U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

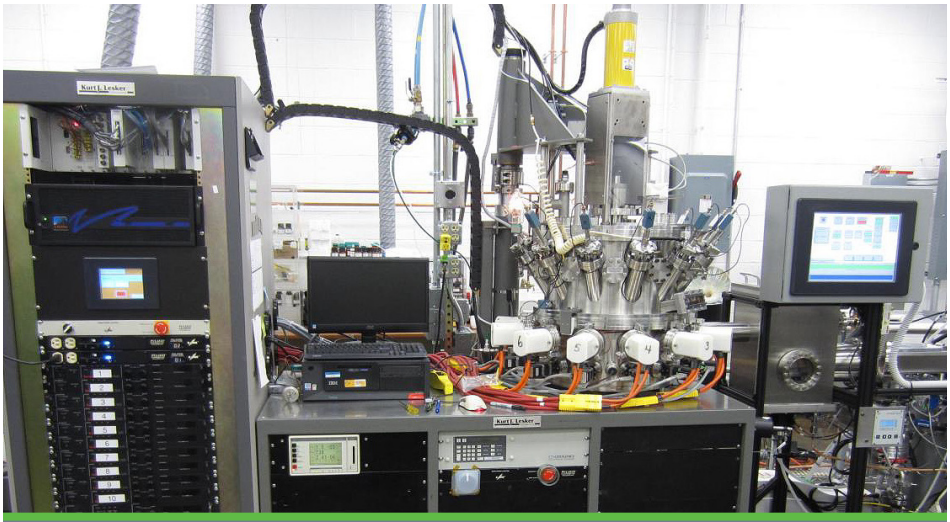
R&D Investments Help OLEDs Become Viable Energy-Efficient Complements to LEDs for General Illumination

In research projects partially funded by DOE, OLEDWorks is successfully addressing the two biggest barriers to OLED lighting: cost and performance.

OLEDWorks is a manufacturer of OLED lighting panels and holds the distinction of being the only such manufacturer in the United States. The company is based in Rochester, NY, not far from the headquarters of Eastman Kodak, where OLEDs were invented in the 1980s. OLEDWorks was founded by former Eastman Kodak scientists and engineers, and is committed to strengthening our nation's economy by maintaining U.S. leadership in OLED research and growing the manufacturing base. U.S. lighting manufacturers have designed a number of commercially available luminaires using OLEDWorks panels.

"DOE funding has been instrumental in the recent improvements in OLED lighting performance, which have made OLED technology much more attractive for luminaire makers to adopt. The funding has helped OLEDWorks improve the efficacy, brightness, lifetime, and reliability of OLED lighting panels; lower their cost; and become the world leader in their commercial manufacture."

— John Hamer, OLEDWorks
Chief Operating Officer



The high-performance deposition system developed by OLEDWorks.
Photo courtesy of OLEDWorks.

OLEDs are organic LEDs, which means that their key building blocks are organic (i.e., carbon-based) materials. The energy-saving potential of OLEDs is similar to that of LEDs, but OLEDs have a number of distinct advantages. In addition to their diffuse nature—which allows them to be viewed directly, decreasing the need for light-absorbing shades, diffusers, lenses, and the like—they can be made very thin, increasing their eye appeal and allowing for easy attachment to the surfaces of walls and ceilings. OLEDs can also be made in almost any shape, can be deposited on flexible substrates, and can be transparent, emitting light from both sides—features that greatly expand the design possibilities, allowing for a completely new lighting experience.

Public-Private Partnership: A Recipe for Success

However, OLEDs are several years behind LEDs in terms of their use for general illumination, and the biggest barrier is their high cost. DOE has funded a series of OLEDWorks projects to help drive down the cost of OLED panels while boosting their efficiency. One of these projects involved the development of an innovative high-performance deposition technology that addressed two major aspects of OLED manufacturing costs: the expense of organic materials per area of useable product, and the depreciation of equipment. The technology developed in this project will help significantly reduce the cost of OLED lighting by, among other things, increasing throughput and raising material-usage efficiency.

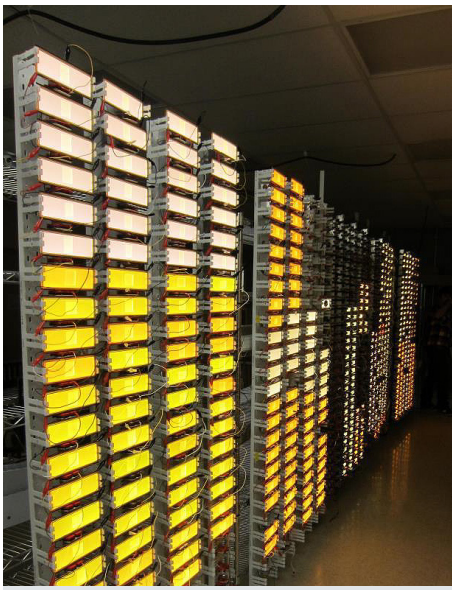
Another DOE-funded project involved developing high-performance OLED lighting panels (>80 lm/W and >85% uniformity) and luminaires (>65 lm/W and >2000 lumens) and integrating cost-effective manufacturing technologies on a large scale, in partnership with Acuity Brands Lighting—addressing low-cost encapsulation, electrode structures, and light-extraction approaches, and using a system approach to determine the best

MARKET IMPACTS

of OLEDWorks' DOE-Funded R&D

In the last five years:

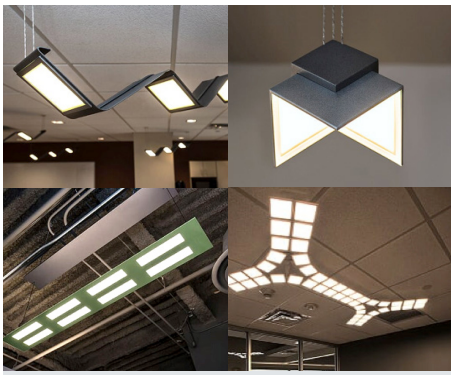
- The cost of OLED panels has decreased more than fivefold.
- OLED panel efficacy has increased nearly fourfold.
- OLED panel lifetime has increased from 15,000 hours to >50,000 hours at 3000 cd/m^2.
- OLED panel color stability ($\Delta u'v'$ over lifetime) has improved from 0.009 to <0.003.
- OLED panel reliability and output have improved significantly.
- OLED panels of various sizes, shapes, and color temperatures have been commercialized.



Panels in testing racks at OLEDWorks
Photo courtesy of OLEDWorks.

combination of component technologies necessary to deliver the desired product performance. Technologies developed in this project will help enable the commercialization in 2018 of the next generation of OLED lighting panels, with target efficacy of 80-90 lm/W.

In still another DOE-funded project, OLEDWorks served as Acuity's partner in developing an OLED luminaire that could lead to more-efficient OLED lighting systems and reduced energy use for building lighting. The luminaire in question features DC-current drivers integrated with each panel, and a base station that interfaces with user control input, provides power to the OLED panels, and translates the control input to desired functionalities of the panels. These projects were key factors leading to the broader adoption of the OLEDWorks Brite2 family of lighting panels into Acuity's Olessense and Trilia fixtures as well as other fixtures Acuity demonstrated at LightFair 2017.



OLEDWorks' panels in commercially available products (clockwise): Limit by Visa Lighting, Petal by Visa Lighting, Trilia by Acuity Brands Lighting, Olessense by Acuity Brands Lighting

In yet another DOE-funded project, OLEDWorks began researching ways to improve device efficiency using a materials approach. Next-generation thermally activated delayed-fluorescence (TADF) emitters and hyperfluorescence (TADF-assisted fluorescence) emitters are being investigated in the hopes of attaining highly efficient and stable blue devices. The project identified key limitations in the TADF approach, enabling OLEDWorks to quickly refocus its efforts on the more promising hyperfluorescence by working with Kyulux, the leader in hyperfluorescent technology development.

Stimulating the U.S. OLED Lighting Industry

In 2014, OLEDWorks came out with its first commercial product, a 1"x4" amber OLED panel that Acuity incorporated into luminaires for the healthcare market. Since then, OLEDWorks has come out with the Brite2 white panel family, the Amber Brite panel, and the Keuka Module (OLED light engine with combined OLED panel and driver), all delivering higher performance for lower cost. The continuous introduction of higher-performance and lower-cost OLED lighting products is providing a boost to the OLED lighting industry, as more luminaire manufacturers introduce products to the market. OLEDWorks' commercial Brite2 panels have achieved efficiencies of 63 lm/W with CRI > 90 and lifetimes of >50,000 hours at 3000 cd/m^2. The target for Brite3 panels, which will be commercialized in 2018, is 80-90 lm/W with CRI >90 and lifetime of >100,000 at 3000 cd/m^2.

OLEDWorks is also a designated testing lab for DOE's OLED Testing Opportunity, which is intended to accelerate developments in OLED lighting technology and manufacturing. The streamlined process enables component makers to incorporate various R&D-stage components into a baseline state-of-the art OLED device. The rapid results of the testing let manufacturers refocus their efforts more quickly than with the formal DOE solicitation process. The collaborative nature of the process also encourages partnerships and accelerates OLED advancements. To date, seven rounds of testing have been completed, involving five different companies.

DOE SSL R&D INVESTMENTS

Goals

1. Maximize the energy efficiency of SSL products in the marketplace.
2. Remove market barriers through improvements to lifetime, color quality, and lighting system performance.
3. Reduce costs of SSL sources and luminaires.
4. Improve product consistency while maintaining high-quality products.
5. Encourage the growth, leadership, and sustainability of domestic U.S. manufacturing within the SSL industry.

Why It Matters

- Technology innovation fuels U.S. economic growth and job creation.
- LEDs and OLEDs that are more cost-competitive will accelerate markets for energy-efficient solid-state lighting, saving energy and money for American homeowners and businesses while creating U.S.-made products that can be sold worldwide.

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