

Organic Light-Emitting Devices

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Editor

Organic Light-Emitting Devices

A Survey

With 158 Illustrations



Springer

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Preface

This volume on organic light-emitting devices (OLEDs) has been written to serve the needs of the beginning researcher in this area as well as to be a reference for researchers already active in it.

From their very beginning, OLEDs, which include both small-molecular- and polymer-based devices, were recognized as a promising display technology. As the dramatic improvements in the devices unfolded over the past two decades, the investment of research and development resources in this field grew exponentially. The fascination with these devices is due to several potential advantages: (1) Relative ease and low cost of fabrication, (2) their basic properties as active light-emitters (in contrast to liquid-crystal displays, which are basically polarizing filters requiring a backlight), (3) flexibility, (4) transparency, and (5) scalability. Once the performance of red-to-green OLEDs approached and then exceeded that of incandescent bulbs and fluorescent lights, it became clear that they are serious candidates for general solid-state lighting technology, competing directly with inorganic LEDs. Hence, while inorganic LEDs are the dominant solid-state lighting devices at present, OLEDs are expected to gradually replace the inorganic devices in more and more niche areas. Finally, OLEDs are attracting considerable attention as building blocks for some types of molecular electronic devices, and, most recently, for spintronic devices. In short, although their introduction into commercial products began only a few years ago, the breadth of their impact is widening rapidly.

The first reports of electroluminescence (EL) from an organic material can be traced back to 1907, and the first actual OLED, based on anthracene, was fabricated

in 1963. However, it was not a thin-film device, and the operating voltage was extremely high. After years of efforts to improve its performance, interest in the subject waned. The breakthroughs that led to the exponential growth of this field and to its first commercialized products can be traced to two pioneering papers. The 1987 paper by Tang and Van Slyke demonstrated that the performance of green-emitting thin film OLEDs based on the small organic molecule tris(8-hydroxy quinoline) Al (Alq_3) is sufficiently promising to warrant extensive research on a wide variety of thin film OLEDs. The 1990 paper by Bradley, Friend, and coworkers described the first polymer OLED (PLED), which was based on poly(*p*-phenylene vinylene) (PPV), and demonstrated that such devices warrant close scrutiny as well. Since then, the competition between small-molecular OLEDs and PLEDs continues in parallel with the overall dramatic developments of this field. This volume has tried to mirror this competition by devoting comparable attention to these two subfields.

The first chapter provides an introduction to the basic physics of OLEDs and surveys the various topics and challenges in this field. It includes a description of the basic optical and transport processes, the materials used in some of the OLEDs that have studied extensively to date, the performance of various blue-to-red OLEDs, and a brief outlook.

Chapters 2 through 4 are devoted to small-molecular OLEDs. Chapter 2 focuses on design concepts for molecular materials yielding high performance small molecular OLEDs, including the recent developments in electrophosphorescent devices. Chapter 3 focuses on the degradation processes affecting Alq_3 , which is arguably the small molecular device material that has been studied in more detail than any other. Chapter 4 is devoted to organic microcavity light emitting diodes, providing a review of the geometrical effects of the OLED geometry on its performance.

Chapters 5 through 9 are devoted to various PLEDs. Chapter 5 provides an extensive review of devices based poly(*p*-phenylene vinylene), which has been studied more than any other light-emitting polymer. Chapter 6 is devoted to the dominant effects of polymer morphology on device performance. Chapter 7 is devoted to studies of the transient EL in PPV-based PLEDs, which exhibit EL spikes and have provided considerable insight into details of carrier dynamics in these devices. Chapter 8 reviews the extensive work on EL of polyparaphenylenes (PPPs), which in 1993 were the first reported blue-light emitting polymers. Although other blue-light emitting polymers have been developed since then, notably polyfluorenes and phenyl-substituted polyacetylenes, PPPs were studied extensively and provided extensive insight into light-emitting polymers in general and blue emitters in particular. Chapter 9 reviews direct and alternating current light-emitting devices based on pyridine-containing conjugated polymers. In particular, it describes the symmetrically-configured AC light-emitters (SCALE) devices and discusses their potential. Finally, Chapter 10 focuses on polyfluorene-based PLEDs which de-

veloped during the past six years and are perhaps the most promising blue devices, and consequently provide a basis for full-color PLED-based displays.

In spite of the fast pace of developments on OLEDs, it is hoped that the topics provided in this volume will be valuable as tutorials for the beginning researcher and as a desktop reference for the advanced researcher for some time to come.

Joseph Shinar

Ames, IA, February, 2003

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