Preface

Over the last two decades, significant progress has been made in the growth, doping and processing technologies of III-nitride based semiconductors which paved the way for high brightness light emitting diodes (LEDs). LEDs have already penetrated traffic signals, signage lighting, and automotive applications. However, its ultimate goal is to replace traditional lamps, such as incandescent and fluorescent varieties fuelled by the fact that LED lighting substantially reduces energy consumption and thus the carbon footprint. Despite breathtaking advances in LED technologies (e.g., growth, doping and processing technologies), there remain critical issues for further improvement for the realization of LED lighting. Considering that there are already several books dealing with known and basic issues in III-nitride-based optoelectronic devices including LEDs and laser diodes, this book aims to provide the readers with contemporary LED issues which have not been comprehensively discussed and on which the performance of LEDs is critically dependent. For example, most importantly, there must be a breakthrough in the growth of high-quality nitride semiconductor epitaxial layers with low dislocation density, in particular, for Al-rich and In-rich varieties. The materials quality is directly dependent on the substrates used, such as sapphire, Si, etc. In addition, the loss in efficiency at high injection levels, growth on different orientations (giving rise to polar, semi-polar and non-polar material), and polarization are also important. Chip processing and packaging technologies are key issues as well.

Chapter 1 chronicles the low-temperature-deposited buffer layers and the impact they had on nitride research and the subsequent development of devices. Chapter 2 deals with a perspective on the future of LED efficiency. Chapter 3 reviews the development of GaN epitaxial growth on Si using different methods and nitride LED performance on Si. Chapter 4 presents the properties and the fabrication processes associated with patterned sapphire substrate (PSS) and applications of this technology to growth of non-polar and semi-polar GaN layers. Chapter 5 provides an overview of epitaxial growth and optical properties of IIInitride LEDs on non- and semi-polar orientations. Chapter 6 presents different techniques utilized to assess the internal quantum efficiency (IQE) in LEDs. Chapter 7 reviews the IQE loss mechanisms. Chapter 8 describes electrical properties, reliability, and electro-static

discharge robustness of InGaN-based LEDs. Chapter 9 treats simulations of light extraction efficiency (LEE) as a function of the major materials parameters and geometries in the mainstream LED structures. Chapter 10 deals with fabrication methodologies for high efficiency LEDs for relatively high LEE. Chapter 11 provides an overview of phosphors and LED packaging configurations for while light emission. Chapter 12 discusses the optoelectrical characteristics, various designs, and developments of high voltage and alternating current (AC) LEDs. Chapter 13 gives an overview of the fundamentals of chromaticity and color rendering, the two important aspects of color quality for general lighting. Chapter 14 describes possible future system level applications of LEDs from the viewpoint of emerging trends in lighting related to human health, communication, and display technologies.

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http://www.springer.com/978-94-007-5862-9

III-Nitride Based Light Emitting Diodes and Applications
Seong, T.-Y.; Han, J.; Amano, H.; Morkoç, H. (Eds.)
2013, XIII, 390 p., Hardcover
ISBN: 978-94-007-5862-9