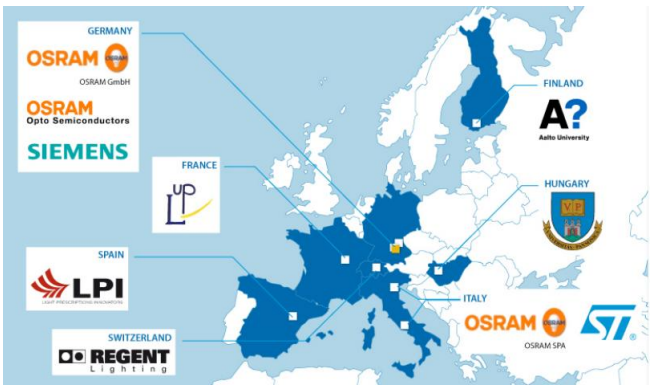
Solid-State Lighting for Europe
Newsletter #4
December 2012

Introduction

Welcome to the fourth Newsletter from the SSL4EU project!

SSL4EU stands for Solid State Lighting for Europe. It is an Integrated Project funded by the European Commission under the 7th Framework Programme. It gathers 10 partners from 7 different member states for a period of 3 years until 2013.

Consortium



Our Goal

Explore universally applicable LED light engines with high colour rendering, a tuneable light output spectrum and an adaptable light output level. These will keep Europe at the forefront of the energy-saving SSL business and serve as leverage to push the LED luminaire business in Europe.

The SSL4EU consortium includes large industrial companies, two SMEs and two universities:

<u>OSRAM AG</u>
OSRAM Opto Semiconductors
OSRAM IT
SIEMENS Corporate Technology
ST-Microelectronics
LPI
REGENT
Aalto University
University of Pannonia
L-UP

Summary of Progress

During the last half year there was much progress in the SSL4EU project. You will find here the description of what was achieved within all work packages.

WP1 High quality LEDs

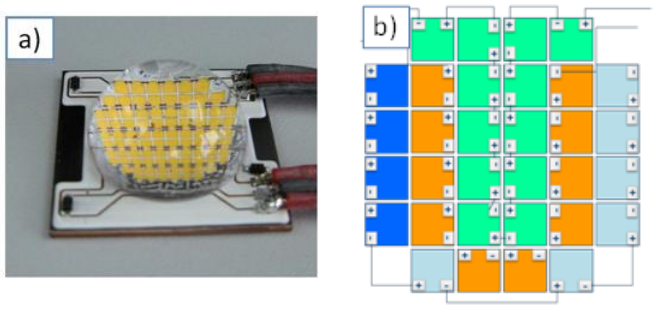
Until M30 of the project, the focus for the development of warm white ceramic phosphor platelets has been to optimize the final processing as well as the respective thickness of the yellow, red and intermediate layer. For that colour coordinate steering has been done by assembling

the platelets in GD+[1] state of the art high power LED packages.

For the development of multi chip spot light engines with densely packed chip arrays and bond wire free contact technology, one major issue has been robustness tests. Cycling tests (-40 °C to 125 °C) of the 37-chip spot light engine with optimized layout have been performed showing no failures until 2000 cycles. Measurements on the 37-chip light engine using standard silicone based converter platelets lead to efficacies as high as 90 lm/W for 4000 lm output and 124 lm/W for 1000 lm output.

Additionally, the assembly of an 88-chip spot light engine that comply with the second Zhaga[2] diameter for the light emitting surface has been started.

Beside the single colour warm white light engine, a colour tunable light engine is a second goal for work package 1. For that, a 3-string module comprising red, blue and mint converted LED chips will be realized. The colour mixing will be done by pulse width modulation.



a) 88-chip spot light engine with planar interconnect technology and extraction dome, b) layout of a 3-channel CCT adaptable light engine

[1] GD is short term for "Golden Dragon", a well know package type of the Osram OS LED packages.

[2] Zhaga is a consortium for the standardization of LED engines. For further details please go to: http://www.zhagastandard.org/

WP2.1 Electronics

Hereunder you will find the description of work performed in WP2.1:

1) Definition of ASIC

Definition of ASIC specifications is completed considering the outcomes presented on the M24 meeting (ST + OS-IT).

This activity does not involve other WPs.

The IC design is proceeding with definition of internal structures and relevant simulations (ST).

2) CCT electronics

Realization of a fully working demonstrator.

Implementation of color sensor measurement.

Feasibility study to obtain the final architecture based on a LED module embedding a microcontroller for color measurement and OS proprietary algorithm calculation and an AC/DC component embedding an application specific device to digitally control the average value of the current of each channel.

WP1 and WP3 are involved into this activity.

3) Sonotrode driving

Electrical characteristic received and preliminary study ongoing.

Practical sonotrode delivered.

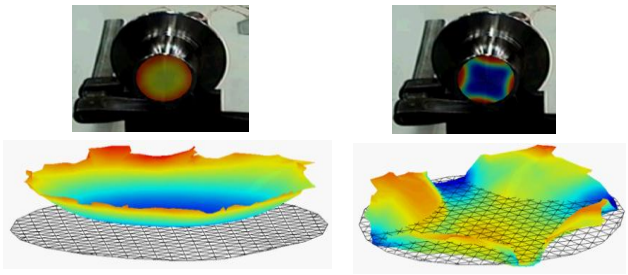
Resonant solution is under consideration as final proposal.

WP3 is involved into this activity.

WP2.2 Thermal management

The goal of the work in Task 2.2 was the development of efficient sonotrodes for ultrasonic cooling. The cooling behaviour of ultrasonic sonotrodes have been investigated. The resonant electromechanical system with the piezo actuator exhibits some complex behaviour. It is able to recover energy back to the power supply on the one hand and it is emitting energy to the ultrasonic field on the other hand. To reduce the energy recovery back to the power supply a matching impedance Z has been placed between power generator and piezo actuator, thus the overall input power sunk to a minimum.

New mushroom like sonotrodes based on the former ultrasonic vaporizer have been manufactured from titan and aluminium which operate in the frequency range up to 50kHz. The fundamental mode at 31304 Hz and a higher mode at 45257 Hz have been investigated in detail. Best cooling performance has been reached at the higher asymmetric mode of 45257 Hz. The cooling performance of the titan sonotrode in this specific set-up is better than those of the aluminium sonotrode. The titan sonotrode driven by 1.5 Watt input power resulted in doubling the cooling performance compared to free convection. The type of mode shows a pronounced influence on the cooling performance. Different compact disk sonotrodes have been designed, modeled and manufactured. in spite of the large amplitude the cooling performance of the disc sonotrodes is considerable lower compared to the titan (mushroom) sonotrode. Obviously the type of mode in combination with the heat sink configuration has a pronounced influence on the cooling performance.



Mode 1: f=31304 Hz Mode 2: f=45257 Hz
Surface-Scan by 3D-Laser-Doppler-Vibrometer (LDV)
of a titan sonotrode at different modes

WP2.3 Optics

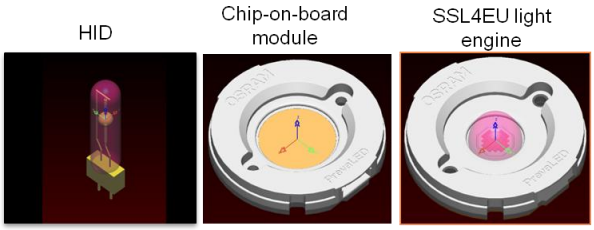
From the optics standpoint, two main tasks are currently running in parallel.

The first one is trying to improve the design of the shell mixer so that it fits both with Zhaga geometrical constraints and dome lenses that help rising the flux extracted from the chips. Such a shell mixer has not an overall hemispherical shape anymore (rather, it is somewhat elliptical) and is not designed as an isolated part with regards to the dome: rather, both shapes are designed together. The resulting design is likely to become more complex to manufacture, but this will not be clear till the CAD models have been completed.

The second one is analyzing the optical architectures needed to build up a color-tunable light engine, in coordination with LED development and electronic partners. The preferred colour sensors (enabling colour and flux corrections in real time) work with very low irradiance values and are sensitive to rays hitting the sensor under ±10deg. The location of the optical feature that means to cast the signal onto the sensor, along with its size and shape (which define whether this optical feature “sees” all chips within the package, and how light hits the sensor) are key values for the proper performance of this feature.

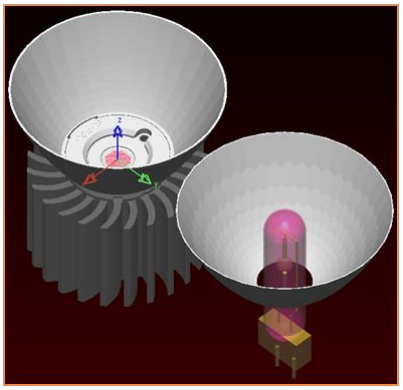
WP2.4 Universally applicable LED-modules: System Integration and Reliability analysis

In this workpackage simulation studies have been made in order to investigate whether the SSL4EU light engine can be used as a real HID replacement with respect on downward flux and beam angle. A typical HID lamp as well as a state of the art chip-on-board light engine (with a light emitting surface diameter of 22 mm) has been simulated together with the SSL4EU light engine with a diameter of 9mm (with outcoupling lens) for a total flux of 4000 lm.



HID lamp and ligh engines for simulation of the downward flux

The reflector of the LED-lamp was choosen to match the outline of an HID reference reflector:



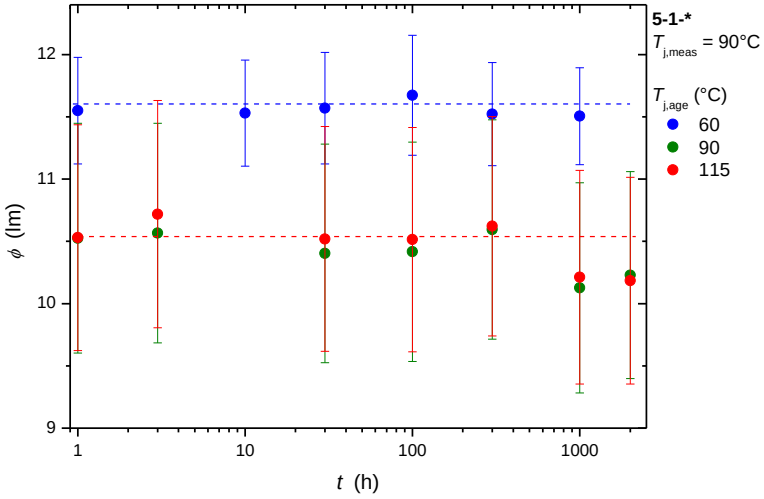
SSL4EU light engine and HID lamp with reflector

The calculation of the center intensity gives 37 kcd and a beam angle of 13° for the HID lamp, 16 kcd and 17° for the chip-on-board light engine and 67 kcd and 8° for the SSL4EU LE. This means that only the SSL4EU light engine can be used as a real HID replacement with similar reflector size and even exceeds the downward flux of the HID lamp with lower beam angle.

The following targets had been set for this period:

1. Continuation of ageing investigations and spectral data measurements for chips
2. Extension of the ageing equipment
3. Data base design, construction and incorporation of existing data into the data base.

Results:
18 blue chips of the first version of chips operated in three groups with different average junction temperatures (60, 90, and 115°C) at 350 mA have been aged until 3000h. Corresponding TERALED/CAS measurements (electrical data and spectra) have been performed for 1, 3, 10, 30, 100, 300, 1000, and 2000h. Exemplarily, in the figure below the average luminous flux is plotted versus time for a measurement T_j = 90°C.



Average luminous flux of the three aging groups vs. time measured at $T_{j,meas}$ = 90°C.

195 chips of the second chip version (red, blue, mint and sunrise) were received from Osram Semiconductors. Meanwhile most of the preparation work (T3ster measurements) for starting the ageing process has been completed
The rack's wiring has been extended to allow the operation of 28 boards. Further, for a direct comparison of experimental results with modelling, the modelling has been refined. After doing this a very good agreement was achieved.
The data base creation has pushed forward using MySQL. Meanwhile, most of the measured spectral data have been incorporated into the data base.

WP3 LED Luminaires

In the past months WP3 has built two prototypes besides benchmarking and revising the group's specification.

During the constant market surveillance and analysis of the trends WP3 evaluates the project's goals. These analyses, especially based on this year's trade show light & building yield that it is a realistic goal to achieve a luminaire with 100lm/W by the end of the project. Therefore, the project's specifications were confirmed.

In preparation to the group's meeting in Madrid, WP3 produced two demonstrators, one spotlight

and one tunable downlight. The downlight's purpose was primarily to have an apparatus to test the new 3-channel driver.

The spotlight (see picture) was built on a new platform of fixture to test realistically the high density M18-LED module. The module's 37 LEDs placed in only a LES diameter of 9 millimetres let the luminairemakers produce very narrow beam fixtures with good light control. The LED module could demonstrate that the required 3000lm will be achieved by the end of the project. The efficiency goal was not quite met, but a remarkable improvement of over 50% over the last demonstrator was shown.
WP3 is on track to achieve the projects final goal.

Spotlight demonstrator (D3.3)

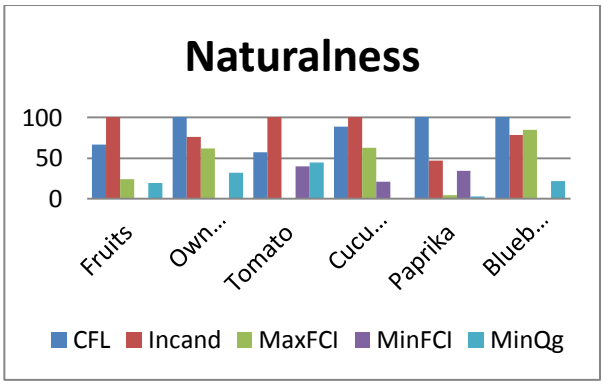
WP4 Acceptance studies

University of Pannonia:

The influence of five sources has been investigated on the appearance of fruits and the own hand. An incandescent lamp was compared with a CFL and three LED spectra optimised for CFL (max and min) as well as minimum of Qg. 18 observers conducted the experiment and answered to the following questions: naturalness, brightness, contrast of objects, softness and warmth of the scene, how stimulating the atmosphere was, whether it gave a happy feeling, and whether the observer would be pleased to see the scene in such a light, and finally whether he would prefer to use such lighting.

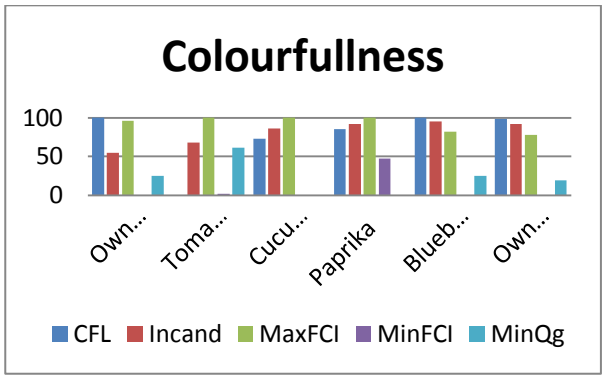
Two statistical methods were used to evaluate the results, called KIPA[3] and AHP[4]. The two methods gave practically the same rank order for the sources, but the rank order for different questions was different: For naturalness non of the colour preference metrics gave good results, while for colourfulness max.FCI was favoured. Highest brightness scores were given to the minFCI and the incandescent lamp. The two figures show naturalness and colourfulness scores for the different objects in the booths.

Two sets of light source spectra were also designed for the full scale experiments, one for the living room and one for the kitchen/dining room area. Visual experiments in these rooms are under way.



Visual scores for naturalness under different light sources for different objects (Own: own hand, Cucu: cucumber, Blueb: Blueberry).

[3] Saaty, TL, Multicriteria Decision Making: The Analytic Hierarchy Process, 1988; Revised and published by the author; Original version published by McGraw-Hill, New York, 1980.
[4] Kindler J., Papp O. (1977). Komplex rendszerek vizsgálata, összemérési módszerek. Műszaki Könyvkiadó : Budapest, 41. 151-175.



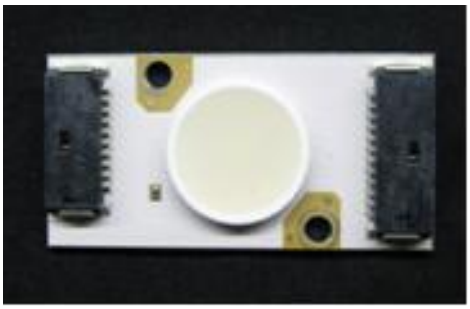
Visual scores for colourfulness under different light sources for different objects (Own: own hand, Cucu: cucumber, Blueb: Blueberry).

OSRAM Opto Semiconductors:

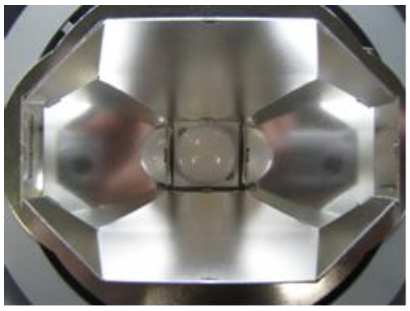
The acceptance studies in the shoplighting application are advancing steadily. The luminaire for the salad bar in the EUREST cantina was reworked due to some space constrains. The housing of the salad bar was welded together so that a normal and easy dissemble was not possible. The reworked luminaire will now be installed. The thermal management inside the housing will be evaluated to ensure a safe operation during the evaluation.

Luminaire for the cantina

The challenge with the light mixing box for the full scale study in the EDEKA shop has been solved by using a new prototype light source. The light source has been equipped with a special set of chips to achieve the special spectral power distribution. The operation of the light source is still a challenge due to the difficult DMX driving. The solution to this issue has been found in a special prototype driver used in another application. The reprogramming and adaptation of the driver is ongoing.



Light engine for shop lighting study



Luminaire for shop lighting study

The light source will be placed in the existing luminaires and equipped with a small light mixing dome to ensure a homogeneous distribution of the different colours of the channels.

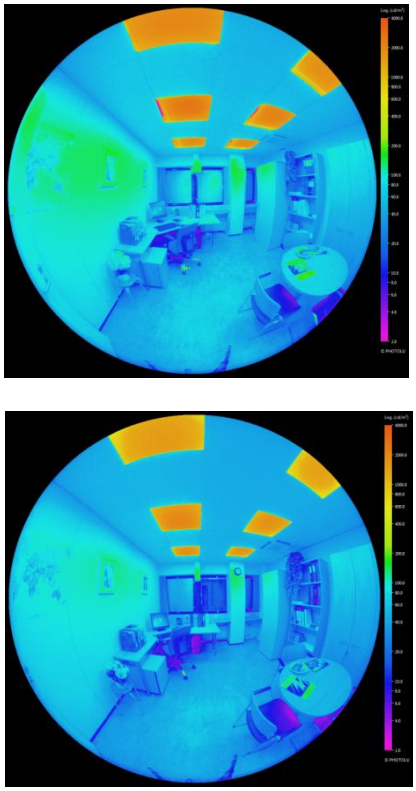
Regarding the textile shop for the full scale study we successfully convinced a local shop in Regensburg. They agreed to change the illumination in the dressing room area after the Christmas business.

Aalto:

During the month 25-30, the goal was to complete the establishment of full scale experimental setup and carry out the full scale experiments. Another goal during this period was to modify the luminaire used in small scale experiment and set up verification experiments.

Setup of office room with Fluorescent luminaire was completed before month 24. However, due to the delay in receiving LED luminaires, set up of office room with LED luminaire has been completed during current period (25M-30M). The questionnaires developed for full scale experiments were tested during this period by conducting experiments using 10 observers in office room with fluorescent luminaire and the

feedback obtained from observers was valuable to design the final questionnaires. Other tasks carried out during this period include installation of luminaires, solving the problems related to noise generated by cooling fans, generation of spectra to be tested, running the system and continuous measurements to test the stability and carrying out modifications because of change in spectra, and generation of final spectra and start of full scale experiments. Additionally, LED luminaire used in small scale experiment has been modified to get simplified spectra for verification experiments. Verification experiment spectra are currently being tested.



Luminance map: Test office room with LED luminaires (up) and with fluorescent luminaires (down) at Aalto

Interviews

SSL4EU Newsletters offer you the possibility of getting to know some of the Project Partners a little better… Thus, the Interviews section will let you discover the day-to-day life of the people involved in achieving the SSL4EU goals.

In this edition of the SSL4EU Newsletter #4, we propose you to join us in promoting the gender equity in scientific research within the 7th Framework Programme. You are about to find out how female scientists working within the SSL4EU consortium deal with the gender equity issue.

Interview with Dr Marjukka Puolakka, Senior Research Scientist at Aalto University Finland

Q1: Research and development are generally perceived as a mainly male domain. As a female engineer participating in a European collaborative project, what can you tell us about this experience? How are gender aspects considered in European research projects?
A1: In my view the fine thing is that you do not separately have to consider them; whether you are male or female researcher does not pay a difference, it is that you are an expert in your field. In the European projects that I have participated, the gender issues have been no problem; there have been both male and female professors, researchers and PhD students on board.

Q2: What is the impact of a project like SSL4EU on the gender equity issue at the European level?
A2: I think these projects are good ways to show the academic and industrial world, that high-level engineering research is done by consortia, where both female and male researchers work in constructive and smooth co-operation, and reach excellent results.

Q3: What are your recommendations to make science and technology more women-friendly and to increase women's visibility in this field?
A3: One thing is for sure in the dissemination; tell the young students of the fascinating opportunities you can have in the engineering field; today both the basic and applied research is getting more and more multidisciplinary, and besides the engineering skills you need much more. Visibility of research should be increased also in the public media to increase the interest of the future researchers.

Interview with Aleksandra Cvetkovic, Optical designer at LPI-Europe

Q1: Research and development are generally perceived as a mainly male domain. As a female engineer participating in a European collaborative project, what can you tell us about this experience? How are gender aspects considered in European research projects?
A1: I think that R&D is manly male domain only for technical sciences and I think that the case is other way around for humanities. In LPI, as an example is an R&D company, 40% are women. Anyway, from my experience, as a female participant in EU project I have never noticed any discrimination from any partner. I've participated in only two EU project (parts of FP5 and FP7 programs) and I think that treatment is equal for both genders even though that number of participants is not. I can also notice that in SSL4EU (FP7 program) there are more female participants than there were back there in 2004 (FP5 program).

Q2: What is the impact of a project like SSL4EU on the gender equity issue at the European level?
A2: Every partner in SSL4EU has female participants that are considered equal as any other and their opinions and contribution are evaluated and considered in the same way. In almost all groups there is at least one woman and with same importance for the project as any other participant. Women are not a majority but this could be a small contribution on gender equity at European level.

Q3: What are your recommendations to make science and technology more women-friendly and to increase women's visibility in this field?
A3: I think that the most important for making science and technology more women-friendly would be making important changes in basic education. In many countries there is an unofficial separation of man and women job types and what is being transmitted to children in different ways (family, school, media). This could be changed by showing from early age examples that are not following common stereotypes and making the same offer to every kid. I think what also would be really helpful is making science more attractive to children and maybe more emphasis on mentoring young women particularly to give them better picture of what life as scientist or women engineer is like. That should make them more interested in a careers connected with technology and science. At the end, I think that one can be whatever she wants to be!
Considering women's visibility is tricky question. Probably making outer stimulation (like awarding women participation in projects) is a good option. But visibility of women unfortunately depends on many factors, that include not only society in general, and stimulations that should be introduced before equality is reached (so-called positive discrimination) but also will of women to be exposed in "man world". First of all at this point there are less women than men in technology and science (here I refer only to technical science), so visibility can't be the same. That brings us back to the educational problem.
Anyway, I think that women promotion in R&D and technology business, or even in science, is slow process and that we are on the good way. If you look back only 10 years, the percentage of women in technology was much lower. So this makes us think that we are doing something that makes sense.

LEDs News

Aalto University (Finland) has launched **the Aalto Energy Efficiency Research Programme**, which is an interdisciplinary programme focusing on practices and changes in operating environments that promote efficient energy use. The programme strengthens internationalisation and research training. Among the three projects started in 2012 is the **Light Energy** coordinated by Aalto lighting Unit. Light Energy aims to increase the energy-efficiency of outdoor lighting by developing smart lighting controls and promoting the use of **LEDs**. See: http://energyefficiency.aalto.fi/en/

A new publication co-authored by one of the SSL4EU Partners has appeared in the *ASME Journal of Thermal Science and Engineering Applications.* The publication in question entitled „Noiseless cooling by ultrasonic streaming in resonant mode" was written by Thomas Knoche, Gunther Reinhart, Martin Honsberg-Riedl and Gerhard Mitic.

LEDs Events

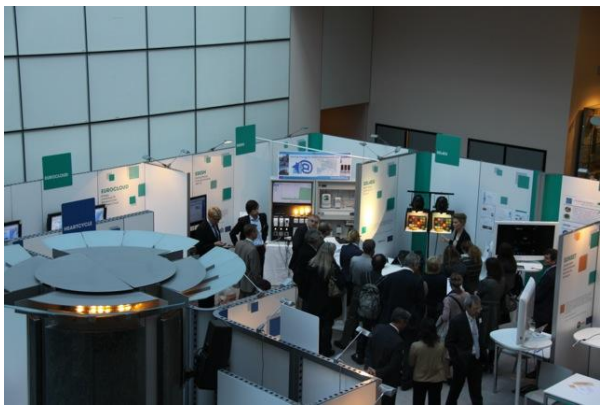
The SSL4EU Partners participated in the Project Month 24 Review Meeting held with EC Representatives and Reviewers. The meeting was organised on 27th September 2012 at the LPI facilities in Madrid, Spain. The event went off in a very productive atmosphere and it was an occasion to present the progress of work within the second year of the Project. Hereunder you will find some photos of this event.

SSL4EU Month 24 Consortium Meeting

SSL4EU Month 24 Consortium Meeting

Spotlight demonstrator (D3.3)

The ICT event "Made in Europe – ICT Building blocks tackling societal challenges" organised by the EC was held at the European Parliament in Brussels on 8-10 October 2012. The SSL4EU project had an exhibition booth represented by Osram AG who tried to familiarize the exhibition audience with the SSL4EU goals and showed the demonstrators developed within the project: the 4000 lm light engine and theluminaire from Regent equipped with this light engine. To demonstrate SSL4EU activities on user acceptance Osram AG set-up light boxes and showed different LED lighting scenarios to create more awareness of the unique possibilities of LEDs to tune the light and match user's preferences.



Made in Europe – ICT Building blocks tackling societal challenges, 2012 Edition

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Here you can find a blog article “LED’s save energy” posted by Berit Wessler on the digital agenda page:
http://ec.europa.eu/digitalagenda/en/blog/led%E2%80%99s-safe-energy

The **CIE** (International Commission on Illumination) is celebrating its one hundredth anniversary! The two-day conference will take place on **April 15-16, 2013 in Paris**, where the CIE was officially created and hosted 100 years ago.
Source: http://cie.co.at/

The next SSL4EU Consortium Meeting will take place on the 14-15 January 2013 at the ST Microelectronics facilities in Milan, Italy. If you feel like meeting one or several Partners at this occasion, please do not hesitate to contact us!

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