Publishable JRP Summary Report for ENG62 MESaIL Metrology for Efficient and Safe Innovative Lighting

Background

The European 2020 Strategy is pursuing the overall objective of saving 20% of the Union's primary energy consumption by 2020. This is possible when for instance energy efficiency of innovative lighting is enhanced, by improving product quality and assuring longer lifetime.

Initial commercial first generation Solid State Lighting (SSL) products, based on light-emitting diode (LED) technology, suffered from reduced light quality and variable performance. The development of basic metrology for SSL (ENG05 "Metrology for Solid State Lighting") led to considerable improvements towards the reliable measurement of SSL performance.

The gradual maturing of SSL technology has led to a steady improvement in product quality and increased lighting efficiency, but also demands an advanced metrology framework. This project will strengthen the metrological framework for novel SSL, notably organic light-emitting diodes (OLEDs)/OLED arrays and pulsed SSL. This project will make a first step towards meeting metrological needs for nano-structured and flexible LED systems.

Advancement of the metrology framework will be accomplished through: 1) development of missing measurement methods and equipment, 2) delivery of traceability for pulsed SSL and lifetime assessment, 3) quality improvement by developing metrics accounting for health aspects and 4) assuring excellence via collaboration with academic research and create impact via close collaboration with stakeholders (industry, test laboratories and standardisation bodies). This project aims to help speed up the standardisation process related to SSL by providing technical inputs to written standards at International (CIE) and European (CEN) levels.

Need for the project

SSL technology is developing continuously and new types of SSL products frequently appear on the market, notably OLED and flexible LED, phosphor-free LEDs and pulsed LED systems. These products have distinct characteristics, which have to be taken into account in the measurement procedure to avoid measurement errors.

Measurement solutions have to be developed to deal with large area and curved light emitting surfaces (e.g. OLED and flexible SSL). Metrics and validated measurement procedures have to be developed to cover safety and health aspects. To drive novel SSLs new electronic circuits are being developed. Electrical parameters measurement has to keep pace with these developments.

The need for reliable methods for lifetime determination is broadly felt. End-users are not ready to pay for unproven/unlabelled highly priced products. Lifetime is an important factor to be determined accurately, because it does not only govern the long-term quality experience of users but it also underpins economic models for lamp replacement. User confidence may be damaged by faulty lifetime estimates and uptake will suffer.

Since metrology for SSL covers a wide set of parameters; related to optical output, electrical aspects, reliability, perception, and safety, a broad expertise is indispensable. Only through the cooperation of NMIs and academic partners with complementary knowledge and facilities will this project succeed, strengthening the metrological framework for SSL and create the expected impact.

EMRP
European Metrology Research Programme
Programme of EURAMET

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EURAMET

Scientific and technical objectives

The aims of this project are to deliver an advanced metrological framework for novel SSL by providing transfer standards applicable at NMI and test laboratory level, to develop measurement solutions for large area and pulsed SSL, to provide metrics and equipment accounting for safety and comfort aspects of novel SSL, and to assure longer lifetime and provide its traceability.

The technical objectives of this JRP are to:

Objective 1. Develop sets of optical and electrical reference standards to calibrate as well as to characterise the setups used in testing laboratories and to verify their capability to perform particular measurements of novel SSL;

Objective 2. Improve measurement methods and decrease uncertainty in 1) photometrical parameters of OLED measurements, 2) electrical power measurements of AC-operated (developing an impedance stabilisation network) and pulsed SSLs. Study the feasibility of using standard measurement equipment for 3D complex goniometric measurements of large area and complex SSL (3D nano-structured);

Objective 3. Deliver a full set of metrics for safety and comfort aspects of novel SSL through development of full measurement solutions and by performing physiological studies on (a) flicker/stroboscopic effect, (b) blue hazard, (c) well-being/comfort experience and (d) lighting quality perception.

Objective 4. Develop measurement solutions and establish traceability for lifetime and reliability testing of SSL products. Investigate various aging mechanisms involved in material degradation of novel SSL devices.

Expected results and potential impact

This project will deliver an advanced metrological framework for novel SSL. This will enable the reliable measurement of SSL performance in the broadest sense, including basic light output and efficacy, light distribution, light quality, light perception, safety aspects and life-time aspects. A particular emphasis will be on novel SSL technologies, which with the proper metrological support, will become more important in the coming years.

The project has an expected impact across the entire SSL value chain; providing developers, designers, producers, distributors and end-users with the tools they need to improve, predict and specify SSL performance based on reliable measurements.

Europe is an active member of the global lighting market and holds a traditionally strong position. Leading European industrial stakeholders make significant contributions to the gross domestic product of the EU and to the employment levels across Europe. However, competition from outside Europe is growing rapidly. An advanced metrological framework will assure the competitive advantage of European industry and safeguard against unfair competition.

A particular emphasis in the project will be on providing input to standardisation activities. Efficient knowledge transfer to International and European standardisation organisations (CIE, ISO and CEN) is embodied in the project. Several dedicated reports, relevant guidelines and recommendations will be delivered. For instance, a formal reportership to CIE Division 2 will be established to facilitate the dissemination of the results.

For end-users, the improved energy efficiency will help to reduce energy bills and the availability of reliable data on light output, energy consumption, safety/health aspects and lifetime will allow informed and objective decisions.

30 months of joint work have brought the following results and impact, in particular:

Objective 1. ***In relation to optical reference standard:***

According to the strategy documents prepared for the development of the multiple reference standard (MTS), five MTSs have been designed, built and further distributed within the consortium for characterization and optimisation. Based on the feedback from users, the design and software were reviewed and optimised. The optimised MTSs equipped with the specific diffuse fixtures are now being characterised by partners using their facilities. The impact of the MTS's modes (different time dependent light output features) on goniophotometer mismatch was investigated. An LED-based mosaic test standard device for ILMDs was developed with the following features: 1) dynamic variation of the radiance, 2) three colours (RGB), to assess for spectral dependence, 3) size covering the field of view of a typical camera with and objective lens of 50 mm, 4) good reproducibility of the emission.

In total 50 SSL devices were purchased and tested. The artefacts selected from these 50 devices will be used in the comparison in the later stage of the project. The technical protocol of the comparison has already been prepared.

In relation to electrical reference standard:

The electrical multiple reference standard (e-MTS) was designed and all components were purchased. The reference e-MTS is capable of simulating up to 8 different SSL lamps and 1 incandescent lamp. One of the key elements of the reference standard, the transconductance amplifier has already been assembled and tested, and the result is satisfactory.

Objective 2. ***In relation to electrical methods:***

The design of the first prototype of the Impedance Stabilisation Network (ISN) is now complete and has been written into a report. Optimisation was done especially on reducing the power consumption of the ISN. The first-round interlaboratory comparison (ICL) on the electrical parameter measurements of 7 SSL products was organized among three partners and the results were shared and discussed. The final design will be achieved based on this.

In relation to optical methods:

A procedure for reducing uncertainties in measurements of OLEDs using a camera goniometer has been developed. Moreover, measurements of OLEDs with an especially characterised integrating sphere have been completed at one of the partners and results will be compared with the results of the measurement by far-field goniospectrometer at another partner. The main purpose of the measurements is to study the influence of arbitrary geometrical alignment and edge-emission of OLEDs on the measured luminous efficacy, as well as the spectral and spatial corrections needed in the measurements with integrating spheres.

Within feasibility study task, novel 3D nano structure LEDs have been realised and their functionality is demonstrated. The first batch of the devices, the core-shell LEDs have been tested. The emission directionality measurement result shows the 3D nano LEDs are not Lambertian and the directionality is related to the 3D geometry of the microstructures. An adopted processing and packaging was discussed and prepared with respect to the characterization results of the first batch. Two prototypes from the second batch with improved packaging will be investigated regarding operation time and temperature dependence.

Objective 3. ***In relation to photo-biological health concern:***

The measurements of the spectral transmittance of 6 intraocular lenses (IOLs) with the modified blue hazard lighting (BHL) are complete. Significant differences among the various IOLs have been obtained: complete absorption of UVC (200 nm - 280 nm) and UVB (280 nm - 320 nm); however their behaviour inside the UVA range (320 nm - 400 nm) differs considerably.

The spectral power distribution (SPD) of different white LEDs (Blue and Violet LED) have been measured. Using the modified BLH action spectra, the potential hazard of measured sources has been calculated. Blue LED technology shows a non-significant increase of the hazard factor

with respect to a standard eye can be suggested; however, a hazard factor increases to as large as 30% for the SSL devices with Violet LED technology.

In relation to flicker health concern:

The measurement chain for the temporal characterization of flicker as well as the facilities for validation and traceability are ready. A review of parameters related to high-frequency flicker effects of lightings including stroboscopic effects is finalised. Two modulated light sources have been studied, based on LED current modulation and optomechanical chopping. For psychophysical models of flicker effects on humans, a survey has been carried out. An extra result of the measurement of the frequency response of the Switched Integrator Amplifier (SIA) is added to the deliverable.

The report on validation and traceability of measurement systems to characterise flickering lighting for temporal and spatial distribution of photometric and colorimetric quantities is ready.

Objective 4. ***In relation to lifetime:***

There are 3 papers related to reliability and lifetime are submitted.

In relation to ageing:

For natural ageing, the measurement protocol has been implemented by two partners who started with their natural ageing measurements. The natural ageing is continuing according to plan. The preparation of accelerated ageing setup is complete in some laboratories and the ageing of 40 SSL devices of type OLED, CoF, CoB and GaN-Si have started. The UV ageing of OLED devices is also undergoing.

Creating Impact

- The webpage of the project (www.eng62-mesail.eu) is kept up-to-date.
- A first stakeholder workshop has been organised in connection to the CIE Tutorial and Expert Symposium on Measurement Uncertainties in Photometry and Radiometry for Industry in Vienna, Austria (http://div2.cie.co.at/?i_ca_id=939) on 12 September, 2014. Several partners have contributed to the workshops. During the first meeting a Stakeholders Committee has been established and the Terms of Reference have been agreed.
- A second stakeholder meeting was organized in November 2015 by PTB in connection with the CIE Tutorial and Expert Symposium in Braunschweig, Germany (http://div2.cie.co.at/?i_ca_id=974) and was well attended by 32 participants, 12 of them (not including consortium partners) signed a document vowing their interest to take part in the comparison measurement of the Multiple Transfer Standard (MTS) developed. During this meeting, the stakeholders were informed about the progress of the project and demonstrated the MTS developed.

The JRP output and impact report list 11 publications,16 presentations/posters and **no** patents for the life of this project.

JRP start date and duration:	1 June 2014, 36 months
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