

# 2017 U.S. DEPARTMENT OF ENERGY SOLID-STATE LIGHTING R&D WORKSHOP AGENDA

January 31 – February 2, 2017 • Long Beach, CA

## TUESDAY, JANUARY 31

7:00 a.m. *Registration Opens and Continental Breakfast*

### PLENARY SESSIONS

8:00 a.m. **WELCOME AND INTRODUCTION**

The solid-state lighting revolution embodies a profound shift in how we use and consider lighting. It offers not only unprecedented opportunities to save energy, but also improved performance and value of lighting through enhanced controllability, connectivity, functionality, and novel form factors. This workshop will share the latest on SSL advances, examine market forces that are shaping SSL technology, and explore how the technology is defining new market opportunities. What further research and technology developments are needed in order to exploit the full potential of SSL?

JAMES BRODRICK, U.S. DEPARTMENT OF ENERGY

8:30 a.m. **INNOVATIONS IN SOLID-STATE LIGHTING**

The pace of innovation in today's lighting industry shows no sign of slowing. New products with advanced features continue to broaden the appeal and energy-saving impact of SSL. Cutting-edge research and technology in long wavelength InGaN LED sources, the highest efficient tunnel-junction (TJ) blue LEDs with a wall-plug efficiency of more than 50% (EQE>70%) at the current density of  $35\text{Acm}^{-2}$ , mitigation of droop in LEDs, and the impact of laser diodes for lighting and communications will be presented. This talk will highlight technology challenges that remain in the path of continued growth and performance of SSL.

SHUJI NAKAMURA, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

9:15 a.m. **TURNING PHOTONS INTO FOOD: THE FUTURE OF LEDS IN AGRICULTURE**

Plants require 100 times more light for normal growth than people require for optimal function. Advances in lighting technology have facilitated the year-round production of fresh food in remote locations and the use of LED lighting for horticultural lighting is growing rapidly. This talk will review the recent findings on the unique value of narrow band LEDs to manipulate plant shape, photosynthesis, and growth and discuss the changing economics of LEDs in glass house and indoor horticulture. The initial capital cost of LEDs is still more than five times the cost of 1000-watt, double-ended HPS technology, per photosynthetic photon. A range of opportunities for use of LED technology in the production of fresh food will be discussed.

BRUCE BUGBEE, UTAH STATE UNIVERSITY

10:00 a.m. *Refreshment Break*

10:30 a.m.

**PANEL | ENGINEERED LIGHT: ACTION SPECTRUM AND BEYOND**

Solid-state lighting offers new levels of engineering control over light spectra, but we almost exclusively consider the photopic “action spectrum” associated with the standard human observer when developing products/solutions and specifying/defining the lumen content of light. In fact, as low-cost, engineered solid-state lighting becomes more and more available, different ways in which light will be used will require consideration of different action spectra: human melatonin response, museum-art degradation, cameras for machine vision, plants, animals, etc. Moreover, action spectra interact with other characteristics of light (intensity distribution in time and space) that may also be engineered. This panel will explore the use of engineered light — light whose spectral intensities are tailored in time and space — to accommodate various applications and the action spectra associated with those applications.

MODERATOR: JEFF TSAO, SANDIA NATIONAL LABORATORIES  
WOUTER SOER, LUMILEDS  
PO-CHIEH HUNG, KONICA MINOLTA  
SCOTT ROSENFELD, SMITHSONIAN AMERICAN ART MUSEUM  
TESSA POCOCK, RENSSELAER POLYTECHNIC INSTITUTE

*Noon*

*Lunch*

1:00 p.m.

**PILOTING THE SMART CITY: LESSONS FROM LOS ANGELES ON URBAN SOUNDSCAPES AND THE LIGHTING GRID**

By 2030, 60% of the world’s population will be living in cities, increasing the pressure on urban infrastructure. At the same time, digital technologies have permeated almost every aspect of daily life. City leaders are trying to harness these same technologies — LED lighting among them — to meet the challenges of urbanization. Furthermore, they are keen on enabling new benefits for their constituents such as data-enabled services or cost-savings. In Los Angeles, the Bureau of Street Lighting is building upon its groundbreaking work on LEDification and remote lighting management to pilot new capabilities powered by their ubiquitous network. This presentation will report on some of the lessons learned from the four-month pilot (September – December 2016) which explored lighting grid health for operational efficiency gains and acoustic monitoring to model urban soundscapes via an open smart lighting management system.

SUSANNE SEITINGER, PHILIPS LIGHTING

1:45 p.m.

**THE STORM BEFORE THE STORM: THE LUMINAIRE INDUSTRY BEYOND LED REPLACEMENT**

As a result of the LED revolution, the past few years have been very tumultuous for the lighting industry as a whole. Zumtobel has been on the forefront of this development, and with more than 80% of its revenue now coming from LED products, one could assume that things would slowly be reaching calmer waters. The reality, however, is different, as the full impact and potential unlocked by the LED transition are just now beginning to become apparent on the luminaire level. As a result, luminaire manufacturers are now facing a new set of challenges both in traditional fields like optics, mechanics, and electronics, but also increasingly in the field of communication and software.

MARTIN SIEGEL, ZUMTOBEL

*2:30 p.m.*

*Refreshment Break*

3:00 p.m.

**PANEL | THINKING AHEAD FOR DOMESTIC SSL MANUFACTURING**

U.S. luminaire manufacturers are well-positioned to benefit from the SSL revolution. Manufacturing plants are transitioning from conventional to SSL products, and increasing customization requires localized suppliers and solutions. As new value propositions for lighting are developed, what can be done to maintain and grow U.S.-based manufacturing across the entire value chain, and to expand export opportunities for U.S. products? This panel will explore developments in technology, applications, and manufacturing approaches that will drive SSL manufacturing decisions going forward.

MODERATOR: MORGAN PATTISON, SSLS, INC.

MARK BENGUEREL, FINELITE

MARK HAND, ACUITY BRANDS

ERIC HAUGAARD, CREE

WARREN WEEKS, HUBBELL LIGHTING

4:30 p.m.

**WORKSHOP MISSION**

The DOE SSL R&D Workshop provides an opportunity for stakeholders to provide input to the DOE program. This talk will recap the DOE R&D planning process, share highlights from a series of roundtables and meetings held in 2016, and set the stage for in-depth discussions in the track sessions to come.

MORGAN PATTISON, SSLS, INC.

5:00 p.m.

*Adjourn*

6:00 p.m.

**OPTIONAL TOUR: SSL STREET LIGHTING IN LOS ANGELES (Registration Required)**

This guided bus tour will provide an inside view of Los Angeles' streetlight evolution: past, present, and future.

## WEDNESDAY, FEBRUARY 1

7:00 a.m. *Continental Breakfast*

### PLENARY SESSIONS

8:00 a.m. **DOE SSL PROGRAM DIRECTION**

An overview of the DOE SSL R&D program direction and areas of focus, and a look ahead to what's coming in the next decade.

JAMES BRODRICK, U.S. DEPARTMENT OF ENERGY

8:30 a.m. **PANEL | LIGHTING AND DISPLAY TECHNOLOGY SYNERGY**

Advancements in display and lighting technology have come hand in hand, from LED back-lit LCDs to OLED displays to quantum dot displays and now micro LEDs. What can the lighting industry learn from the experiences and technology advances of displays, and what overlap is there between lighting and display manufacturing? This panel will explore the impact of OLEDs, quantum dots, and micro LEDs and their role in the design and manufacturing of lighting products.

MODERATOR: NORMAN BARDSLEY, BARDSLEY CONSULTING

BARRY YOUNG, OLED ASSOCIATION

ROBERT JAN VISSER, APPLIED MATERIALS

JUANITA KURTIN, PACIFIC LIGHT TECHNOLOGIES

CHARLES LI, PLAYNITRIDE

10:00 a.m. *Refreshment Break*

### TRACK SESSIONS

10:30 a.m. **LED TRACK I: LUMINAIRE INTEGRATION, DRIVERS, AND CONTROLS**

This discussion will cover opportunities and challenges for developing luminaires that demonstrate value beyond traditional lighting expectations.

MODERATOR: MORGAN PATTISON, SSLS, INC.  
RAMANUJAM RAMABHADHAN, GE GLOBAL RESEARCH

ALIREZA SAFAEE, OSRAM  
CHAD STALKER, ACUITY BRANDS  
DORENE MANICCIA, PHILIPS LIGHTING RESEARCH NORTH AMERICA

**OLED TRACK I: CHALLENGES IN MANUFACTURING**

In order to scale up OLED panel production, manufacturing advancements are needed for encapsulation, electrical connections, the incorporation of internal extraction layers, and control of the active organic materials.

MODERATOR: NORMAN BARDSLEY,  
BARDSLEY CONSULTING

JOHN HAMER, OLEDWORKS  
CHRIS BROWN, KATEEVA  
DAVID ROWE, 3M

Noon

*Lunch*

1:00 p.m.

**LED TRACK II: NEW SSL MANUFACTURING METHODS**

This session will explore new manufacturing methods on the horizon for luminaires, quantum dots, power supply components, and optics.

MODERATOR: JEFF TSAO, SANDIA NATIONAL LABORATORIES  
SRIDHAR NIMMA, EATON CORPORATION  
JONATHAN OWEN, COLUMBIA UNIVERSITY  
SETH COE-SULLIVAN, LUMINIT  
JUAN RIVAS-DAVILA, STANFORD UNIVERSITY

**OLED TRACK II: PRODUCT DESIGN AND INTEGRATION**

To realize the full aesthetic and performance potential of OLEDs in lighting products, the total system needs to be considered, including panel, driver, and luminaire designs.

MODERATOR: LISA PATTISON, SSLS, INC.  
MIKE LU, ACUITY BRANDS  
JACKY QIU, OTI LUMIONICS  
ALIREZA SAFAEE, OSRAM  
JEFF SPINDLER, OLEDWORKS and  
LARRY SADWICK, INNOSYS

2:30 p.m.

*Refreshment Break*

3:00 p.m.

**PANEL | LIGHTING INTEGRATION INTO BUILDINGS**

New opportunities for integrating lighting into the building (or roadway) are emerging. Mechanical, electrical, and even optical integration of lighting into a building should be reconsidered within the context of new SSL sources. Mechanically, lighting can be attached or embedded into our built environment in new ways. Electrically, DC grids or connected systems can be used to minimize AC-DC conversion losses, simplify installation, and provide a common platform for lighting along with other building systems. Optically, SSL can be designed to use the optical properties of surfaces in the space to provide enhanced lighting performance and aesthetics. This panel will review different integration concepts and the value propositions they present.

MODERATOR: MONICA HANSEN, LED LIGHTING ADVISORS  
SCOTT HERSHMAN, LF ILLUMINATION  
BRAD KOERNER, PHILIPS  
EVAN PETRIDIS, ENLIGHTED  
WEN-LIN TSAO, CISCO

4:30 p.m.

**LEVERAGING DOE SSL R&D**

The DOE SSL program supports the development of energy-saving SSL products directly through Core, Product Development, and Manufacturing R&D projects, funded via the solicitation process. But where a broader approach is needed, the program supports other R&D efforts designed to accelerate technology and product advances in ways that benefit the lighting industry as a whole. The speakers in this session will review the typical FOA process as well as new R&D efforts within the DOE SSL program related to OLED testing, connected lighting systems, and more.

JOEL CHADDOCK, NATIONAL ENERGY TECHNOLOGY LABORATORY  
MARC LEDBETTER, PACIFIC NORTHWEST NATIONAL LABORATORY

5:00 –  
7:30 p.m.

## RECEPTION/POSTER SESSION

Project posters will be presented by research team representatives, providing an opportunity for one-on-one discussions with SSL's leading scientists.

## POSTER PRESENTERS AND EXHIBITORS

Acuity Brands	OLEDWorks
Arizona State University	Pacific Northwest National Laboratory
Carnegie Mellon University	Penn State University
Columbia University	Philips Lighting
Cree	Philips Lighting Research North America
Eaton	PhosphorTech
GE Global Research	Pixelligent
InnoSys	Princeton University
Iowa State University	RPI Center for Lighting Enabled Systems & Applications
Konica Minolta	RTI International
Los Alamos National Laboratory	SC Solutions
Lucent Optics	Sinovia Technologies
Lumenari	University of California, Los Angeles
Lumileds	University of California, Santa Barbara
Lumisyn	University of Michigan
MicroContinuum	University of New Mexico
MoJo Labs	UbiQD
National Energy Technology Laboratory	Utah State University
National Institute of Standards and Technology	Vadient Optics
National Renewable Energy Laboratory	Vitro Architectural Glass
Navigant Consulting	
North Carolina State University	

## STUDENT POSTER CONTEST WINNERS

Indrani Bhattacharya, Rensselaer Polytechnic Institute  
Hao Chen, University of Central Florida  
Clayton Cozzan, University of California, Santa Barbara  
Jinyuan Zhao, Boston University

## THURSDAY, FEBRUARY 2

7:00 a.m.

*Continental Breakfast*

### PLENARY SESSION

8:00 a.m.

#### **MARKETS FOR SSL TECHNOLOGIES**

This talk will provide an overview on the global market for LEDs, lamps, and luminaires along with markets for new lighting applications such as connected and horticultural lighting.

SPEAKER TBA (INVITED)

### TRACK SESSIONS

8:30 a.m.

#### **LED TRACK III: LED OPTICS AND DOWN-CONVERTERS**

Beyond the LED chip itself there are important areas for improvement in the package. This panel will explore R&D in various down-converter materials and primary optics designs for improved efficiency.

MODERATOR: MONICA HANSEN,  
LED LIGHTING ADVISORS  
OLEG SHCHEKIN, LUMILEDS  
JONATHAN MELMAN, LUMENARI  
JENNIFER HOLLINGSWORTH, LOS ALAMOS  
NATIONAL LABORATORY  
RALPH TUTTLE, CREE

#### **OLED TRACK III: LIGHT EXTRACTION AND UTILIZATION**

OLED light extraction efficiency and optical utilization will be discussed as this panel explores novel materials and approaches for light extraction and preliminary experiments into directionalizing the light output of OLED devices.

MODERATOR: LISA PATTISON, SSLS, INC.  
STEVE FORREST, UNIVERSITY OF MICHIGAN  
GREG COOPER, PIXELLIGENT  
SEBASTIAN REINEKE, TECHNISCHE  
UNIVERSITÄT DRESDEN

10:00 a.m.

*Refreshment Break*

10:30 a.m.

#### **LED TRACK IV: PROGRESS ON MATERIALS AND DEVICE RESEARCH**

This session will explore new research results in light-emitting materials, physics, and devices, including those that intersect two ongoing key challenges: efficiency droop and the “green gap.”

MODERATOR: JEFF TSAO, SANDIA NATIONAL  
LABORATORIES  
COLIN HUMPHREYS, UNIVERSITY OF  
CAMBRIDGE  
JAMES RARING, SORAA LASER  
JIM SPECK, UNIVERSITY OF CALIFORNIA,  
SANTA BARBARA

#### **OLED TRACK IV: ADVANCES IN ORGANIC MATERIALS AND ELECTROLUMINESCENT QUANTUM DOTS**

Advancements in organic emitter materials research are still necessary to meet the ultimate potential of OLEDs. The availability of a highly efficient stable blue emitter system is problematic, and the performance of solution-processed materials still lags that of those deposited in vapor. New materials and approaches to enhance the overall device performance will be explored.

MODERATOR: NORMAN BARDSLEY,  
BARDSLEY CONSULTING

TETSUYA TAKEUCHI, MEIJO UNIVERSITY

CHRIS GIEBINK, PENN STATE UNIVERSITY  
PAUL HOLLOWAY, NANOPHOTONICA  
MARK THOMPSON, UNIVERSITY OF SOUTHERN CALIFORNIA

Noon

Lunch

## PLENARY SESSIONS

1:00 p.m.

### LED AND OLED TOPIC TABLES

Attendees will break into small groups to discuss a variety of topics considered key to furthering SSL technology advances. Each table will focus on a specific R&D topic, allowing for a more detailed exploration of the topic and related issues. Input will guide the choice of priority R&D topics and other updates to metrics and milestones in the DOE R&D Plan.

2:30 p.m.

Refreshment Break

3:00 p.m.

### LED AND OLED TOPIC TABLE REPORT-OUT

3:30 p.m.

### PANEL | CREATING VALUE FROM HUMAN PHYSIOLOGICAL RESPONSES TO LIGHT

It's still early, but the understanding of physiological responses to light is advancing rapidly. There can be numerous benefits from lighting that is more tailored to human physiological responses. Light will play an important role in healthy and productive lifestyles, can be part of therapy and care for certain illnesses, and can be tuned to minimize problems caused by travel and work-cycles that misalign our circadian rhythms with normal diurnal cycles. This panel will explore how our current understanding of these responses can be applied and what further research is necessary to develop further applications.

MODERATOR: MORGAN PATTISON, SSLS, INC.

WINDY BOYD, NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES

JAMIE ZEITZER, STANFORD UNIVERSITY

MICHAEL HERF, F.LUX

SMITH JOHNSTON, NASA JOHNSON SPACE CENTER

5:00 p.m.

Adjourn