Preface

The last 20 years have seen the rise of three-dimensional quantum-confined nanostructures, so-called quantum dots, and the birth of entirely new device architectures based on them. These structures may be fabricated by top-down methods, such as lithographic techniques, or by self-assembly, as in the formation of epitaxial quantum dots or chemical synthesis of colloidal dots. There are significant efforts to control the size, shape, and distribution of quantum dots, to characterize their optical and electronic properties, and to find their technological applications. The research on quantum dots has a strong impact in terms of both physics and devices. The future development of this field largely depends on how quantum dots can be used as nanomaterials in real-world applications. This book aims to convey the current status of quantum dot devices and how these devices take advantage of quantum features.

Quantum dot lasers have been extensively investigated and many advanced characteristics due to quantum confinement have been demonstrated. Therefore, a significant part of the chapter contributions deals with lasers. Chapter 1 covers optically injected single-mode quantum dot lasers. Chapters 2–4 focus on mode-locked lasers. Chapter 2 reviews two exotic behaviors, dark pulses mode-locking and wavelength bistability, both leading to unexpected and exciting performance characteristics. Chapter 3 analyzes the spectral splitting effects in the ground state and their influence on the performance of quantum dot mode-locked lasers. Chapter 4 reports on characteristics of passively mode-locked lasers based on quantum dots and their manipulation via external optical injection. Chapter 5 continues the focus on quantum dot lasers but emphasizes the catastrophic optical damage in high power applications.

The post-growth intermixing effect was studied in Chap. 6, not only for its impact on high power lasers but also on broadband devices such as quantum dot superluminescent diodes and amplifiers. Both Chaps. 7 and 8 cover quantum-dot applications in photonic crystals. Chapter 7 starts with the basics of photonic crystal cavities and continuous wave lasing in quantum dot nanobeam cavities, followed by a discussion on the dynamics of low-threshold quantum dot photonic crystal lasers and an introduction to electrical pumping of photonic crystal and nanobeam devices. Chapter 8 reports on submonolayer quantum dot photonic-crystal light-emitting diodes for fiber optic applications.

Progress toward all optical signal processing is discussed in Chaps. 9–12. Chapter 9 presents a theoretical study of a quantum optical transistor with a single quantum dot in a photonic crystal nanocavity and a quantum memory for light with a quantum dot embedded in a nanomechanical resonator. Chapter 10 investigates in detail all optical quantum dot switches using a vertical cavity approach and demonstrates that quantum dots are promising candidates for next generation photonic devices needed for power efficient optical networks. Chapter 11 describes experimental studies of ultrafast carrier dynamics and all-optical switching in semiconductor quantum dots using ultrafast terahertz techniques. Chapter 12 offers an extensive overview of nonlinear optics and saturation behavior of quantum dot samples under continuous wave driving.

Quantum dot photovoltaic applications are the subject of Chaps. 13 and 14. Chapter 13 theoretically and experimentally demonstrates that quantum dots with engineered built-in charge can significantly enhance the device performances of solar cells and infrared photodetectors. Chapter 14 studies the performance of semiconductor quantum dot-sensitized solar cells employing nanostructured photoanodes with different morphologies.

Chapter 15 highlights a plethora of optoelectronic applications of colloidal quantum dots, including not only photoluminescent devices, light-emitting diodes, displays, photodetectors, and solar cells but also other novel device concepts such as biomolecule-based molecular sensors.

Last but not least, the editor wishes to thank all the authors for their excellent contributions. It took longer than planned to finalize the book because of the editor's move from the United States to China to accept a professorship in the national 1,000-talents program, and I am grateful to the chapter authors for their patience and understanding.

Chengdu, February 2012 Zhiming M. Wang

Springer

http://www.springer.com/978-1-4614-3569-3

Quantum Dot Devices
Wang, Z.M. (Ed.)
2012, XIII, 370 p. 242 illus., 146 illus. in color.,
Hardcover
ISBN: 978-1-4614-3569-3