OPTOELECTRONIC DEVICES AND PROPERTIES

Edited by **Oleg Sergiyenko**

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Preface

Optoelectronic devices impact many areas of society, from simple household appliances and multimedia systems to communications, computing, spatial scanning, optical monitoring, 3D measurements and medical instruments. This is the most complete book about optoelectromechanic systems and semiconductor optoelectronic devices; it provides an accessible, well-organized overview of optoelectronic devices and properties that emphasizes basic principles. Coverage combines an optional review from key concepts such as properties of compound semiconductors, semiconductor statistics, carrier transport properties, optical processes, etc., up to gradual progress through more advanced topics. This book includes the recent developments in the field, emphasizes fundamental concepts and analytical techniques, rather than a comprehensive coverage of different devices, so readers can apply them to all current, and even future, devices.

In this book are introduced novel materials and physico-chemical phenomena useful for new tasks solution. It discusses important properties for different types of application, such as analog or digital links, the formation and analysis of optical waveguides; channel waveguide components; guided wave interactions; electrooptical effects; time dependence, bandwidth and electrical circuits.

Given the demand for ever more compact and powerful systems, there is growing interest in the development of nanoscale devices that could enable new functions and greatly enhanced performance. Semiconductor nanowires are emerging as a powerful class of materials that, through controlled growth and organization, are opening up substantial opportunities for novel photonic and electronic nanodevices.

Also progress in the area of nanowires growth is reviewed, as well as the fundamental electronic and optoelectronic properties of semiconductor nanowires and nanowire heterostructures, as well as strategies for and emerging results demonstrating their promise for nanoscale device arrays. Nanowires made could be ideal building blocks for making nano-optoelectronic devices; the nanowires sometimes show periodic defect structures along their lengths, which may be crucial for determining the optical properties of the material, so nanostructures may lead to further novel properties and promising applications such as point defects and stacking faults.

A significant part of optoelectronic methods are contributed in various geometric measurements like rangefinders, various 2D and 3D vision systems, with several applications in robot navigation, structural health monitoring, medical and body scanners.

Optoelectronic measurements are still among of the most attractive tools in a both spatial and frequency domains.

Independently a review of a wide range of optical fiber communication and optoelectronic systems is presented. In such networks, the electrical and the optical characteristics of guided-wave devices have a profound effect on the system design and overall performance. This book generally combines both the optical and electrical behavior of optoelectronic devices so that the interwoven properties, including interconnections to external components. It also shows the impact of material properties on various optoelectronic devices, and emphasizes the importance of time-dependent interactions between electrical and optical signals. It provides the key concepts and analytical techniques that readers can apply to current and future devices.

This is an ideal reference for graduate students and researchers in electrical engineering and applied physics departments, as well as practitioners in the optoelectronics industry.

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Part 1

New Materials in Optoelectronics

1

Organic-Organic Semiconductor Interfaces for Molecular Electronic Devices

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1. Introduction

Molecular (Plastic) electronics encompasses the materials science, chemistry and physics of molecular electronic materials and the application of such materials to displays, lighting, flexible thin film electronics, solar energy conversion and sensors. The field is a growth area, nationally and globally, evidenced by the rapidly expanding organic display and printed electronics industries. Organic semiconductors combine the semiconductor properties traditionally associated with inorganic materials with the more desirable properties of plastics. Moreover, the organic syntheses of these materials allow for great flexibility in the tuning of their electronic and optical properties. By combining these properties, organic semiconductors such as conjugated polymers have been demonstrated as the active material in light-emitting diodes (LEDs), transistors, and photovoltaic (PV) cells. Furthermore, these conjugated polymers provide a new way of looking at many of the broad fundamental scientific issues related to using molecules for electronics. A great deal of the physics which governs the behaviour of molecules for electronics occurs at the organic-organic interfaces (heterojunctions). For example, the nature of organic interfaces determines the fate of excitons to be either stabilised (for efficient LEDs) or destabilised (for efficient PV cells) at the interfaces. Therefore, by selecting semiconductors with proper band-edge offsets between their conduction and valence bands, different device characteristics can be readily achieved. While significant progress has been made in developing the materials and high performance organic devices, many fundamental aspects of organic-organic semiconductor interfaces remain to be understood. In particular, fundamental understanding of the correlation between nanostructures and interfaces of organic semiconductors in thin films and multilayers and associated device performance still remain to be fully explored. In this Chapter, we will introduce how to control and characterise various length-scale organic-organic interfaces facilitating the rational design of materials, device architectures and fabrication methods via increased understanding of fundamental properties of organic-organic interfaces and their modification due to processing. In particular, we will address the distinctive optoelectronic and charge transport properties which have been observed across different organic-organic interfaces depending on their length-scale (micron-scale in the blends down to molecular-scale in the copolymers) and nature (interchain vs intrachain), providing the deeper understanding of organic interfaces and their vital roles in various optoelectronic devices. The key advances in organic semiconductor interfaces achieved so