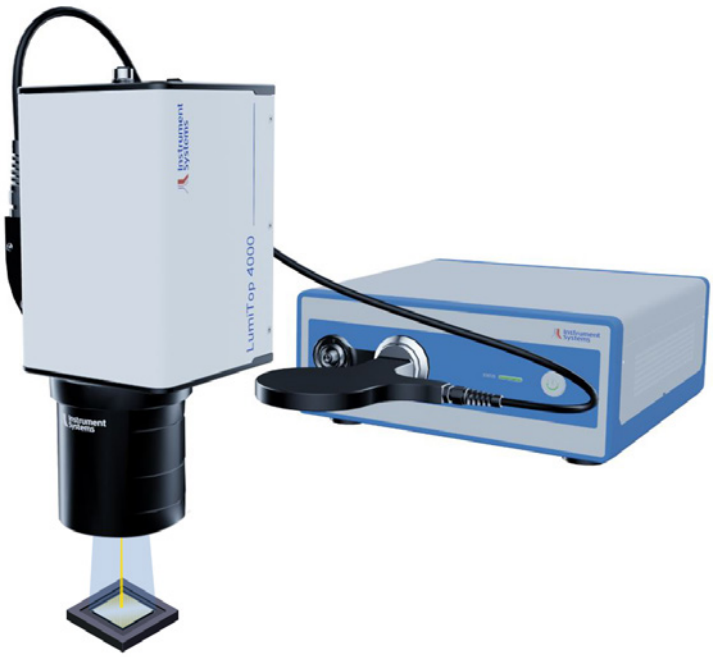
Instrument Systems
KONICA MINOLTA Group

2D measurement of µLED arrays for AFS (automotive adaptive front lighting system)



USE
CASE

\\ 1. DEVICE UNDER TEST: µLED ARRAY FOR CAR HEADLIGHTS

Adaptive front lighting systems (AFS) can dynamically adapt the light output pattern to the environment. An adaptive headlamp masks out other road users detected in the light cone, and prevents them from being dazzled. Recent developments use a µLED array with more than 1000 pixels as a light source that allows a much finer beam control, as each pixel can be individually controlled (Fig. 1). This “digital headlight” also enables projections on the road (Fig. 2).

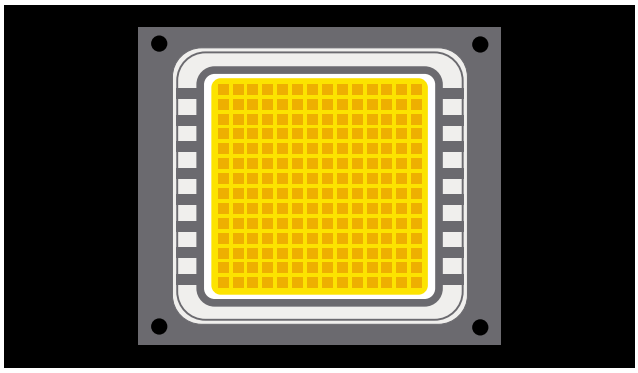


Fig. 1: Schematic µLED array as used for adaptive front lighting systems (AFS).

Fig. 2: Digital light allows projections on the road (Source: Mercedes-Benz).

\\ 2. MEASUREMENT REQUIREMENTS AND CHALLENGES

For quality assurance the overall uniformity, brightness and color of the individual LEDs must be measured, and defects identified.

Challenge 1: Temperature dependence on measurement

The major challenge for high-power LED measurement is LED self-heating when powered on. The resulting heat causes a drop in output and results in a color shift (Fig. 3).

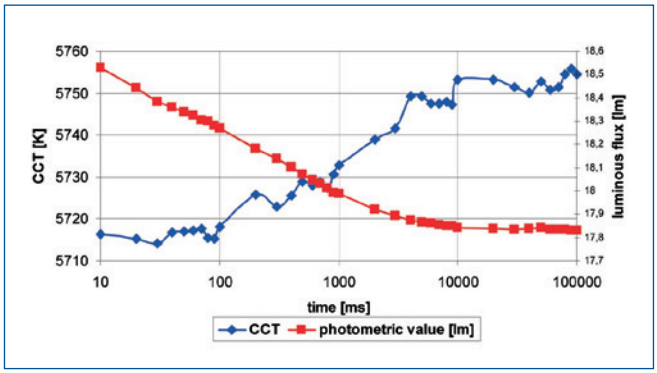


Fig. 3: Exemplary drift of brightness (red) and color temperature (blue) of a white LED after turning on.

This calls for:

- a measurement duration short enough to avoid a larger temperature drift, and
- a measurement process that is synchronized with the power source, so that measurement starts instantaneously after the LED is turned on.

Challenge 2:
High accuracy at high measurement speed

A traditional one-by-one process as used for single LED measurement would be very time-consuming for a µLED matrix with over 1000 LEDs (Method A).
An alternative and much faster solution is the use of a camera-based 2D measurement system that can measure all LEDs simultaneously (Method B).
An advanced system is required to quickly achieve the required accuracy level.

Method	A: One-by-one approach – each LED measured individually	B: 2D approach – LED array measured in one shot
System	Spectrometer and sphere; only one LED is turned on for measurement	Camera-based system; measurement of all LEDs in one shot
Pro	Highly precise measurement of LED power and spectrum	Very fast measurement of LED power and color
Contra	Time consuming	Challenging to achieve high accuracy of camera readings

Table. 1: Measurement methods for LEDs

\\ 3. OUR SOLUTION: LUMITOP – A UNIQUE, SPECTRALLY ENHANCED IMAGING COLORIMETER

LumiTop system for µLED array measurement in AFS application:

- LumiTop 4000 with 12-megapixel camera and a 100 mm lens
- Smallest field of view: 10 x 14 mm
- High accuracy CAS 140D spectrometer
- For measurement in the lab or production in-line testing

Fig. 4: LumiTop 2D measurement system.

The innovative LumiTop system not only combines the benefits of the one-by-one and 2D approach. It also overcomes the temperature challenge when measuring high-power LEDs.

The LumiTop principle

The LumiTop 2D measurement system consists of a LumiTop 4000 combined with a fiber-connected CAS 140D spectrometer (Fig. 4). The innovative LumiTop design with a beam splitter enables the integrated RGB camera and spectrometer to measure at the same time. The extremely accurate spectral information of the spectrometer measurement in the center spot (Fig. 5) is used as a reference for camera measurement, thus improving accuracy across the whole 2D image.

Based on the corrected 2D measurement data, the overall uniformity, brightness and color of individual LEDs can be evaluated, and defects identified (Fig. 6). The system is calibrated to luminance (in cd/m^2) as an optical quantity. That is the standard for measuring the emission of a 2D emitter.

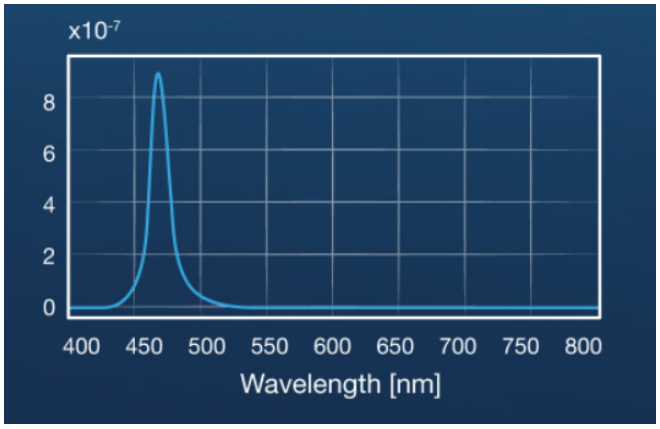


Fig. 5: Spectrometer reference spot spectrum.

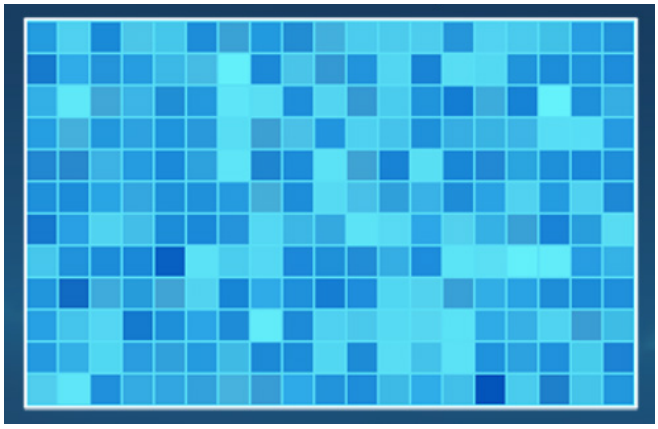


Fig. 6: 2D results: LED Uniformity Map.

Avoid LED heating-up issues

Traditional filter-based 2D camera systems use color filters and require at least three sequential color measurements (red, green and blue filter). Such measurements usually take several seconds while the LED is heating up and its color and intensity are constantly changing. This leads to inaccurate results.

The recommended LumiTop system solves the heating-up problem by measuring all color channels in a single shot. The system uses a RGB camera with Bayer-pattern color filters for 2D measurement. This allows very fast 2D color measurements and enables high measurement speeds (in the millisecond range). This also makes the LumiTop system ideal for in-line production testing. Due to a hardware trigger, the LumiTop can be synchronized with the LED power source, and completes measurement before the LED heats up.

High accuracy

Besides the temperature challenge, the LumiTop system also overcomes the accuracy challenge. To achieve the required accuracy, the system is coupled to a high-precision spectroradiometer that corrects the camera readings to an extraordinary level of precision (Fig. 4). The absolute system calibration of our solution is the key to high accuracy: Instrument Systems is an ISO 17025-accredited testing lab, and the accuracy of each system is verified before shipment.

Due to its design, accuracy, speed and resolution, the LumiTop 4000 with 100 mm lens is perfectly suited to LED array measurement in the lab or production in-line testing for AFS applications.

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