Introduction

Is the revolution running in lighting? Indeed, the lighting domain is facing a unique technology breakthrough with the emergence of new kinds of devices and luminaries based on semiconductor chips, so-called Light-Emitting Diodes or LEDs. In the beginning, the low power and fluxes of LEDs impeded them from being used for lighting and kept them confined to indicator applications. However, the invention of the blue LED in the middle of the 1980s gave access to white light combining red, green and blue LEDs or by means of partial photoconversion of blue light to yellow light using phosphors. White LEDs in their turn have made ?electronic lighting? accessible, opening new business opportunities to companies. Consequently, labs and companies have focused their efforts on increasing LED efficiencies and fluxes. All these efforts have already led to significant results.

LED-based lighting is a recent phenomenon, but LED deployment in this field of application now seems inevitable. The LEDs have become a credible alternative to incandescent lamps, soon to be banned because of their energy inefficiency. The multiple benefits of LEDs and the continuous increase in their performance allied to the decrease of their manufacturing costs are likely to make them competitive when compared to fluorescent lamps and tubes. Will 2009 mark the true take-off of LED lighting? We do not know yet, but in any case High Brightness white LEDs have become a reality and it is the objective of this book to give to its readers a wide scientific and technological overview of what they are, including all LED manufacturing steps, aspects related to their photoelectric characterization up to characteristics of the light they produce. It also opens up opportunities in organic LEDs.

Chapter 1 starts with a quick history of LEDs, then positions them within the lighting problematic, before setting out issues and challenges still facing High Brightness LEDs. We can consider this chapter to constitute the actual introduction to this book.

The next four chapters describe the successive LED manufacturing steps.

First, Chapter 2 presents the gallium nitride (GaN) material, the semiconductor on which any blue LED is achieved and the problems bound to its epitaxy on so-called "hetero-substrates". Basic techniques of metallo-organic vapor phase epitaxy are presented and finally some results on bulk GaN crystal growth are given.

Chapter 3 is devoted to the junction itself. After a short history of the discovery of blue LEDs, the authors focus on the achievement of the p-n junction in the GaN semiconductor and then on quantum wells inserted into the p-n junction as a way to increase the LED efficiency. Next, they discuss diode optical properties and radiation efficiency before commenting on possible future developments.

Chapter 4 focuses on processing of diode heterostructure wafers to achieve a high efficiency LED. Different LED structures are described and the evolutions of LED design are presented with their advantages and drawbacks. Then, the successive technological processing steps are discussed.

Chapter 5 deals with LED chip packaging. It presents a quick historical review from the first LED devices to today's products. Then, problems specifically bound to High Brightness LEDs and related to thermal management are discussed. It then addresses primary optics issues with light extraction and related materials. Finally, the different characteristics given in the LED technical data sheet are discussed.

Chapter 6 is devoted to LED characterization. It begins by focusing on its photometric aspects, i.e. on their luminous behavior, and then looks at their electrical and thermal characterization.

Lighting by LEDs, however, requires the LEDs to reach a certain level of light quality: this is the subject of Chapter 7. It outlines the fundamentals of white light, before addressing the various ways to produce white light from

LEDs. Finally, the author presents and discusses some recent works on the estimation of the quality of light coming from LED-based sources from a lighting point of view.

Finally, if the very concept of LED is the result of the invention of blue LED on gallium nitride, which now holds pride of place, the emergence of OLEDs, or Organic Light-Emitting Diodes, must be taken into account now. Chapter 8 discusses the technology originally developed for display, considering here its application to lighting. We hope that, by presenting this comprehensive overview, this book will meet the expectations of engineers, teachers and students concerned with the technology that aids breakthroughs and opens up possible sources of innovation in an area, lighting, which until a few years ago we imagined would have technical relative stability.

I would like to express my extreme thanks to the authors for their great contributions to this book.

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