52. IWK

Internationales Wissenschaftliches Kolloquium
International Scientific Colloquium

PROCCEDINGS | **10 - 13 September 2007**

FACULTY OF COMPUTER SCIENCE AND AUTOMATION

COMPUTER SCIENCE MEETS AUTOMATION

VOLUME II

Session 6 - Environmental Systems: Management and Optimisation

Session 7 - New Methods and Technologies for Medicine and Biology

Session 8 - Embedded System Design and Application

Session 9 - Image Processing, Image Analysis and Computer Vision

Session 10 - Mobile Communications

Session 11 - Education in Computer Science and Automation

TECHNISCHE UNIVERSITÄT
ILMENAU

Bibliografische Information der Deutschen Bibliothek
Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbiografie; detaillierte bibliografische Daten sind im Internet über **http://dnb.ddb.de** abrufbar.

ISBN 978-3-939473-17-6

Impressum

Herausgeber:	Der Rektor der Technischen Universität Ilmenau Univ.-Prof. Dr. rer. nat. habil. Peter Scharff
Redaktion:	Referat Marketing und Studentische Angelegenheiten Kongressorganisation Andrea Schneider Tel.: +49 3677 69-2520 Fax: +49 3677 69-1743 e-mail: kongressorganisation@tu-ilmenau.de
Redaktionsschluss:	Juli 2007
Verlag:	Technische Universität Ilmenau/Universitätsbibliothek Universitätsverlag Ilmenau Postfach 10 05 65 98684 Ilmenau www.tu-ilmenau.de/universitaetsverlag
Herstellung und Auslieferung:	Verlagshaus Monsenstein und Vannerdat OHG Am Hawerkamp 31 48155 Münster www.mv-verlag.de
Layout Cover:	www.cey-x.de
Bezugsmöglichkeiten:	Universitätsbibliothek der TU Ilmenau Tel.: +49 3677 69-4615 Fax: +49 3677 69-4602

Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52nd International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.
I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.

Professor Peter Scharff
Rector, TU Ilmenau

Professor Christoph Ament
Head of Organisation

Table of Contents

C O N T E N T S

Page

6 Environmental Systems: Management and Optimisation

7 New Methods and Technologies for Medicine and Biology

8 Embedded System Design and Application

9 Image Processing, Image Analysis and Computer Vision

10 Mobile Communications

11 Education in Computer Science and Automation

R. Burdick / T. Lorenz / K. Bobey

Characteristics of High Power LEDs and one example application in white-light-interferometry

ABSTRACT

Even with binned LEDs there is a strong spread of characteristics. Therefore the selection, seasoning or homogenization of LEDs are important tasks to be solved in measurement applications. Characteristics of LEDs like uniformity and long-term stability for LED measurement applications are discussed in this paper. Furthermore their use in the measurement process, in particular the influences of some LED characteristics on a white-light-interferometer (WLI) line scan sensor are discussed.

INTRODUCTION

LEDs have found their application in general lighting and illumination applications today. Examples are LED spot lights for surgery or LED headlamps in the automotive environment, where they were employed for the first time during the past two years. This strongly drives the development of white and warm white high power LEDs. At the beginning of this year Osram announced that for the first time in the Migros supermarket in Eschenbach (Switzerland), LEDs are used not only for extraordinary effects but also to provide basic lighting. Considering the characteristics and working conditions of this type of LEDs they are very well suited for the use in measurement devices like a WLI. Devices with high luminous efficiency are for example the Seoul Semiconductor P4 and the Cree XLamp-XR LEDs with approx. 70 - 80 lm/W. Depending on the heat sink these single emitter LEDs allowed an absolute maximum electrical power dissipation of 4 W. A long term stable LED Light source, developed by the authors, enabled - together with image-taking colorimeters - quick and reproducible measurements of LED lamp distributions [1].

LED CHARACTERISTICS

LEDs are solid state light sources whose lighting characteristics are completely different from those of conventional incandescent lamps. The tungsten filament of an incandescent lamp used in projection systems is usually precisely positioned at the stage of gluing the glass bulb into its socket. This, however, is not possible with LEDs, where a misalignment of the LED-dye in its plastic encapsulation can lead to non-axial symmetric radiation patterns, as can be seen in Fig. 1 for the example of a T-1¾ housing.

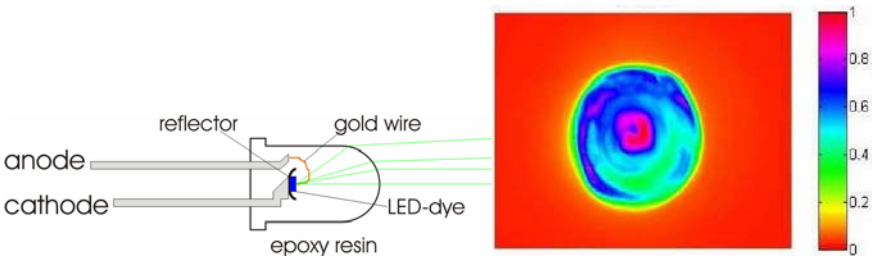

Figure 1: T-1¾ LED housing and a typical radiation pattern.

The spectral distribution and the intensity are temperature-dependent, with the intensity being subject to degradation processes. P-n heterojunctions are commonly employed in LEDs where the carriers are confined by the heterojunction barriers. This increases the carrier concentration, because the active region is by orders of magnitude smaller than the diffusion length. Therefore the radiative recombination rate increases and leads to devices with high external efficiencies as can be seen in Fig. 2.

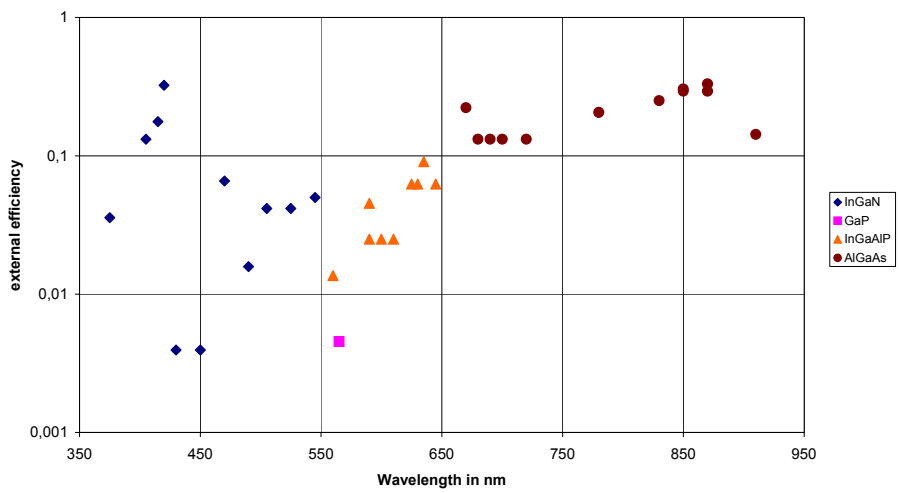

Figure 2: External efficiencies of different III-V-LED materials from Epitex Inc.

Unfortunately some problems can arise with heterostructures. One of them is the heating of the active region caused by heterostructure resistance of the abrupt heterointerface, especially in high-power devices. This can be avoided by a complex grading process. Another problem is the carrier loss beyond the active region, called carrier leakage effect. The energy distribution of carriers is given by the Fermi-Dirac distribution. Thus, the fraction of carriers residing in the active region which have a higher energy than the energy of the barrier is temperature-dependent. With increasing temperature the exponentially temperature-dependent carrier leakage effect leads to a decreasing internal efficiency. With large-band gap materials like InGaN this effect is minor, so that these LEDs can be used at higher temperatures. The emission spectrum of LEDs is also temperature dependent. With increasing temperature the peak wavelength decreases for InGaN-LEDs while it increases for GaAlInP-LEDs.

The generation of white light with LEDs can be achieved in three different ways. The light from three LEDs with the colors red, green and blue mixed in a given fraction of intensity is perceived as white. This is also possible with one UV-LED and three phosphors. The most common way to generate white light is to combine one blue LED with one $Y_3Al_5O_{12}$ (yttrium aluminium garnet or YAG) phosphor of the complementary wavelength or more phosphors as can be seen in the spectral distribution in fig. 3.

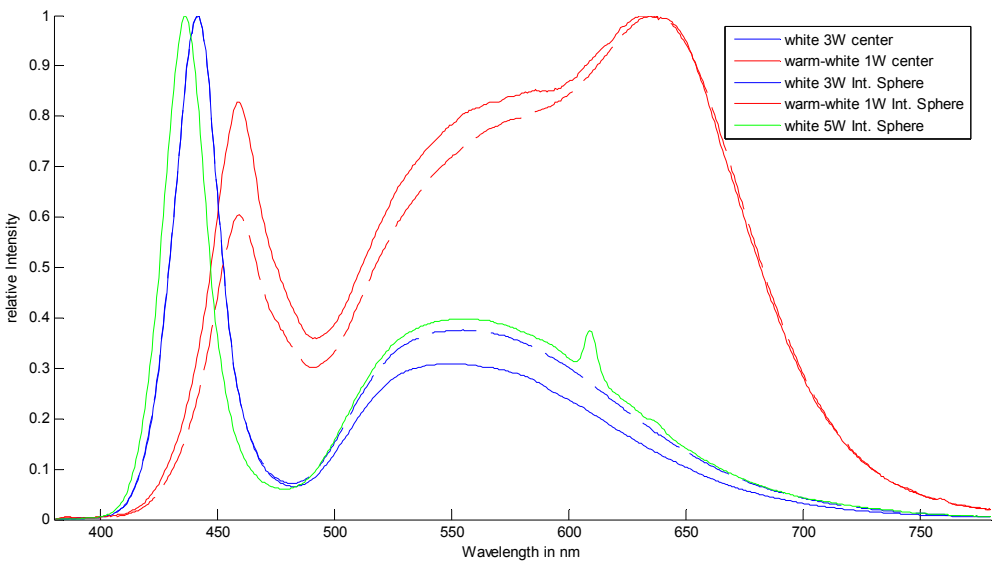

Figure 3: Spectral distribution of various luxeon star LEDs in the center axis and averaged with an integrating sphere.

Presently, the blue LED chip with a yellow phosphor provides the highest luminous

efficacy. However, the ability to render all the colors of an illuminated object is poor. The radiation pattern of phosphor is, depending on the deposition process, nearly a lambertian distribution while the blue LED has a distribution under a small angle, which leads to more or less spatial color changes (see fig. 3).

Generally, the life time of mature technology LEDs like GaAlInP is very long, lying around some ten thousand hours. The ageing of an LED describes the loss of intensity over the whole operation time, as can be seen in fig. 4. The lifetime is usually defined as a loss of rated luminous flux of 30 % or 50 %. The measurement conditions for lifetime estimation have not been standardized yet. To understand the mechanisms behind ageing it is helpful to differentiate between internal and optical efficiency. The ageing of the optical efficiency is a function of ambient conditions such as moisture and mechanical stress. The ageing of the internal efficiency is at least a two-step mechanism.

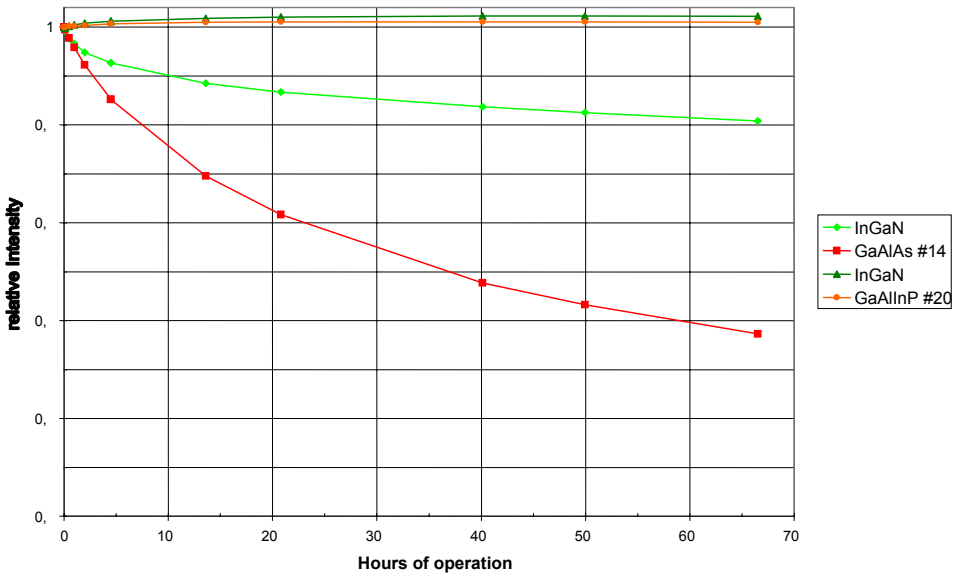

Figure 4: Ageing of different LED materials.

During the first hours of operation, an increase in intensity can sometimes be observed. This behavior depends on the forward current. For GaAlInP-compounds it might be related to a reduced carrier leakage[2]. For InGaN-compounds, a connection with the activation of magnesium acceptors due to the destruction of residual Mg-H complexes has been found [3]. After this initial process, the long-term behavior leads to a continuous decrease in the intensity, which slows down over time. The degradation is a function of the temperature and of the forward current in the active region, mainly caused by an increasing rate of nonradiative recombinations and carrier leakage effects.

As shown in a publication by OSRAM [4] for GaAlInP-compounds, the degradation is also color dependent.

WLI application

WLI is a key technology for highly accurate inspection of nearly any kind of surfaces regardless of their textures. This means that smooth as well as rough surfaces are accessible to WLI. A white-light-interferometer mainly based on a Michelson arrangement uses a short coherent light source and thus, interference fringes can only be observed if the optical path difference between the two arms is less than the coherence length.

Replacing one mirror by the object and scanning its surface in depth i.e. by moving the reference mirror along the optical axis leads to a cosinusoidal intensity modulation weighted by the fringe visibility function at each point in the image plane [5]. The scan position at which the fringe visibility has its maximum yields the height of the corresponding point on the surface. Therefore, the main task to obtain height information is to find the maximum value of the envelope and its location with respect to the scanning axis for each interference pattern. As the coherence length depends on the spectral bandwidth, the use of a broad bandwidth illumination which results in a narrow envelope is necessary for high resolution measurement of surface heights. Furthermore, the shape of the envelope which is obtained from the spectral distribution by means of a Fourier transform should come close to a Gaussian distribution which can be easily fitted and hence simplifies the detection process. To archive these recommendations with a white High Power LED the blue peak in the spectral distribution of the LED must be suppressed. Otherwise, the superposition of two interference patterns one formed by the blue spectral range and the other one formed by the remaining spectral range give rise to a slightly distorted fringe pattern which lets increase uncertainty in finding the peak of the envelope (see Fig.5 (a)).

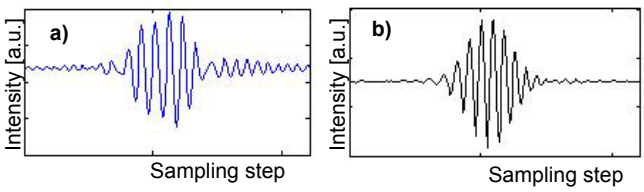

Figure 5: White-light interference pattern formed by a white High Power LED without (a) and after suppression of the blue peak by use of a yellow 475nm longpass-filter (b)

As shown in Fig.5 (b), the suppression of the blue peak by use of a yellow 475nm long-pass filter results in a symmetrical interference pattern with an envelope close to a Gaussian distribution. Another advantage of filtering out the blue peak is an improved spatial homogenous spectral distribution. Otherwise, it can be observed that more blue light is residing close to the optical axis than at the edge of the field of view. As a result, the center wavelength which forms the white-light interference pattern differs slightly in dependence of the location within the field of view. This can cause problems in WLI when measuring smooth surfaces and using phase information in conjunction with coherence information to increase the resolution.

As a conclusion one can say that with a simple filter technique spectral distribution can be improved to make white High Power LEDs capable in WLI. A white Seoul Semiconductor P4 is actually in use in a demonstrator of a line-profiling white-light interferometer developed at HAWK in cooperation with Mahr inc. Alternatively, a warm white P4 will be tested soon promising a larger amount of optical power in the long wavelength range due to further suppression of the blue peak.

References:

[1] Burdick R, Krüger U, Schmidt F, Schanda J. Properties and Applications of Stable LED Light Sources in Automotive Measurement. International Symposium on Automotive Lighting, (2007)

[2] Alteri P, Jaeger A,Windisch R, Lindner N,Stauss P, Oberschmid R, Streubel K. Internal quantum efficiency of high-brightness AlGaInP light-emitting devices. Jornal of Applied Physics 98, 086101 (2005)

[3] Manyakhin F, Kovalev A, Yunovich A.E. Aging Mechanisms of InGaN/AlGaN/GaN Light-Emitting Diodes Operating at High Currents. MIJ-NSR Volume 3, Article 53. 1998

[4] Alteri P, Jaeger A,Windisch R, Lindner N,Stauss P, Oberschmid R, Streubel K. Color-dependent degradation of high-brightness AlGaInP LEDs, SPIE 5349-416, 2004

[5] Hariharan P. Optical Interferomety. Elsevier Academic Press, 2nd edition, 2003

Authors:

MSc. Robert Burdick
Dipl.-Ing. Timo Lorenz
Prof. Dr.-Ing. Klaus Bobey
HAWK FH HHG, Von-Ossietzky-Str. 99
37085, Göttingen
Phone: (49)551-3705238
Fax: (49)551-3705101
E-mail: burdick@hawk-hhg.de