



U.S. Department of Energy  
Energy Efficiency and Renewable Energy

# DOE Solid State Lighting Status and Future

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US Department of Energy  
Office of Energy Efficiency and Renewable Energy  
Buildings Technologies Program

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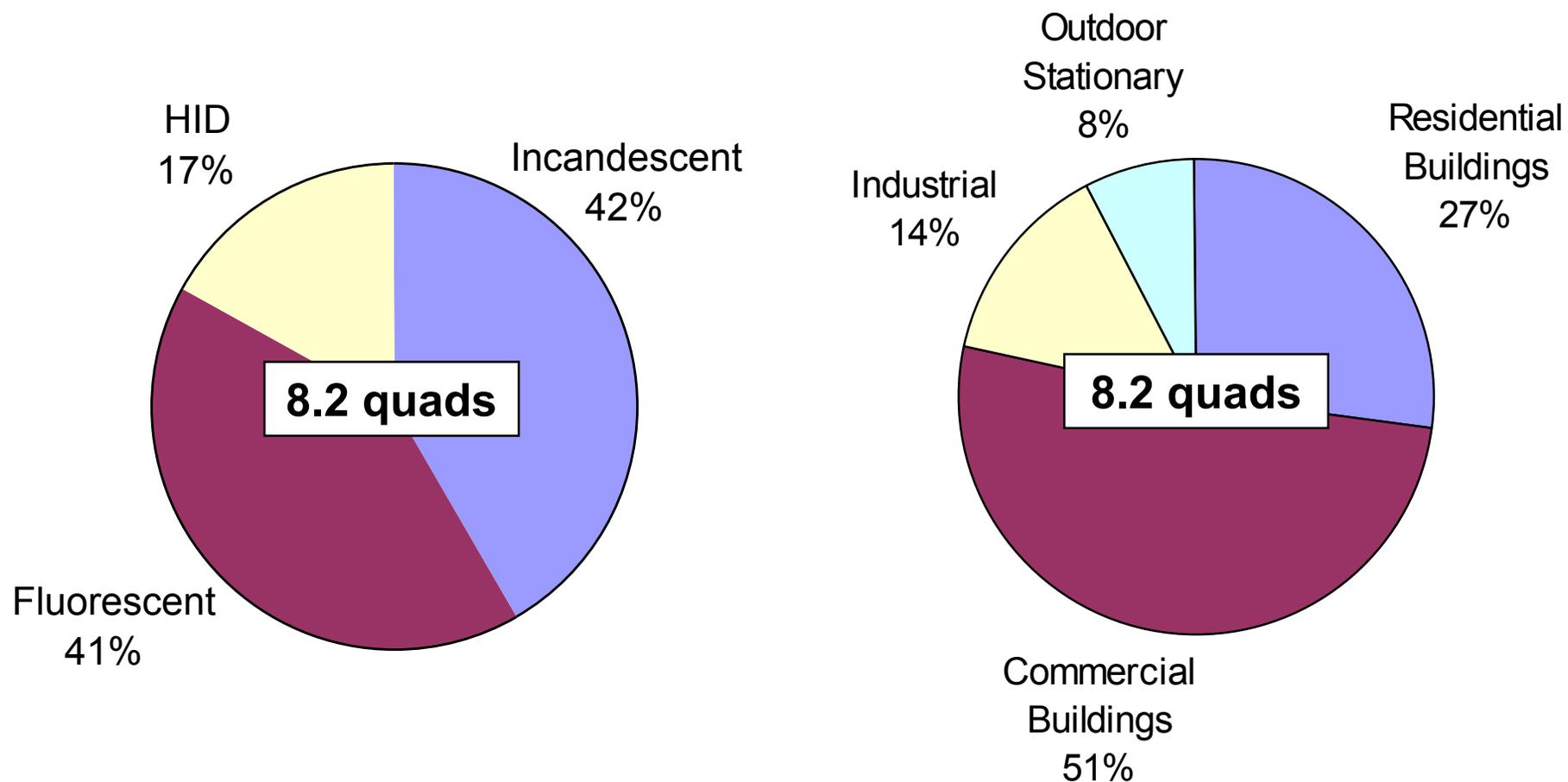
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# U.S. Lighting Energy Consumption



*Quantity of primary energy consumed to provide electricity for lighting.*



## Typical Light Sources Today

### Source Efficacy

- Incandescent (75W) ~13 lm/W
- Fluorescent (T8) ~83 lm/W
- HID (Metal Halide) ~100 lm/W
- SSL (White LED) ~20 lm/W

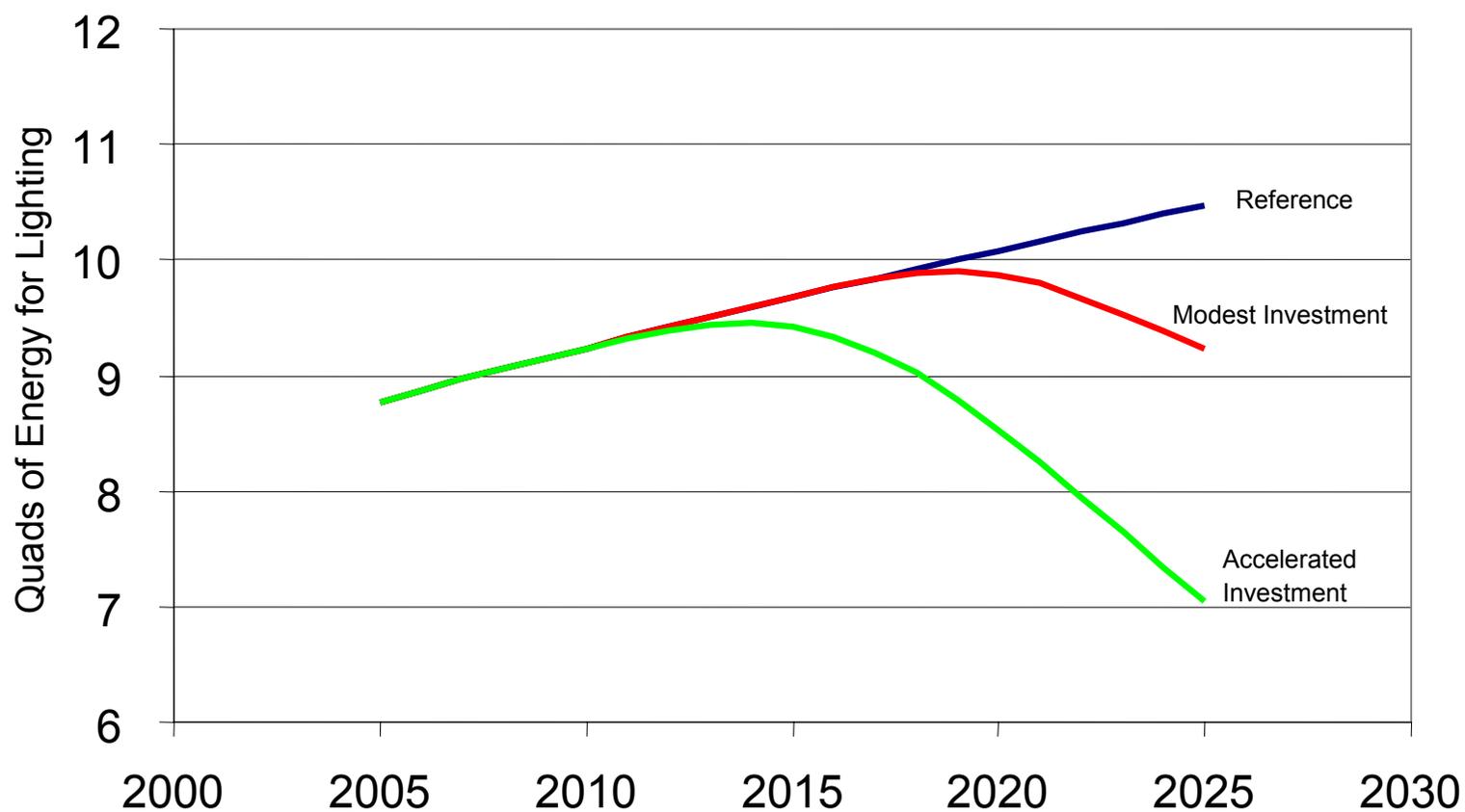
### Lamp Price

- Incandescent (75W) ~0.60 \$/klm
- Fluorescent (T8) ~0.73 \$/klm
- HID (Metal Halide) ~1.27 \$/klm
- LED (White, 2003) ~350.00 \$/klm





## Energy Savings Potential of SSL





## **Benefits of SSL Energy Savings**

- **Energy Savings**
  - Lower energy bills for consumers
  - Peak power savings (and T&D network)
  - Avoid need to build power plants
  - Emission reductions
- **Improved Service and Features**
- **U.S. Employment**
- **Durability**
- **Less Hazardous Material**



# **Mission Statement**

## **Solid State Lighting Program Mission**

**Guided by a government-industry partnership, the mission is to create a new market for high-efficiency, general illumination products through the advancement of semiconductor technologies, to save energy and enhance the quality of the lighted environment.**



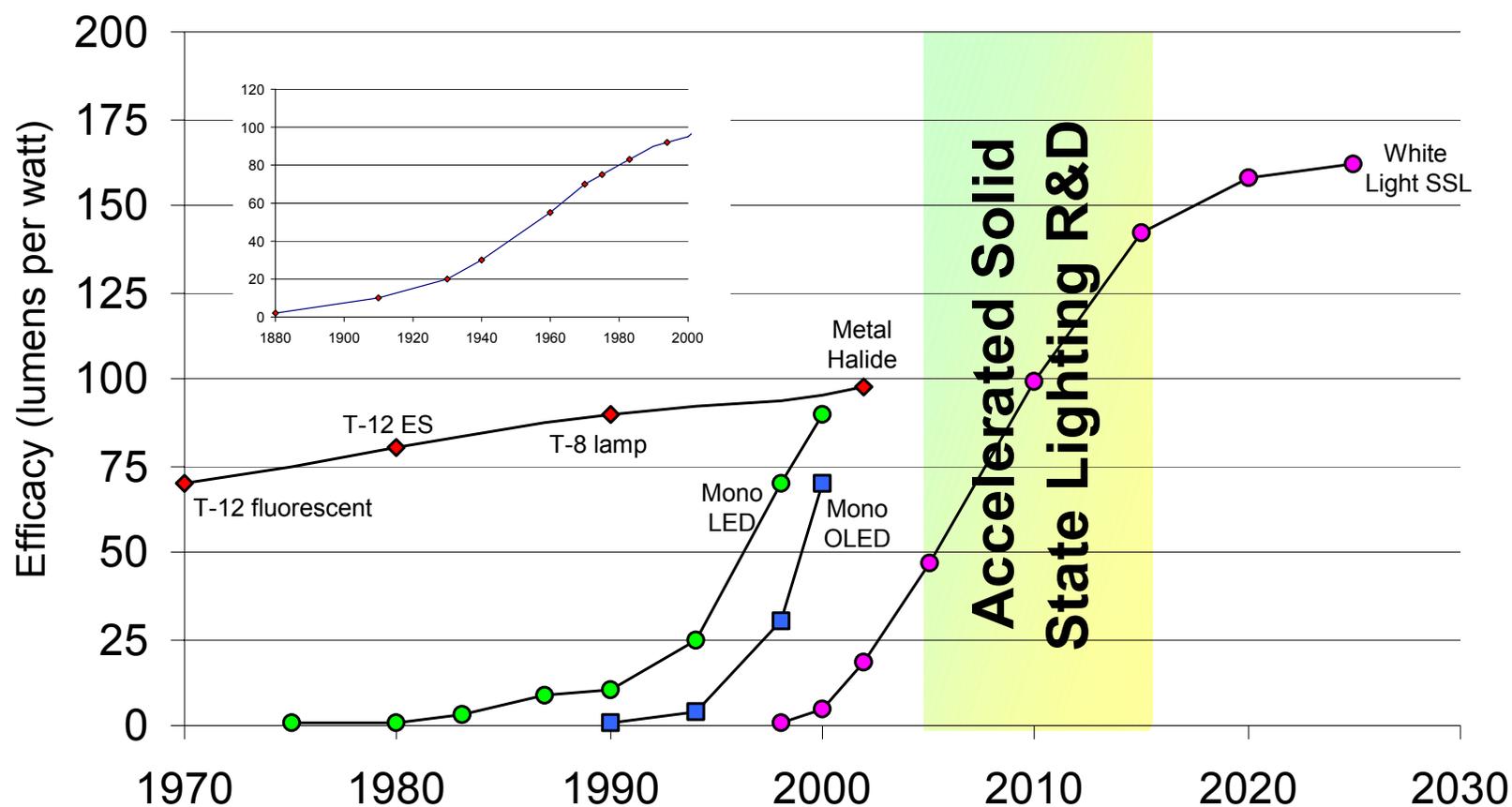
## **Goal Statement**

### **Solid State Lighting Program Goal**

**By 2015, develop advanced solid state lighting technologies that compared to conventional lighting technologies, are much more energy efficient, longer lasting, and cost-competitive by targeting a product system efficiency of 50 percent with lighting that accurately reproduces sunlight spectrum.**



# Accelerated R&D for White Light SSL





# SSL Research Facets to Achieve White Light





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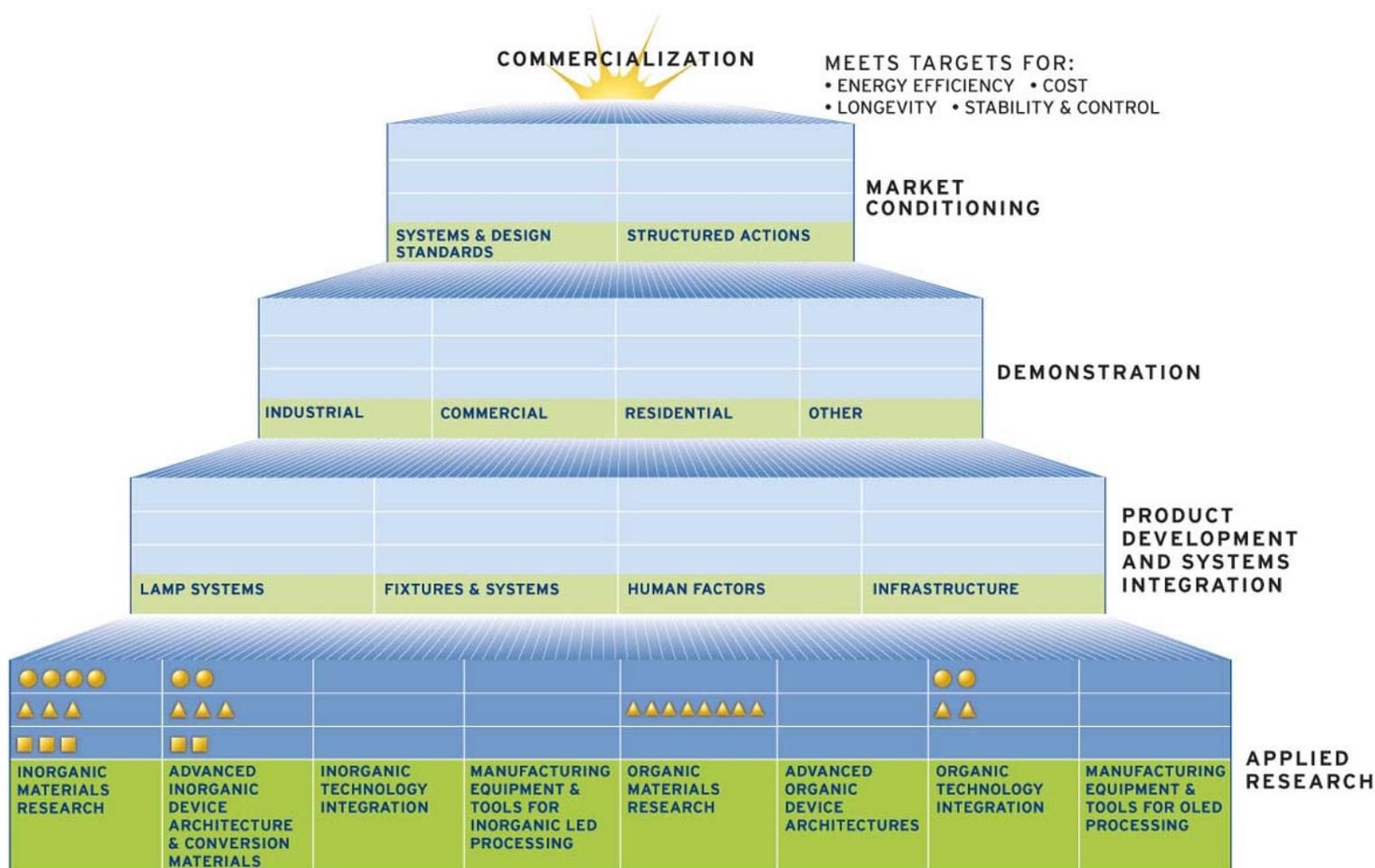
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# The Pyramid of SSL White Light



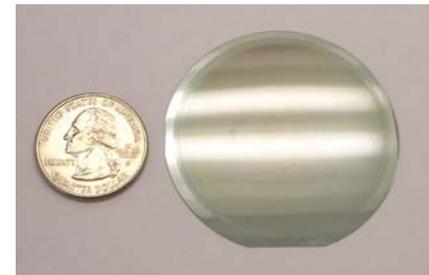
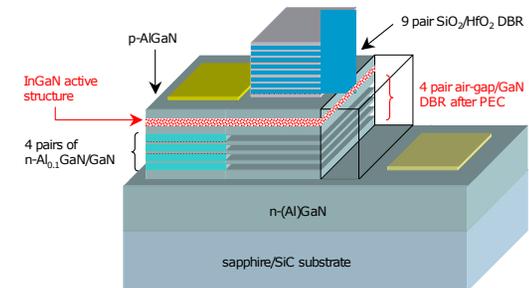
**FUNDING SOURCES**

● BUILDING TECHNOLOGY/NETL    ▲ SMALL BUSINESS INNOVATION RESEARCH (SBIR)    ■ EE SCIENCE INITIATIVE (EESI)



# Light Emitting Diodes

- **Brown University**
  - Improve nanomaterials to increase light emission
- **Cermet**
  - Develop AlN substrate for UV LEDs
- **Cermet**
  - Grow conventional materials on novel substrates to improve efficiency





# Light Emitting Diodes

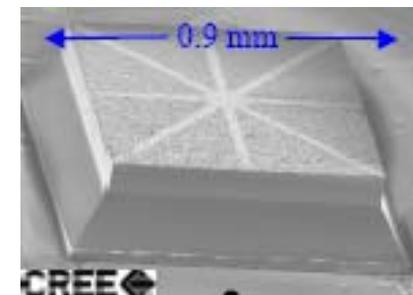
- **Cree Lighting Company**

- Improve package efficiency and brightness through the development of new materials and structures



- **Cree Lighting Company**

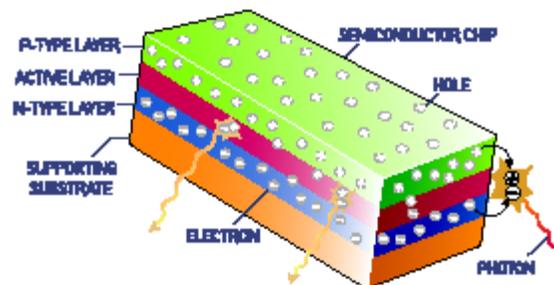
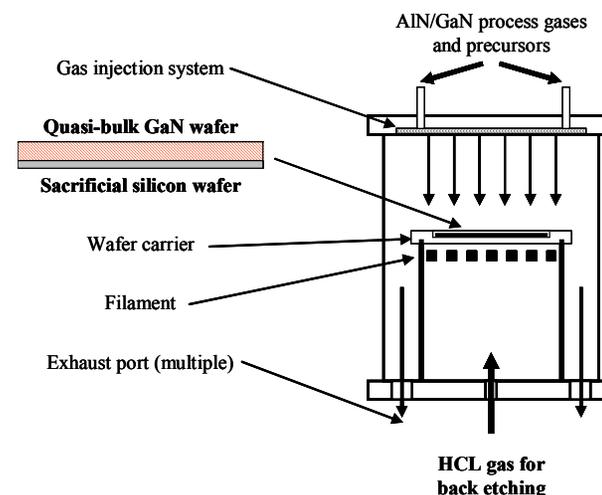
- Increase current densities and decrease life-cycle costs of white LEDs





# Light Emitting Diodes

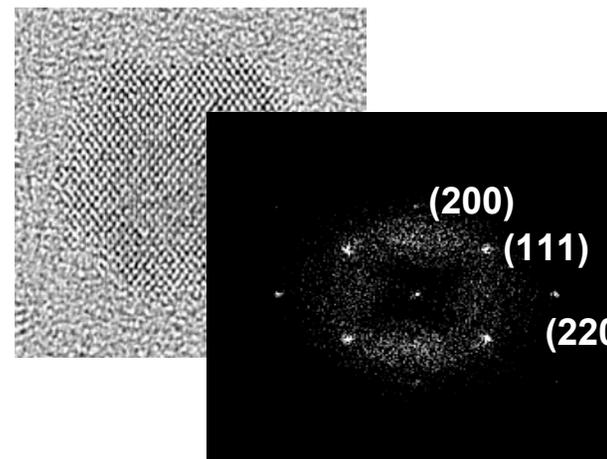
- **Georgia Tech Research Foundation**
  - Study GaN substrates for use as solid state sources
- **Georgia Tech Research Foundation**
  - Provide understanding of the chemical processes behind light production





# Light Emitting Diodes

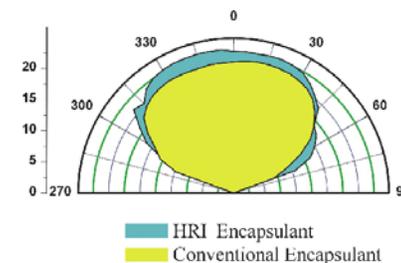
- **InnovaLight**
  - Development of silicon nanocrystals as white phosphors
- **Kyma Technologies**
  - Improve gallium nitride substrates





# Light Emitting Diodes

- **LumiLeds and Sandia National Lab**
  - Improve LED substrate performance through the study of reactor tools and the testing of new materials
- **Nanocrystals Technology**
  - Enhance optical efficiency of LEDs with unique nanophosphors

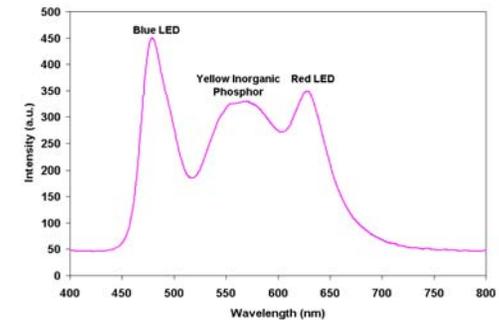
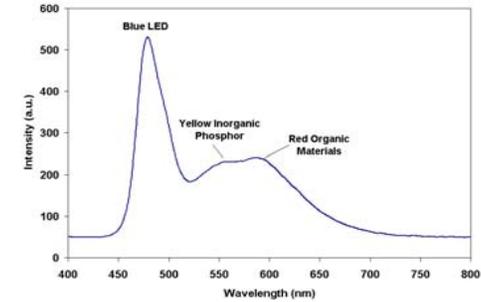




# Light Emitting Diodes

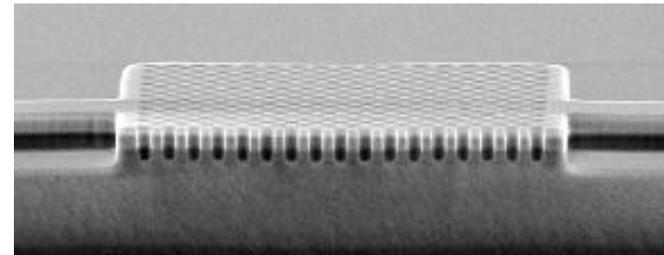
- **PhosphorTech Corporation**

- Develop efficient hybrid organic / inorganic phosphors for more efficient LEDs



- **Sandia National Labs**

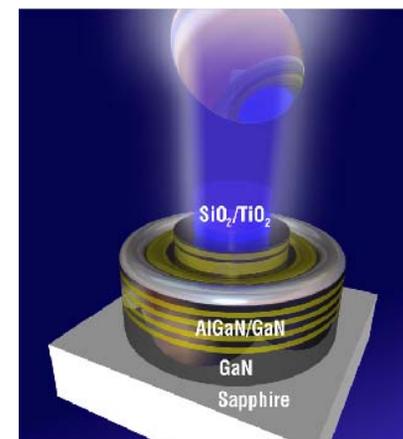
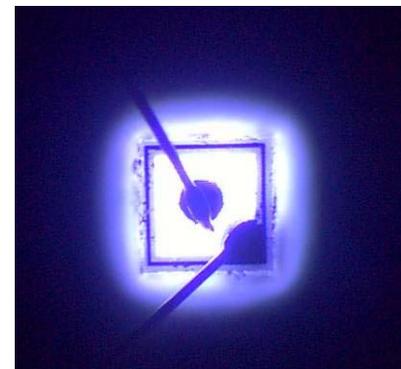
- Development photonic crystals to improve the efficacy of LEDs





# Light Emitting Diodes

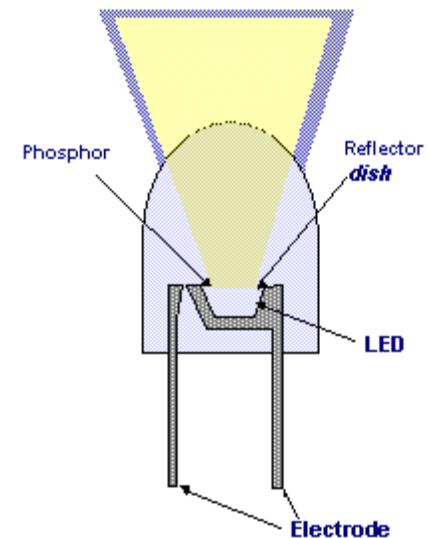
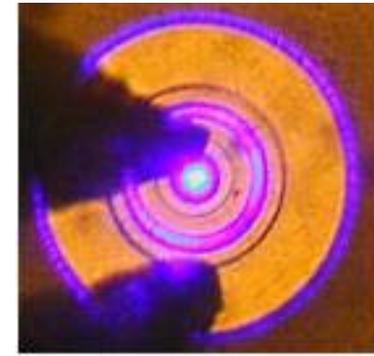
- **Technologies and Devices International**
  - Develop novel epitaxial structures for GaN-based devices and packaging
- **University of California – San Diego**
  - Research novel white-emitting phosphor technology





# Light Emitting Diodes

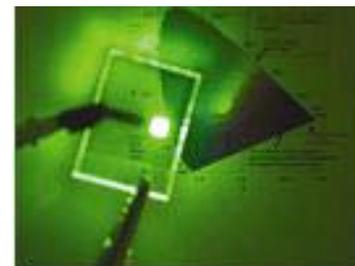
- **University of California – Santa Barbara**
  - Develop vertical cavity emitting structures to boost light extraction efficiency
  
- **University of Georgia Research Foundation**
  - Development of UV-LED phosphor coating to improve conversion efficiency





# Organic Light Emitting Diodes

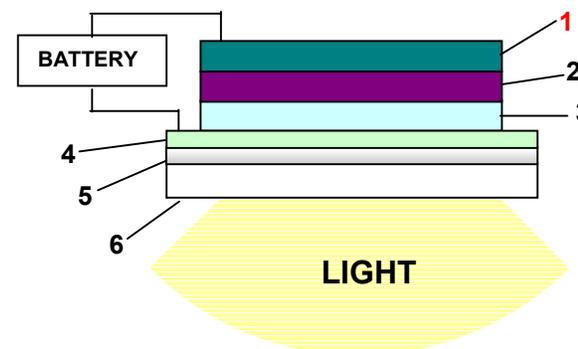
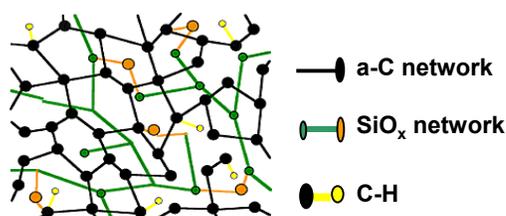
- **General Electric Global Research and Cambridge Display Technology**
  - Improve performance and durability of OLEDs
  
- **Intelligent Optical Systems, Inc.**
  - Reduce OLED costs and improve CRI through the use of novel materials





# Organic Light Emitting Diodes

- **International Technology Exchange**
  - Develop new stable cathode material for OLEDs



- **Maxdem, Incorporated**
  - Develop phosphorescent single-layer OLEDs

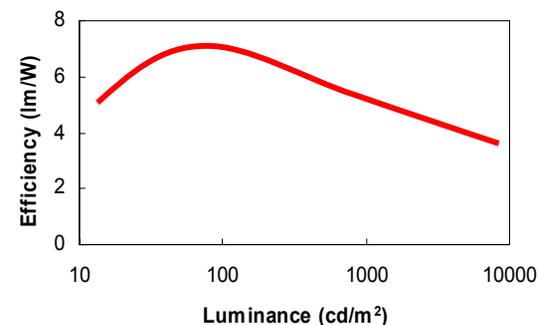




# Organic Light Emitting Diodes

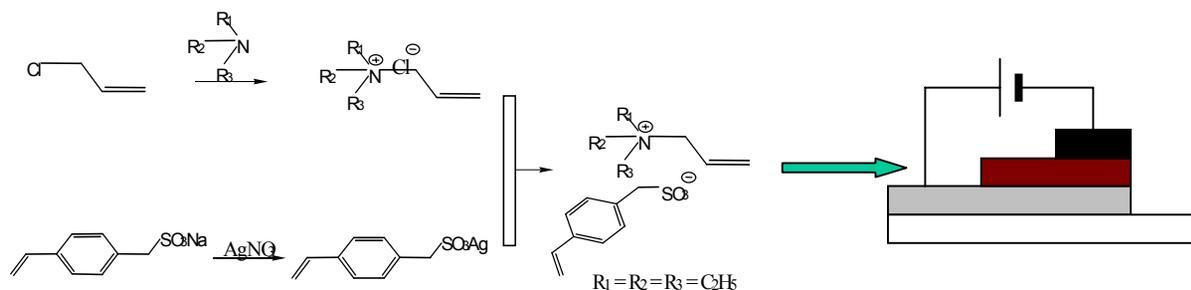
- **OSRAM Opto Semiconductors Inc.**

- Demonstrate a polymer OLED with improvements in size, efficacy and life



- **Reveo**

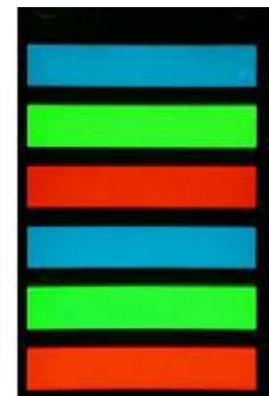
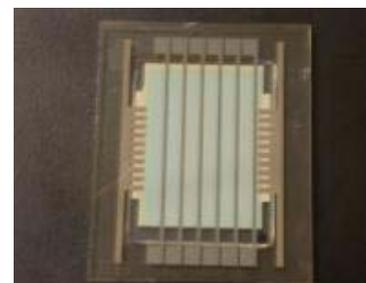
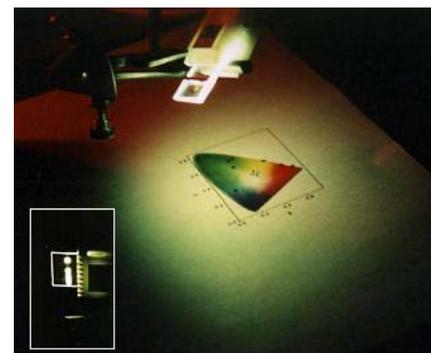
- Develop light emitting electrochemical cells for white OLEDs





# Organic Light Emitting Diodes

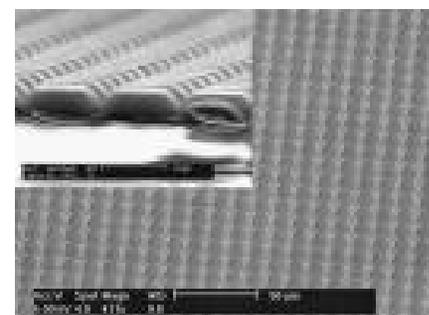
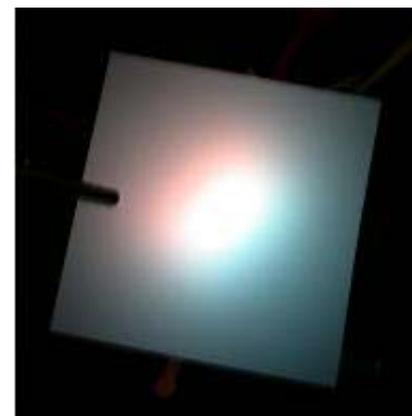
- **Universal Display Corporation, Princeton, and the University of Southern California**
  - Develop monomer-excimer phosphorescent OLED technology
  
- **Universal Display Corporation, Princeton, and the University of Southern California**
  - Develop striped phosphorescent OLED technology





# Organic Light Emitting Diodes

- **Universal Display Corporation, Princeton, and the University of Southern California**
  - Develop white OLEDs with efficiency greater than 20 lm/W
- **Universal Display Corporation and Princeton University**
  - Develop innovative techniques to improve OLED power efficiencies through better light extraction techniques





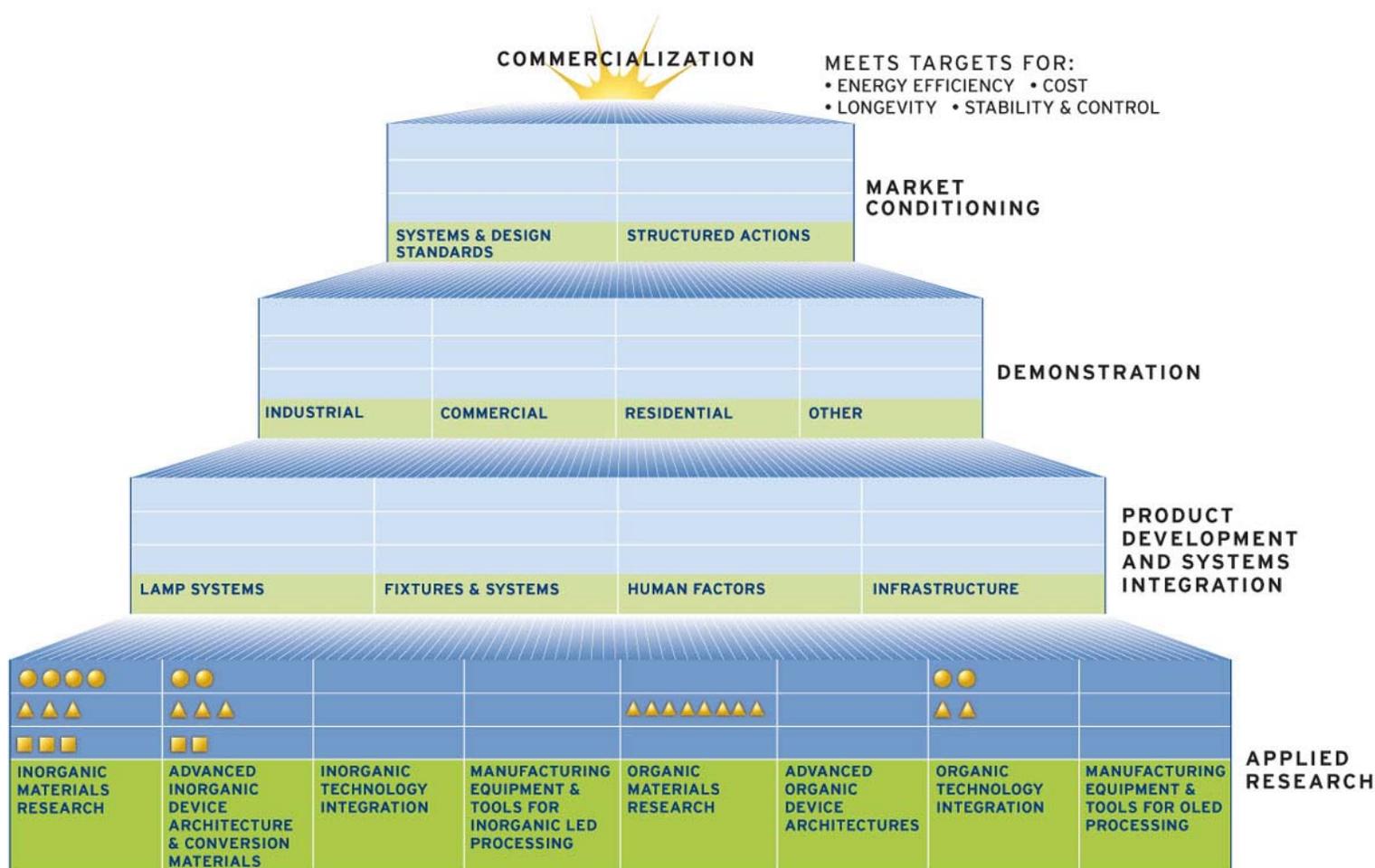
# Organic Light Emitting Diodes

- **Universal Display Corporation and the University of Southern California**
  - Develop novel, lower voltage, light emitting structures





# The Pyramid of SSL White Light



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# DOE Funding Opportunities

Research		Development			Demo	Sales
Basic	Applied	Exploration	Advancement	Engineering		
Basic Energy Science (Office of Science)						Commercialization
	EE Science (Office of EERE)					
	Building Technology/NETL (Office of EERE)					
Small Business Innovation Research (Office of Science)						
			State Technologies Advancement Collaborative (Office of EERE/States)			
			Inventions and Innovation (Office of Industrial Technology)			



## DOE Funding Opportunities

- Office of Science, Annual Solicitation Process  
*<http://www.science.doe.gov/grants/Fr04-01.html>*
- Office of Energy Efficiency and Renewable Energy, Science Initiative  
*<http://www.naseo.org/stac/>*
- Office of Energy Efficiency and Renewable Energy, BT/NETL Solid State Lighting Technology Solicitation  
*<http://www.netl.doe.gov/business/> or <http://www.netl.doe.gov/ssl/>*
- Office of Science, Small Business Innovation Research  
*<http://sbir.er.doe.gov/sbir>*
- Office of Energy Efficiency and Renewable Energy / States, State Technologies Advancement Collaborative (STAC)  
*<http://www.naseo.org/stac/default.htm>*
- Office of Industrial Technology, Inventions and Innovation  
*<http://www.oit.doe.gov/inventions/solicitations.shtml>*



## DOE Affiliated Solicitations

Open, due Jan 6, 2004	<ul style="list-style-type: none"><li>• Small Business Innovation Research (SBIR) Program</li></ul>
TBD	<ul style="list-style-type: none"><li>• EE Science Solicitation, through State Technologies Advancement Collaborative (STAC)</li></ul>



## Illuminating Ideas

- DOE engages community in an open, competitive process
- Sharing of risk
- Collaborative partnerships to tackle technical challenges
- Improve price and performance of white light SSL devices
- National energy security and benefits

