SPECTRORADIOMETRIC MEASUREMENT OF PULSED HIGH-POWER LEDS

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Over the past years the demand for LED measurement equipment has experienced a powerful growth. Especially high-power LEDs play a major and increasing role in many key applications in the field of automotive and general lighting. The requirements for reliable measurements of photometric and colorimetric quantities of such devices lead to substantial difficulties arising from the thermal properties of the LEDs: Since the heat dissipation of high-power LEDs is concentrated at a very small area given by the size of the LED die, it only takes microseconds for the drive current to increase the junction temperature. The forward voltage, however, directly depends on the junction temperature and therefore also the readings for luminous flux and chromaticity coordinates. Typical values for the temperature sensitivity of the forward voltage are in the range of -2…-4 mV / K. It is therefore essential to control the thermal status of the LED junction carefully during the whole measurement. Two approaches are discussed in detail in this presentation.
The device under test (DUT) may be driven at the full operating current which is kept constant for the whole measurement time. Such a steady-state measurement requires a sophisticated thermal management system consisting of cooling devices typically based on Peltier elements. Fig. 1 shows an actively cooled test fixture for high-power LEDs up to 10 W together with an FEM simulation of the internal heat dissipation.

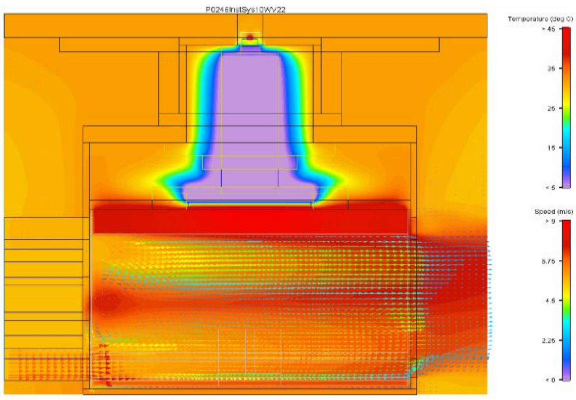

Fig. 1: Test fixture with Peltier based active cooling, FEM simulation of the heat sink

Unfortunately the temperature of the LED junction cannot be directly measured. Depending on the various thermal resistances involved a significant temperature gradient between the LED junction and the heat sink of a test fixture may occur. In order to overcome this general problem, the concept of pulsed LED measurements was developed. Sequences of short current pulses in the 1μs range and duty cycles of about 1 % cause no significant heating of the DUT. This can be demonstrated by monitoring the forward voltage of a DUT for a group of ten measurement sequences as shown in fig. 2.

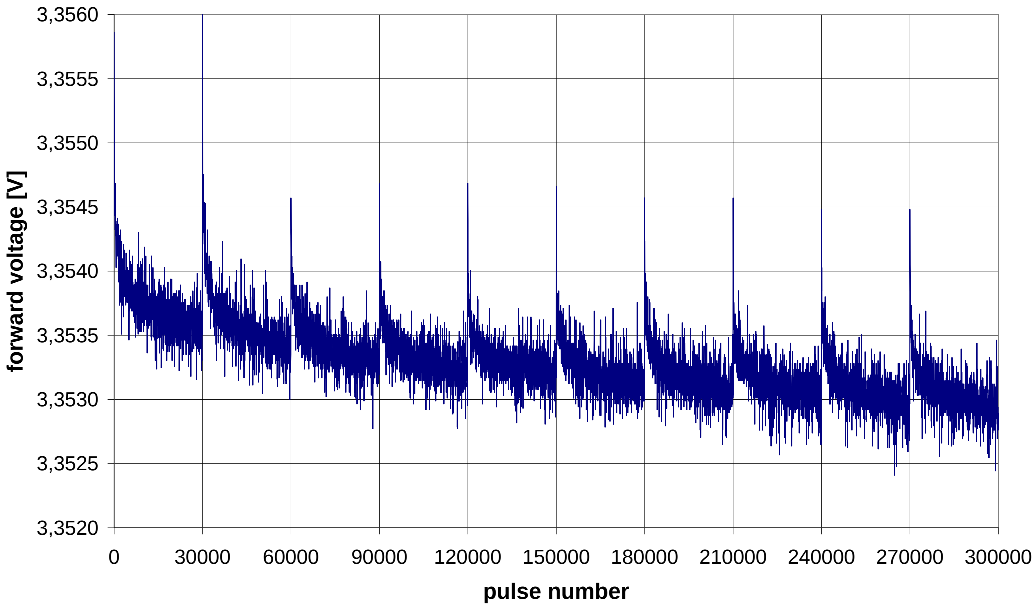

Fig. 2: Forward voltage of a white high-power LED, measured in pulsed mode

Each individual sequence consists of 30.000 single measurements. The variation of the forward voltage within one sequence is typically 2 mV. This causes a higher junction temperature in the range of 1 K. Small enough not to affect the photometric and colorimetric values of the DUTs significantly. Fig. 3 shows the measurements over time for a white high-power LED (1W). All values agree very well within the required specifications.

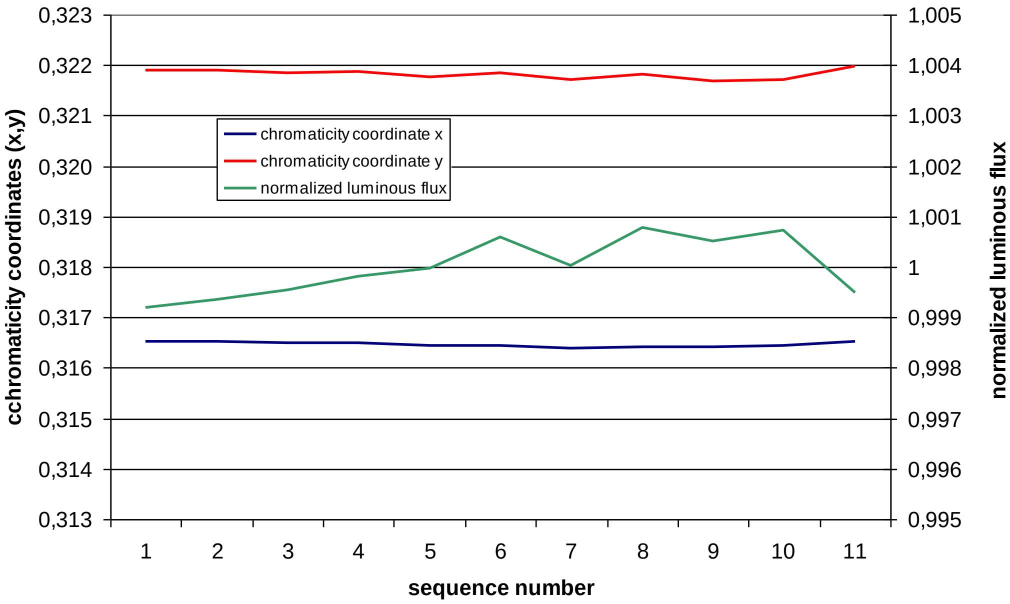

Fig. 3: Luminous flux (normalized) and chromaticity coordinates x,y for a group of 11 pulse trains

For low measurement uncertainty each component of the system has to fulfil certain requirements: Spectroradiometers have turned out to serve as ideal tools to evaluate photometric, radiometric and colorimetric properties of narrow band light sources. The set-up consists of an array spectroradiometer, an integrating sphere (diameter: 500 mm; calibrated to luminous flux) and appropriate test fixtures. The system is completed with customized control software.

For future developments it is conceivable to control both the temperature of the test fixture and the pulsed measurements simultaneously with the same software. This enables a direct correlation of the results from steady-state measurements (i.e. field conditions) with data obtained in pulsed mode where the junction temperature differs from the temperature of the heat sink by small amounts only.