HIGH THROUGHPUT, HIGH PRECISION HOT TESTING TOOL FOR HBLED TESTING

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Objectives

- Develop an advanced hot test tool that will provide the industry with a pathway to one or two MacAdam ellipses of color accuracy
- Throughput of the planned tool will greatly exceed current solutions and will provide lower capital costs to manufacturers
- Provide accurate bins at customer use conditions that will result in improved product yield and reduced rework at luminaire manufacturer
- Benefits both LED chip makers with lower cost binning, as well as luminaire manufactures with higher quality, consistent product
Binning Requirements are Getting Tighter

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NEMA SSL 3-2011
LED Color Coordinates Shift with Temperature and Drive Current

Data from HBLED Manufacturer
Hot Test Concept

- The phosphor in an LED will get hotter than the GaN due to Stokes shift and other losses.
- This temperature distribution will affect the color and luminous flux.
- We have developed a method to emulate the actual steady state temperature distribution in an LED at high speed by using a laser to pre-heat the device.
- A bench tester has been built to test the validity of the concept.
LED Test Bench Concept

- Laser
- Reference Light Source
- Alignment Camera
- Integrating Sphere
- XY Stage 150mm
- Spectrometer
- Temperature Controller
- LED Power Supply
- Pogo Pins
- Manual XY Stage
Lab Setup

Bench with stage, integrating sphere, spectrometer, reference light source, and alignment camera

Bench with control computers, pulsed power supply, and other test and measurement equipment

Dye laser
Phase 1 - Integration of Toshiba TCD1304AP CCD-array detector in the Torus optical bench with microsecond triggering.

Phase 2 - Development of a custom order sorting filter to further reduce stray light.

Phase 3 - Development of stray light correction software and algorithms to provide enhanced color accuracy.

Phase 4 - Integrate alternative detectors with improved signal to noise and dynamic range and microsecond triggering in the Torus optical bench.
Absolute Calibration Standards Developed

- High brightness warm white and cool white LED sources, 100 ~ 200 lumens, turn-key devices with integrated temperature and current controllers
- Expanded absolute uncertainty of total luminous flux: ± 1.3%
- Expanded absolute uncertainty of color coordinates: ± 0.002 (less than 1 MacAdam ellipse)
- Traceable to fundamental SI units through NIST (master standards directly certified by NIST)
- ISO 17025 accreditation planned
Comparison of Thermal Simulations: 1W CW electrical heating vs pulsed laser heating

There is a very close match between the thermal profiles of CW electrical operation and laser heating (purple curve at 8msec)

1 Watt Operation

Laser Heating 35W 1mSec
Experimental Setup For Thermal Measurement of Phosphor LED

- Hot Plate Used for Emissivity Calibration
- Heat Sink
- FLIR
- Phosphor (no dome)
- Ceramic
- Camera reflection
Initial Bench Results

- Data taken on KLA-Tencor bench setup
  - Laser is not yet integrated
  - Data taken with Ocean Optics spectrometer
- Data taken on sample level 1 tile from LED manufacturing partner
KLA-Tencor is working with DOE and partners to develop a better tool for hot test of LEDs

The tool will allow for better color control at actual operating temperature and may also enable better manufacturing process control

We have finished a prototype bench design and are starting to test the technology on actual product