

Volume preface

Biology and medicine are increasingly exploiting physical techniques for basic research, laboratory analysis, clinical diagnostics and even therapeutics. In this regard the amount of scientific work on the properties of optical and laser devices is continually expanding, such that it may be difficult for anyone to keep up to date. Hence, a comprehensive view of the state-of-the-art and perspectives of future applications of optical and laser techniques in photobiology and photo-medicine should be widely welcomed and appreciated. Clearly, not all of these issues can be encapsulated in one volume; nevertheless the present endeavour attempts to cover the broad range of topics that hitherto have been scattered throughout various books and specialized journals.

The present volume, the fourth of a series entitled “Comprehensive Series in Photosciences” has been solicited by the European Society for Photobiology and assembled to try bridge the gap between the increasing offering of innovative technologies and the limited demand by the biologists and clinicians who are, with a few exceptions, scarcely conscious, more often entirely unaware, of them. The goal of this endeavour is to offer an extensive and qualified description of the current optical techniques that may stimulate genuine attention (present and future) of many scientists working in the various areas of bio-medicine. This book provides its information through the pen of recognised scientists, each one active in the field.

The authors belong largely to the physics community, but, since the content of the volume (and the aim of the entire series) is mainly dedicated to a life science-oriented auditorium, the basic concepts and essential principles, necessary to understand instrumentation and techniques, are presented in plain language. This, however, is not at expenses of a rigorous approach. Each author gives an initial comprehensive review of laser and/or optical techniques of their interest, goes on to discuss the current, often pilot applications, and concludes by indicating future realistic perspectives in photobiology and photomedicine.

The use of realistic examples has been encouraged especially for those biomedical applications that are currently used and whose knowledge can make other biomedical scientists and clinicians aware of the large and fast growing

potentials of optics in medicine. However, the various chapters not only deal with techniques that are already in everyday practice, but also with (a) techniques that have just exceeded the experimental stage and are entering into routine, (b) techniques that are only promising and (c) even those that need much more experimentation before they can be accepted as real breakthroughs.

Each chapter follows a reasonably logical progression, revealing the relevant research for each topical area. This latter feature makes it quite simple for the reader to understand the scientific basis for the subsequent discussion and to retrieve the relevant references from the bibliography.

Indeed, biology and medicine are increasingly attracting the interest of mathematically literate engineers, physicists and computer scientists. Hence, we hope that this book will attract a wide audience and encourage them to apply their most advanced achievements towards optical techniques, not only to benefit basic science, but even to the relief (especially through reliable diagnosis and/or definite prognosis) of patients. In turn, biology and medicine are increasingly exploiting physical techniques and technological products for research, laboratory analysis, clinical diagnostics and therapeutics.

Nevertheless, many biologists and clinicians are terrified by the unfriendly appearance of mathematical expressions customarily employed by engineers and physicists. This is often enough to prevent from reading even a single article. We appreciate the difficulty for the non-mathematical and/or physical researcher to understand some chapters, but we hope the numerous figures that accompany each chapter will provide key signposts so that the biomedical reader can choose to gloss over the mathematics. We expect that the book will give our (hopefully many) readers a strong feel for the capability of these approaches and promote new interdisciplinary interests.

Despite our efforts some important topics are missing. A complete (is it possible?) book would require an unacceptably long gestation period. Hence, the present volume represents a compromise between the availability (present or forthcoming) of other books and/or review papers on specific topics, the acceptance from leading researchers to contribute to the book, and the failure of a few authors to complete their contribution within the agreed dead line.

Finally this volume comes at the right time since it takes advantage of the maturity reached by lasers and, in general, by opto-electronic sciences.

The Volume

As this volume solicited by the ESP, we tried to involve, whenever possible, mostly European authors. The ratio between the number of chapters written by European/non-European Authors is 3:2, being 16 versus 5 contributions, respectively. Specifically: 2 are from Switzerland, 4 from the UK, 4 from Germany and 6 from Italy, with 4 from the USA, and 1 from Australia.

The Volume is divided into four parts. The apparent dichotomy in the lengths of these parts – some consisting of long, detailed chapters and others consisting of

a limited number – is somewhat in accord with the different levels of awareness and development of the individual application/technique described or proposed. The exhaustive list of references at the end of each chapter is of great value to readers and researchers seeking additional information about individual subjects.

Part I

This covers various topics concerning the basic physics and technology of lasers and lamp sources. This is very important since it is unusual to have a comprehensive presentation of the principal laser and lamp sources within the same book. Such information usually appears separately in different and hyper-specialised publications.

The foremost chapters by King (UK), Lüthy & Weber (CH), Unger (D), and Zellmer & Tünnermann (D) deal with the Laser sources (gas, liquid, solid state, semiconductor, diode-pumped, and fibre lasers). The central part of Part I describes efficiently and clearly different types of lamps (Diffey, UK) and solid state lamps (Diehl, D), their nature and principal uses. Of particularly use is the concluding chapter by Nisoli (I) on pulse generation and control, especially in regard to the interesting foreseen perspectives in both basic and applied research (atto-physics).

Part II

Scientists interested in spectroscopic and imaging techniques will find this section valuable. Part II encompasses three exciting chapters, dealing with the most recent progress in this field. This part emphasizes the scientific and technological aspects of the application of advanced spectroscopy. The contributions come from leading laboratories; they review, discuss and illustrate background and advanced biomedical applications of *Autofluorescence spectroscopy* (Bottiroli & Croce, I), *Reflectance and transmittance spectroscopy* (Fantini & Gratton, USA), and *Fluorescence spectroscopy* (Taroni & Valentini, I; Marcu, USA).

Part III

This is dedicated to optical microscopy and includes four chapters, by Schneckenburger (D); Fusi, Monici, & Agati (I). Ascoli, Gottardi & Petracchi (I); and Diaspro (I); Their content spans from *Optical microscopy* to *Scanning probe microscopy* and *Confocal and multiphoton microscopy*. The incredible diffusion and dissemination of techniques and application of microscopy, plus the lack of a recent comparative treatise on the central methodologies presently used in the field, warrants the assembly and eminence of this part.

Part IV

Part IV provides a valuable background that favours a better understanding of the various imaging techniques described throughout. A particularly relevant chapter by Sampson & Hillman (Australia) outlines the theoretical basis and practical applications of the *Optical coherence tomography* (OCT). Indeed, this article fills a large gap in the literature since it includes most material and key equations that, even being fundamental to understanding in detail OCT imaging, cannot be found elsewhere. It explains the effects of dispersion, describes the OCT 3-D PSF, noise analysis for balanced detection, highlights the key role of the often overlooked cross-beat noise, provides a good description of the frequency-domain delay line and puts the right emphasis on multiple scattering and speckle, which tend to be glossed over in the literature. Further coverage of the imaging topic is provided by two excellent articles by Jacques and by Jacques & Ramella-Roman (USA), who describe in detail, smoothly explaining and clearly indicating, past, present and future applications of *Laser optoacoustic imaging* and *Polarized light imaging*. Finally, a specific chapter by Seeger (CH) is dedicated to *Ultrasensitive fluorescence detection at surfaces systems*. This chapter encompasses a clear explanation of the basic principles, the state-of-art of instrument development and workable applications (present and future) in life science and medicine.

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