Preface

I was introduced to the photorefractive effect in organic compounds in 1994 when I started my career at the Centre Spatial de Liege (Belgium). The objective of the program was to develop nondestructive testing technology to analyze aerospace structures and payloads. At the time, that class of materials had just been discovered and was a scientific hot topic. While the science was interesting, the figures of merit of the materials were marginal, and, unfortunately for me, no application could be developed in the short duration of the project.

Leaving Belgium for the United States, I had the chance to work with one of the most active groups in the field of photorefractive polymers at the University of Arizona. There, Professors Peyghambarian and Marder had assembled a team of scientists ranging the span from organic chemistry through optical characterization and theoretical modeling. That kind of team formed the critical mass necessary to make significant advances in science. During that time, I witnessed the diffraction efficiency and sensitivity of the material multiplied a hundredfold, while the response time decreased by the same order of magnitude. Compositions were being optimized for different regions of the spectrum where proof-of-concept applications were demonstrated. Theories were formulated to explain the behaviors observed in the laboratory, and the predictions of these theories were being tested in quasi real time. Thanks to that effort, and many similar ones all around the world, photorefractive organic materials are now fairly well understood from a theoretical point of view and their properties substantially more developed than they were a decade ago. Today, it is possible to synthesize a stable photorefractive compound with close to 100 % diffraction efficiency, several hundred cm^{-1} of gain, and sub-millisecond response time.

The first chapter of this book (Blanche and Lynn) provides a scientific history of these exciting discoveries, from mathematical modeling to the development of specific organic molecules and compounds, as well as the manufacturing of reliable devices and characterization procedures. Labeled as an introduction, it is an overview of the techniques and progress the field of photorefractive material has experienced the last 25 years.

The second chapter (Fuentes-Hernandez) focuses on the photoconductivity property of organic semiconductors. Not entirely specific to the photorefractive process, photoconductivity is also an extremely important aspect in organic photovoltaics, organic light-emitting diodes, and organic photoconductors, which makes this chapter very important for a wide variety of applications.

Building on the theoretical bases laid down by the second chapter, the third chapter (Tsutsumi and Kinashi) provides a detailed discussion of photoconduction in photorefractive organic material. More specifically, the authors focus on the use of the photoconductivity to optimize response time and sensitivity, which are two fundamental figures of merit of photorefractive organic materials that are still actively investigated today.

The first three chapters cover what can be considered as “classical” photorefractive organic materials. The following three present more “exotic” compositions and configurations. Diving into the core of materials science, the fourth chapter (Vannikov and Grishina) details the photorefractive properties of polymer composites based on carbon nanotubes. The nanotubes, in addition of being a sensitizer, also have a high degree of third-order polarizability that allows them to act as a chromophore. Based on these properties, polymer composites with photorefractive sensitivity in the near-IR region were developed.

Liquid crystals, especially in the smectic mesophases, are the focus of the fifth chapter (Termine and Golemme), which provides a description of the structure and electro-optical properties of the different mesophases, followed by an account of their photorefractive properties.

This naturally leads to the analysis of hybrid photorefractive systems in the sixth chapter (Evans, Cook, Reshetnyak, Liebig, Basun, and Banerjee) where inorganic windows are used along with liquid crystals to enhance some of the relevant properties of both materials.

The final part of the book switches gears to focus on applications. Chapter 7 (Banerjee, Evans, and Liebig) describes the wave mixing process in photorefractive polymers, including an extensive theoretical section on the material in the steady state. This study leads to the modeling of the phase shift between the intensity grating and the induced refractive index grating. The chapter also discusses several image processing applications based on wave mixing.

The loop will be fully closed with the eighth chapter (Georges) that ends the book where I started my career: with the application of photorefractive materials for holographic interferometry and nondestructive testing. What was only a concept in 1994 is now routinely used by the industry, and multiple instruments have been engineered. The chapter not only exposes the techniques but also the material requirements and the future prospects for applications.

I would like to sincerely thank all the authors for their contribution to this book, as well as all the past and present researchers that have participated to build up the knowledge of photorefractive organic materials that we are seeing today. We are really standing on the shoulders of giants.

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