Simulation of Electric and Optical Properties of LEDs

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Recent improvements of efficiencies of ultrabright Light Emitting Diodes (LEDs) offers opportunities for their applications in many fields of lighting and displays. Unfortunately the emission properties of LEDs are strongly influenced by driving conditions. Aside saturation at high currents and thermal quenching of the light output, their emission spectra are affected by temperature increase of the junction, due to power dissipation and electric fields effect in the space charge region. This may give rise to problems, especially, if a set of LEDs with different emission colors are used to create defined color points. In this paper first results simulating these effects are presented.

A computer program was developed to simulate the colorimetric properties (chromaticities and color rendering) of a set of LEDs. The emission spectra can either simulate by superimposing a set of proper functions (e.g. Gaussian -type) and amplitude A, maximum wavelength λ_{max}, and half width $\Delta\lambda_{1/2}$ can be varied. The variation of A, λ_{max}, and $\Delta\lambda_{1/2}$ as as function of temperature and drive current will be performed according to simple one parameter relations, which are deduced from experimental results (e.g. Figures 1 & 2). In addition actual measured emission spectra of LEDs are importable, too. Combination of LED and phosphors can also be simulated (see Fig. 3).

The final aim of this work is, to simulate the colorimetric properties of LEDs only by a simple set of input parameters revealing physical properties of materials and device structures. Therefore investigation of the electric behavior of LEDs have been started. The underlying idea is, to measure the current-voltage characteristic at very low currents, where the junction temperature equals the ambient temperature and describe these by simple pn-junction models. Temperature effects due to power dissipation can be included to describe the J-V curve in the high current region relevant for application.

The results of these simulation will be compared with experimental results obtained for LEDs measured in a set up comparable to the calibration lamp as discussed in Ref. [1].

Reference

[1] T. Welker, Joint International Meeting of The Electrochemical Society and The Electrochemical Society Japan, Honolulu, Hawaii, USA, October 1999

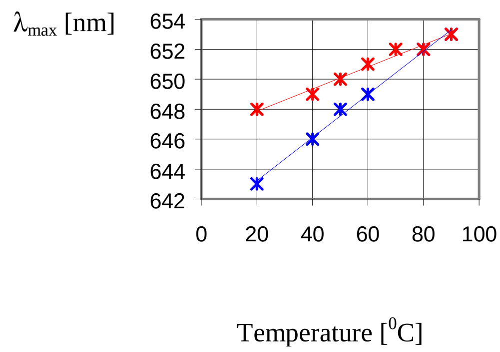

Fig. 1: Maximum wavelength as a function of temperature measured on two red emitting LEDs

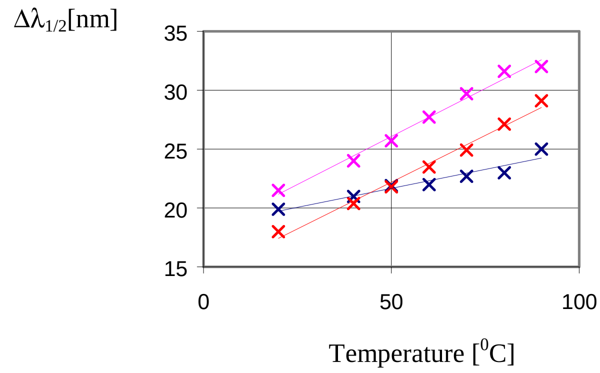

Fig. 2: Half width of the emission band as a function of temperature measured on three red and yellow emitting LEDs

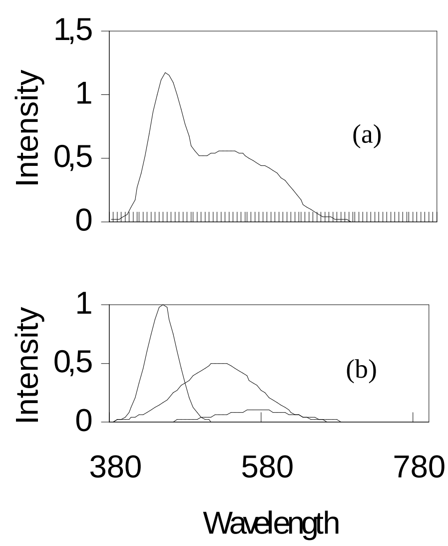

Fig. 3: (a) Emission of a LED-phosphor combination synthesized from (b) three Gaussian-distributions