Dr. Joost Kircz, a former publisher of Elsevier, who provided much help and advice with the publication of earlier volumes in this series. Finally, I wish to thank members of the Editorial Advisory Board of Progress in Optics for their part in having made this series such a successful enterprise.

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October 1999

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POLARIMETRIC OPTICAL FIBERS AND SENSORS

BY

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§ 1. Introduction

Over the last two decades significant progress has occurred in optical fiber technologies from the use of intensity (amplitude) modulation to that of modulation of the optical polarization of the electromagnetic wave propagating along a fiber. At the same time new possibilities have opened up for both optical communication and also optical fiber sensors and systems. The key to successful construction of these new sensing devices and coherent communication systems is in high-performance polarimetric optical fibers and sensors. They are mostly based on highly birefringent (HB), polarization-maintaining (PM) fibers, which have aroused great interest from both theoretical and practical points of view. Although polarization effects in optical fibers initially played a minor role in the development of lightwave systems, their importance is still growing, due to an enormous increase in optical path lengths that can be achieved with single-mode fibers and also to an increase in bit rates in digital systems, as reviewed by Poole and Nagel [1997]. These two events recently precipitated a rediscovery of polarization phenomena in lightwave systems.

Before 1980 it was impossible to exploit the polarization modulation in a fiber for sensing applications, since the conventional single-mode fibers manufactured for telecommunication use do not hold the optical wave amplitude in a particular polarization state. The appearance of HB fibers created a new generation of fiber-optic sensors known as polarimetric fiber sensors, which use polarization (phase) modulation within these fibers or at their output due to various external perturbations describing the physical environment.

The aim of this chapter is to review the foremost achievements and efforts in research activities related to the development of a new generation of polarimetric optical fibers and sensors at both fundamental and applied levels during the past twenty years. The review underlines the physical origin of the perturbations (e.g., those induced by pressure, strain, bend, twist, temperature) on the lowest-order mode propagation in HB polarization-maintaining fibers together with their impact on applications in optical fiber sensors and systems.

Several papers and chapters in textbooks have been published on polarization-maintaining fibers and polarization effects in fibers, for example, by Kaminow [1981], Payne, Barlow and Ramskov-Hansen [1982], Rashleigh [1983a], Noda,

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