Prototype of a white-light organic LED.

European collaboration promises a bright future

The race is on between the USA, Europe and Asia to develop high-efficiency light sources. Through its collaborative OLLA project, Europe aims to be first.

By Andrew Woolls-King & Steven Keeping

Photography: Michel Klop

Despite their incredible foresight, Thomas Edison and Sir Joseph Swan could never have imagined their electric bulbs would remain the foundation of lighting for 125 years. While technology has improved the inventions of course, even the latest halogen lights are simply variations on the incandescent theme.

And, despite the development, traditional lights are guilty of abysmal energy efficiency; a standard bulb converts just 5% of its electrical input into visible light, dissipating the rest as heat.

However, Europeans are now cooperating to investigate alternatives to venerable filament lights. The first objective is to combine high brightness (1000 Cd/m^2) and high efficiency (50 lm/W, comparable to energy saving bulbs), with extended lifespan (10,000 hours like fluorescent tubes), and the color ambience of a light bulb. A secondary aim is to design a flat light source with a large, uniformly diffuse emitting surface, based on durable, lightweight substrates so thin they will be transparent and – with further development – flexible.

Success promises to open up exciting applications beyond traditional lights, and to deliver major energy savings.

Organic LEDs shine

High-brightness Organic LEDs (OLEDs) are one candidate for this new light source. OLEDs exhibit electroluminescence (the release of photons in the visible spectrum) as electrons and holes recombine after the application of current.

“The application of such a solid-state light source would be limited only by the designer’s imagination,” explains Dietrich Bertram, OLED development manager at Philips Lighting. “This might include an homogeneously lit ceiling with intelligent control of light level and color temperature. Or a window that provides natural light during daytime and artificial light at night.”

OLEDs can already be found in display applications for mobile phones and digital cameras. “Yet the potential of OLED technology ranges far beyond displays,” continues Bertram. “Turning this potential into a commercially viable large-area light source, however, is an extremely challenging interdisciplinary undertaking. It will take physicists, chemists, material scientists and engineers working together over many years to overcome the technical challenges.”

EU backs OLED initiative

The EU is supporting OLED development by backing a 12 million-funded flagship initiative called Organic LEDs for ICT and Lighting Applications (OLLA). “More than 20 of Europe’s leading companies and research establishments have joined together in OLLA,” explains Peter Visser, who leads the project management of the organization (see side bar). “The mission of this integrated R&D project is to demonstrate by 2008 an industrially-viable, white light OLED light tile of 15 by 15 centimeters or larger.

"This will be targeted at general lighting applications, and will offer the first really flat light source and – most important of all – a supremely high energy efficiency. In fact OLLA won't just help the world leading European lighting industry with options to grow further – we will also give the world a much more energy-efficient lighting solution."

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>
> Mrs Viviane Reding, European Information Society and Media Commissioner

The stakes for OLEDs in general illumination are high; more research projects around the globe are investigating the topic. OLLA is one of the largest coorperation projects in this field.

"But in such a strong consortium like OLLA we have the unique opportunity to evaluate many promising concepts simultaneously," says OSRAM's OLLA board member Dr Karsten Diekmann. "Different material sets, different methods of light extraction and different approaches for encapsulation are in our focus, and finally the most promising ones will deliver the combination which shows the road to the most efficient and reliable product."

Collaboration shares scientific burden

To help manage successful cooperation, the project is sub-divided into five 'work packages': material development, small molecule devices, polymer devices, light extraction & modeling, and system level design. This allows consortium members to focus on jobs that relate to their experience, expertise, and area of interest.

Nicola Armaroli's group at CNR-ISOF, for example, is working on the small molecules essential to OLED function. "The role of our group is very different from the industrial partners," says Armaroli. "We are chemists. We strive to design novel solid-state light-emitting molecules in the red, green or blue portion of the visible spectrum. We then test their luminescence performance and properties and if they look promising as active OLED materials, we pass them on to the industrial partners.

"Phosphorescent metal complexes are looking the most promising due to their high triplet exciton harvesting efficiencies." (An exciton, generated inside the emissive layer of the OLED, comprises an electron and a hole at a distance from each other but bound by electrostatic interactions. When an electron and hole combine, a photon is emitted.)
"That said," continues Armaroli, "one of the toughest challenges is making the lifetime last nano- or microseconds for device optimal output – and that's not common at all for triplet excitons."

Elsewhere, Dr Jan Blochwitz-Nimoth, CTO of start-up firm Novaled, says the collaboration allows his fledgling company to build a relationship with European lighting giants.

"We focus on a doping technology that allows the power efficiency of the OLEDs to be increased by improving the electrical conductivity of the OLED transport layers," he explains. "Challenges include the fact that the doping material needs to be robust enough to resist cross contamination in a vacuum deposition process and must not diffuse within the OLED over time as that will destroy its light generation efficiency."

Sustainable future

"It's important that power efficiency is increased in our society. OLEDs offer a huge advantage over traditional lighting and this is one of the key reasons why the EU is backing this development", explains European Information Society and Media Commissioner Mrs Viviane Reding.

"OLLA is helping the EU's wider mission to improve the energy efficiency of our society," adds Mrs Reding. "While information and communication technology has improved tremendously the quality of our lives, our new life style is also driving up energy consumption. I want to encourage the high-tech sector to play also a strong role in ensuring development is sustainable and in harmony with the needs of future generations."

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Extra info **www.research.philips.com/password** • OLLA project

OLLA has 24 consortium partners from 8 EU countries

Universities
Ecole Polytechnique Fédérale de Lausanne (Switzerland)
Katholieke Universiteit Leuven (Belgium)
Rijksuniversiteit Groningen (Netherlands)
Technische Universität Dresden (Germany)
University of Kassel (Germany)
Université Louis Pasteur (France)
Universiteit Gent (Belgium)

Research Institutes
CNR-ISOF (Italy)
CNRS-IMN (France)
Fraunhofer Institute for Photonic Microsystems (Germany)
IMEC (Belgium)
Institute of Physical Chemistry Polish Academy of Science (Poland)
National Nanotechnology Laboratory (Italy)
VTT Technical Research Centre (Finland)

Industrial partners
Aixtron (Germany)
Covion Organic Semiconductor (Germany)
H C Starck (Germany)
Novaled (Germany)
OSRAM Opto Semiconductors (Germany)
Philips Research Aachen (Germany)
Philips Lighting (Germany)
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