TOPIC DESCRIPTION: Metrology for Solid State Lighting

Abstract

Present lighting technology uses 19 % of worldwide electrical energy consumption. Solid-state lighting promises a 75 % improvement of the overall energy. In light of this the EC's Energy Using Products Directive (2005/32/EC) [1] has called current inefficient lighting to be phased out by 2012, saving annually close to 80 TWh, and 32 million tons CO_2 emission; or around 20 standard power stations [2].

Consumers have so far been reluctant to embrace solid-state lighting, often due to unjustifiable claims about new products performance, based on poor metrology and conformity assessment. This Call for JRPs aims to develop the metrological background and infrastructure to fully characterise novel light sources including optical, thermal, and electrical measurements. Research is also required into the visual perception of these novel sources. Improved metrology for these novel light sources can support the development of a consumer-led market increasing uptake of these energy efficient light sources and meeting EC targets.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP 2008 [3], section on "*Grand Challenges"* related to *Energy* on pages 8 and 23.

Keywords

Domestic lighting, efficacy of light sources, efficiency, energy loss, energy saving, energy saving lamps, LED, lifetime, light distribution, light management, lighting, lighting design, lumen, OLED, photometry, solid state lighting (SSL), standardisation, street lighting.

Background to the Metrological Challenges

Lighting uses 19 % of worldwide electrical energy, this could be reduced by 75 % if all existing lighting were replaced by solid state lighting as desired by the EC's Energy Using Products Directive [1]. Solid-State Lighting (SSL), most commonly seen in the form of Light Emitting Diodes (LEDs), has the potential to revolutionise the efficiency, appearance, and quality of lighting, as we know it. SSL has been identified not only to fill the efficiency gap but also to replace environmentally unfriendly compact fluorescence lamps and the associated problem of Mercury disposal. Other novel SSLs are under development such as organic LEDs (OLEDs). These are plastic based LEDs that can be manufactured as point sources, or as printed thin films that illuminate a large area. These devices are not yet market ready, but the technology is advancing rapidly and SSL metrology should also be suitable for such devices.

EURAMET, EMRP-MSU
National Physical Laboratory
Hampton Road, Teddington,
Middlesex, TW11 0LW, UK

Phone: +44 20 8943 6666
emrpA169@npl.co.uk
www.euramet.org

First generation LED products have been introduced, though widespread implementation is far from reality for a number of reasons;

- Lighting of public areas is heavily regulated due to safety concerns. The attractiveness of LEDs energy saving is often overshadowed by concerns relating to ambiguous data of novel light sources, including; efficacy claims, light intensity profile, lifetime, and colour spectrum. This lack of confidence in existing data has caused many lighting designers and specifiers to avoid SSL products.
- Consumers have been reluctant to embrace solid-state lighting, often due to a "dislike" of the illumination they produce, and unjustifiable claims about new products performance.

A metrology framework for SSL is lacking, with manufacturers and users of this technology underestimating the intrinsic metrological peculiarities of SSL. More worrying is the fact that use of conventional photometric guidelines for the characterisation of LEDs and OLEDs can lead to measurement errors and incorrect data.

In addition to the optical characterisations of SSL other traceable measurements are required:

- Accurate measurement of conversion efficiency (of electrical power to optical radiation) is essential to the design of the most energy efficient devices.
- Accurate thermal measurement of SSL is required during operation to
    - Best understand ageing effects and lifetime, and to optimise product lifetime
    - Reduce the carbon footprint of novel light sources
- Accurate measurement of electrical pulse width modulation, to enable comparison of pulsed operation with steady state. There is a view that modulation of SSL can extend lifetime, and affect the perceived luminance
- Human Perception of SSL. Street lighting must function in both twilight and darkness for optimum safety. The new mesopic vision measurement system, being adopted by the CIE, will define the visual responses at twilight. Implementing this will require new measurement technologies and procedures, especially for LEDs – where it is likely that lower illumination levels may be possible, offering considerable energy savings.
- Reliable lifetime determination and degradation mechanisms of SSL.

This Call for JRPs requests the development of a metrological framework for the unambiguous and reliable characterisation of Solid-State Lighting. With adequate metrology SSL can be improved to the stage where the market becomes consumer-led rather than legislation-driven. When consumers embrace novel products, the uptake of these energy efficient light sources will accelerate, enabling the EC to meet its challenging targets.

Scientific and Technological Objectives

Proposers should aim to address all of the stated objectives below. However where this is not feasible (i.e. due to budgetary or scientific / technical constraints) this should be clearly stated in the JRP protocol.

The objectives are based around the PRT submissions. As experts in the field, JRP proposers should establish the current state of the art, which may lead to amendments to the objectives - these should be justified in the JRP proposal.

The following objectives shall be covered in order to underpin the development of more efficient and reliable SSL products and to promote their widespread implementation:

1) Develop and validate traceable measurement methods for solid-state lighting products, including optical, electrical, thermal and materials properties. Consider the full range from microscopic properties over single devices, to in-situ solid-state lighting products/systems. Paying particular attention to the measurement of spectral changes over time, with implications for colour rendition, colour appearance etc

2) Develop and validate traceable 'quality-metrics' for the specification of solid-state lighting products/systems, and related optical components.

3) Develop and validate quantitative measurement systems and metrics for the human perception of solid-state lighting products/systems.

Potential impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the "end user" community (eg letters of support) is encouraged.

Where a European Directive is referenced in the proposal, the relevant paragraphs of the Directive identifying the need for the project should be quoted and referenced. It is not sufficient to quote the entire Directive per se as the rationale for the metrology need. Proposals must also clearly link the identified need in the Directive with the expected outputs from the project.

In your JRP submission please detail the impact that your proposed JRP will have on the following Directive of the European Commission:

> Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 "Establishing A Framework for the Setting of Ecodesign Requirements for Energy-Using Products" [1]

You should also detail other Impacts of your proposed JRP as detailed in the document "Guidance for writing a JRP"

You should detail how your JRP results are going to:

- Feed into the development of urgent standards through appropriate standards bodies
- Transfer knowledge to the manufacturers, lighting designers, specifiers, policy makers (in national government and beyond), consumers, and users
- Develop an appropriate European accreditation, testing and standards infrastructure for efficient development of the market and products.

Real engagement plans with stakeholders must be an important element of your JRP. The proposal should clearly indicate how the user community will access and use project outputs; including technical guidelines, new measurement methods, design models and recommendations.

Time-scale

The European Commission has called to phase out incandescent light sources by 2012. This Call for JRPs seeks to support this goal, and remove barriers to the uptake of SSL lighting.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references

[1] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 “Establishing A Framework for the Setting of Ecodesign Requirements for Energy-Using Products” (Eup)

http://ec.europa.eu/enterprise/eco_design/directive_2005_32.pdf

[2] Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for nondirectional household lamps” C(2009) 1907 final SEC(2009) 327 FULL IMPACT ASSESSMENT 18.3.2009 http://ec.europa.eu/energy/efficiency/ecodesign/doc/legislation/sec_2009_327_impact_assesment_en.pdf

[3] European Metrology Research Programme. Outline 2008 Edition - November 2008, http://www.euramet.org/index.php?eID=tx_nawsecuredl&u=0&file=fileadmin/docs/EMRP-outline2008.pdf&t=1248796946&hash=9da9ceb781370f04c322ac48068deca5