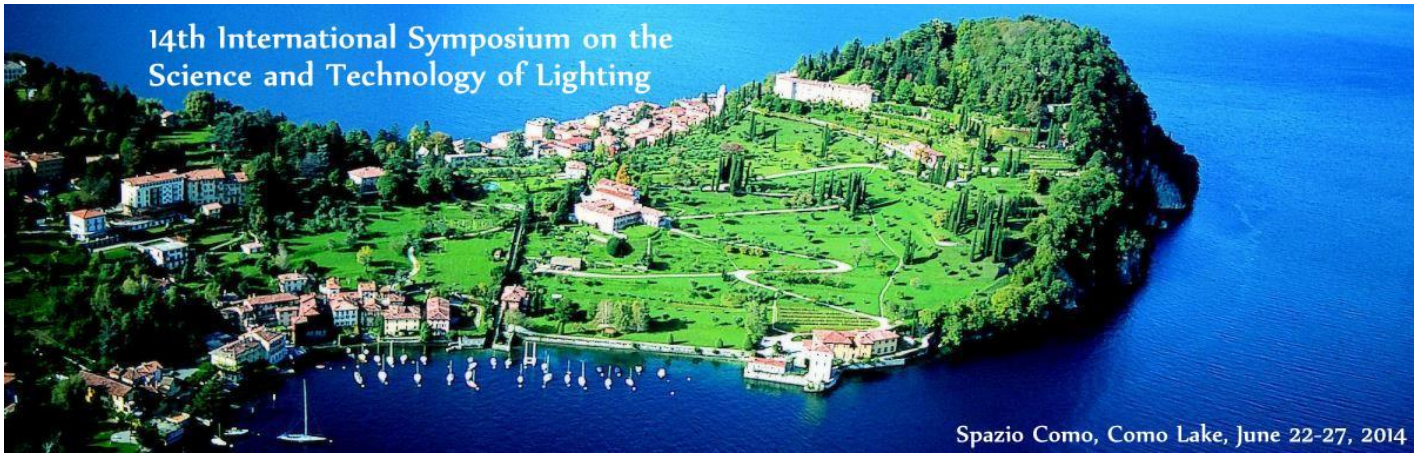
EPIC Members Event Report

The International Symposium on the Science and Technology of Lighting (LS14)

Como, Italy
22-27 June 2014
www.ls14-symposium.org



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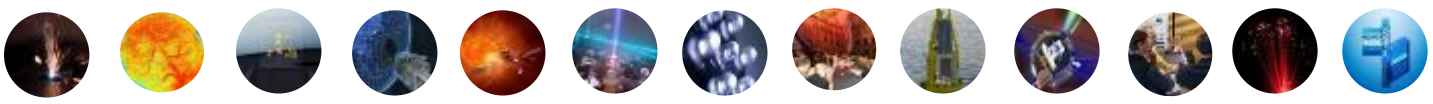
About the EPIC Members Event Reports

Initiated by the founder of EPIC Dr. Thomas Pearsall in 2003, these reports are prepared by members of EPIC to the benefit of the wider community. If you did not have a chance to attend the event but would like to know some key highlight, this report is for you. Emphasis is placed on exploring technical and business opportunities for the members of EPIC.



The International Symposium on the Science and Technology of Lighting (in short LS) is an important conference, regularly held since 1973 and now arrived to its 14th edition. This year the conference was located in the unique scenario of Como Lake and guested in the spaces of the Grand Hotel Como. This edition took place from 22nd to 27th of June and registered the presence of almost 250 attendees from all over the world, with a large presence of Asian and US participants.

The conference traditionally provides unique opportunities for the worldwide community of engineers and scientists involved in the lighting industry to meet, present and discuss all aspects of fundamental and applied research on thermal, discharge, plasma technologies, as well as solid state lighting (both LEDs and OLEDs). Differently from other fairs or conferences where lighting is strictly synonymous of LED, here besides to the main sessions on Solid State Lighting (LEDs and OLEDs), there is still space to discuss on innovations in traditional light sources and an entire session, named with the evocative title of "Legacy and Novel Light Sources", gave space to radical ideas coming from different fields for improving traditional as well as solid state light sources. The content of the session will be detailed in the text.

Moreover in the past years the LS series has made an effort to extend its program also on other important aspects of the lighting. If not fully completed, this process has now to be considered well established, as proven by the rich program with sessions spanning from the economic forecasts to the biological interactions with light or to the artistic, architectural and fashion implications of the lighting.

As a matter of fact the Keynote Lectures held by prof. H. M. Cooper and prof. P. Di Trapani debated respectively on the non-visual functions of the light related to the new insights in human photoreceptor and on the optical effects found in arts and in nature with a poetic description of their analogies and similarities. Just to remark the multidisciplinary of LS14, one of the sessions was jointly organized with the Italian Colour Group and titled "colours and human factors". Such heterogeneous contributions were well grouped in homogeneous sessions and the conference, for most of the time, gave space to a single session per time.

Taking advantage of the privileged location, great attention was devoted to the hospitality and to collateral events, such as Lake Cruise and Gala Dinner on the Lake. A special tour was offered on Friday: while the less experienced participants had the opportunity to take part in technical tutorials (with teacher as renowned as prof. A. Poppe or prof. M. Meneghini) the senior attendees had a tour to Milan Science and Technology Museum.

Going through the program of the conference, day 1 (Monday 23rd) was devoted to "*Technology & application horizons for lighting* "and "*LED Systems and Metrology*", being the first session more dedicated to ***regulation, technology and market trends*** and the second more focused on technical advancements. EPIC gave an important contribution in the organization of the first opening session and Dr. Heinz Seyringer, Head of Research Collaborations at Zumtobel Group, and member of EPIC Board of Directors, provided an interesting overview on the "*Advances in Lighting Technology and Applications*". Milan Rosina, from Yole Développement, expects that LEDs, driven by increased efficacy and more affordable prices in near future, will have a market share of *88% in 2020*. A notable penetration in near future is expected also by Paolo Bertoldi, from the European Commission Join Research Council, who confirmed *EU interest in LEDs* technology as important factor in energy saving and consequent pollution reduction. According with his data, just assuming nowadays performances, a full penetration of LEDs corresponds to shut-down 26 large power plants (1000 MW electric) or, in other terms, to prevent the emission of 77 million tons of CO2. In this context it appears clear the interest expressed by the International Energy Agency through its delegate Peter Bennich, who reported the results obtained within the IEA 4E Solid-State Lighting Annex and the future prospective. In fact, in order to establish performances criteria and quality assurance methods it is important to have a common framework with harmonized regulations and measurement tools (the annex actually describes results on LED test calibration scheme run over 110 accredited laboratories). An original point of view was offered by Stuart A. Mucklejohn and his talk "*The rebound effect and the impact on lighting*". He pointed out that, if not properly

accompanied by price regulation, the declared energy saving on lighting could lead just to re-arrangement of energy consumption and/or increase in illumination demand. As already observed in many cases, the increase in efficiency paradoxically leads to larger consumption!

Concerning the ***technological advancements on LEDs fabrication***, talks of prof. Colin Humphreys and Mike Krames gave two opposite views on the topic. In fact prof. Humphreys emphasized the improvements made on the epitaxial growth of *GaN on Silicon substrates*; in particular he gave an overview of the studies performed at Cambridge Gallium Nitride Centre by the use of AlN and AlGaN intermediate layers to control the thermal stress and silicon nitride interlayer to reduce the density of threading dislocations. On the other side Mike Krames, from SORAA, described the benefit of the *GaN on GaN* technology: using a homogeneous substrate it is possible to get nearly perfect crystals with advantages in terms of maximum current density and thermal dissipation. This strategy, even if more expensive with respect to other technologies, gives the possibility to extract more lumen per active area and "pay-back" the higher cost. Moreover, the possibility to tune the emission to the violet gives an advantage in terms of color rendering, especially for the white products that use luminescent bleaching agents that are excited by near uv radiation.

Regardless of the technology, the ***new LED functionalities*** have been pivotal in many talks: it appears clear that the potential of solid state lighting is not simply related to the cost/efficiency, but is intimately connected with the possibility to *trigger feelings*, *sensations* or even *biological effects*. "*Creating a natural feeling* in partially floodlit spaces: lighting controls for blending LED & daylight" is actually the title of the talk given by Helmar G. Adler from Osram Sylvania. In this contribution it was remarked the importance of natural light but it was also emphasized the possibility to integrate the ambient light with artificial sources for improving comfort and performances. Tailoring of light according to human needs is not an easy task since it requires a precise knowledge of the instantaneous daylight characteristics and dynamic lighting system which increases brightness minimizing color mismatch. Similar requirements are beneficial also in luxury retail as shown in a separate talk, where the light is intended as a key factor in customer's choices: Osram Sylvania exploited the concept to design a *Dressing Room* where the light changes according with the users/clothes in order to emulate the proper scenario. The "*challenges and technologies for connected LED lamps*" were presented by Marcel de Jong from Philips Lighting. Of course tuning color temperature and intensity is important in the mentioned applications and Philips proposed the concept used in designing the *Hue lamp*. This lamp, intended for a broad audience, is made combining red, lime and blue LEDs. At the cost of reducing the gamut, the substitution of green with lime color gave an increase in the CRI preserving the efficacy at values higher than 70lm/W in all the range of available whites (from 2000K up to 6500K). General Electric instead stressed the importance of grid connectivity (E+GRID) and light communication (Intelligent lighting and industrial internet). The *E+GRID* is a platform for outdoor lighting that integrates adaptive LEDs luminaires equipped with motion sensors, photovoltaic panel, battery, bi-directional grid connection and web-based user interface: in this way the system becomes more an investment than a luminaire. The "intelligent lighting" is, according with GE delegate, a complex "big brother"-oriented environment where the control on light consumption provides information on people fluxes and allows forecasting the demand on other correlated services (eg. traffic).

A very exciting part of the conference was dedicated to ***innovative light idea*** applied both on traditional and more recent light sources. Just to have an idea, prof. Mark Raizen proposed to use a balanced *mixture of Hg isotopes* in order to mitigate the phenomenon of light self-absorption and increase the fluorescent lamps efficiency. Remaining stick on traditional fluorescent lamps, Armin Konrad and Alessio Corazza, respectively from Osram and SAES Getters, gave a talk on the lamps' lifetime and showed that, if *Hg dosing* is enough precise, the Hg depletion is not relevant in lamp mortality at 30000hrs even with dosing *as low as 1 mg*. This, of course, pushes forwards the limits of traditional technology in order to be more green and competitive. A different kind of lamp source was presented by prof. Kyu Chang Park who described the fabrication methods to get high performance lighting lamp based on *carbon nanotubes* as electron emitter. The innovative methods/design were specifically developed to get scalable, cheap and long lived devices able to compete with LEDs. Another elegant idea came from Junichi Takahara, Osaka University, who presented a way to re-shape the thermal radiation. Using *2D plasmonic structures* he was able to redistribute the thermal radiation enhancing certain resonances at specific wavelengths.

This "geometrical-trick" actually changes the electronic modes of the surface and shifts the radiation out of the classical Planck distribution. Unfortunately it seems the efficiency in the visible region of the spectrum is still too low. Coming back to LEDs' technology, Yoichi Kawakami from Kyoto University described a way to obtain multi-color emission in InGaN-based LEDs without the addition of phosphor emissive material, thus avoiding the consequent Stokes loss. According to the author, just playing with *three dimensional micro-facet structures* monolithically integrated on the same substrate is possible to tune the electroluminescent spectrum obtaining different colors. The combination of different structures comes out with white emission with desired color temperature. Finally, a more market-oriented approach was introduced by James Hooker from Havells-Sylvania, who described a prototype based on traditional GaN LEDs without the conventional heat sink. Using Hooker's words, "*This paper delivers an insight […] to realize a technologically significant marriage of solid-state and classic technology*". In particular his team exploited a classical incandescent lamp structure where the tungsten filament is replaced with LEDs on a thin strip and the vacuum envelope is instead filled with a light gas (He). This geometry actually exploits the conduction/convection dissipation through the gas to cool the LEDs with relevant benefits in terms of fabrication costs.

OLEDs found their space in several talks. Prof. Gianluca M. Farinola introduced the audience to the guidelines used by chemists to design *electroluminescent materials* for White OLED. In particular he described the different approaches used on modern devices to optimize efficiency and stability and their relationship with the different class of molecules employed so far. Other introductive lessons were offered by Dr. Chiara Botta from CNR, who focused on the OLEDs' working principles and by Manuel Boesing, researcher at Philips Aachen, who focused on *OLED practical aspects* and applications. In this contribution it was comparatively described performances, analogies and differences about the OLEDs now on the market (specifically from LG and Philips). In-depth analysis on the *degradation issues* of emitting organic devices was presented by Jiabril Gigli from SAES Getters. The detrimental effect of water on OLEDs performances is inhibited through the use of both active barriers surrounding the active material and through the dispensation of special scavengers able to trap undesired molecules without interacting with the complex physical mechanisms running into device. Innovative contributions was given by Keiji Sugi who presented a patterned OLED able to emit preferentially on one side preserving a good transparency through the structure.

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