DOE SSL Research & Development Program Update

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DOE Solid-State Lighting Program Mission and Goal

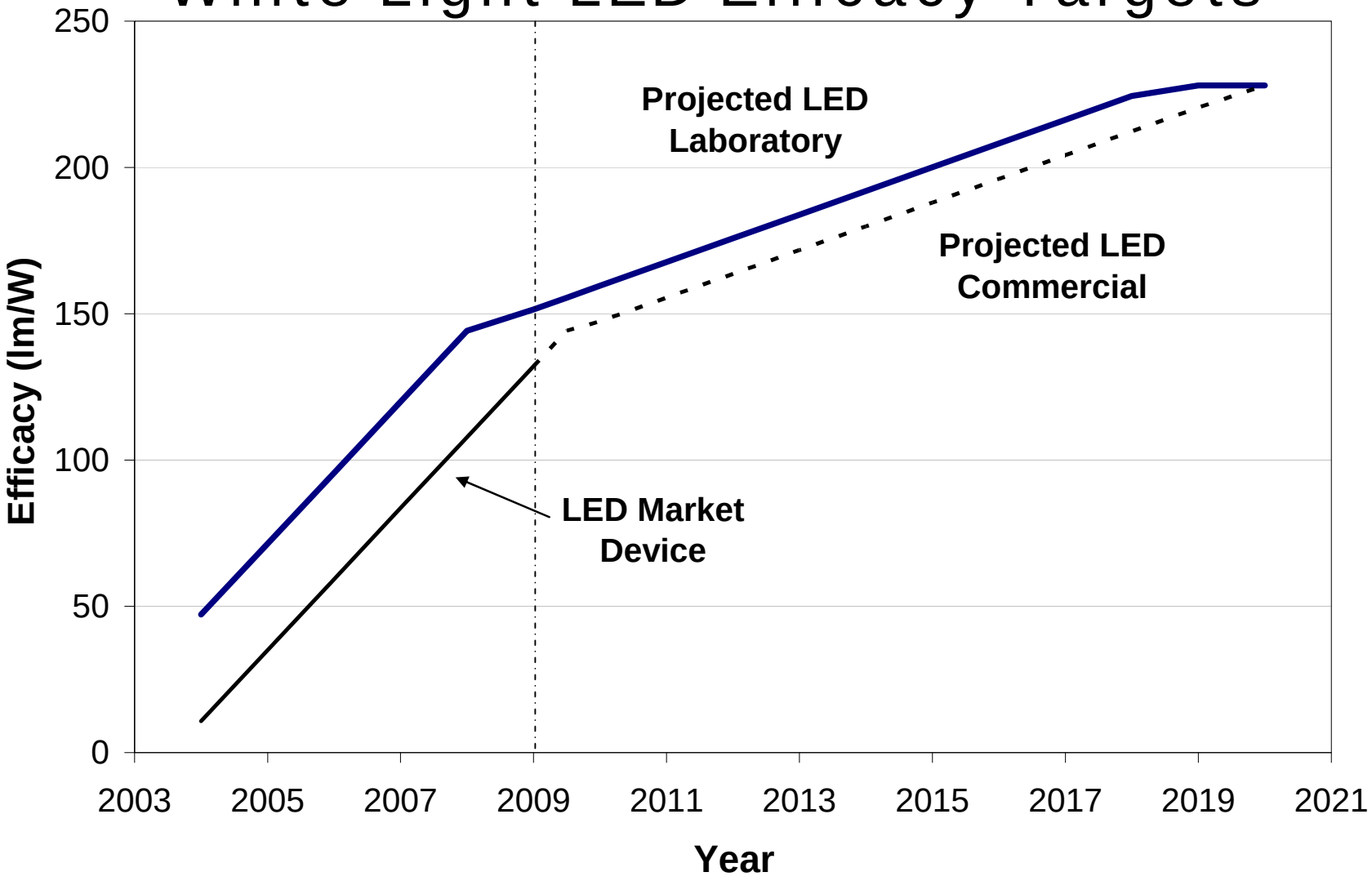
Mission

Guided by a government-industry partnership, DOE's mission is to create a new, U.S.-led market for high-efficiency, general illumination products through the advancement of semiconductor technologies, to save energy, reduce costs, and enhance the quality of the lighted environment.

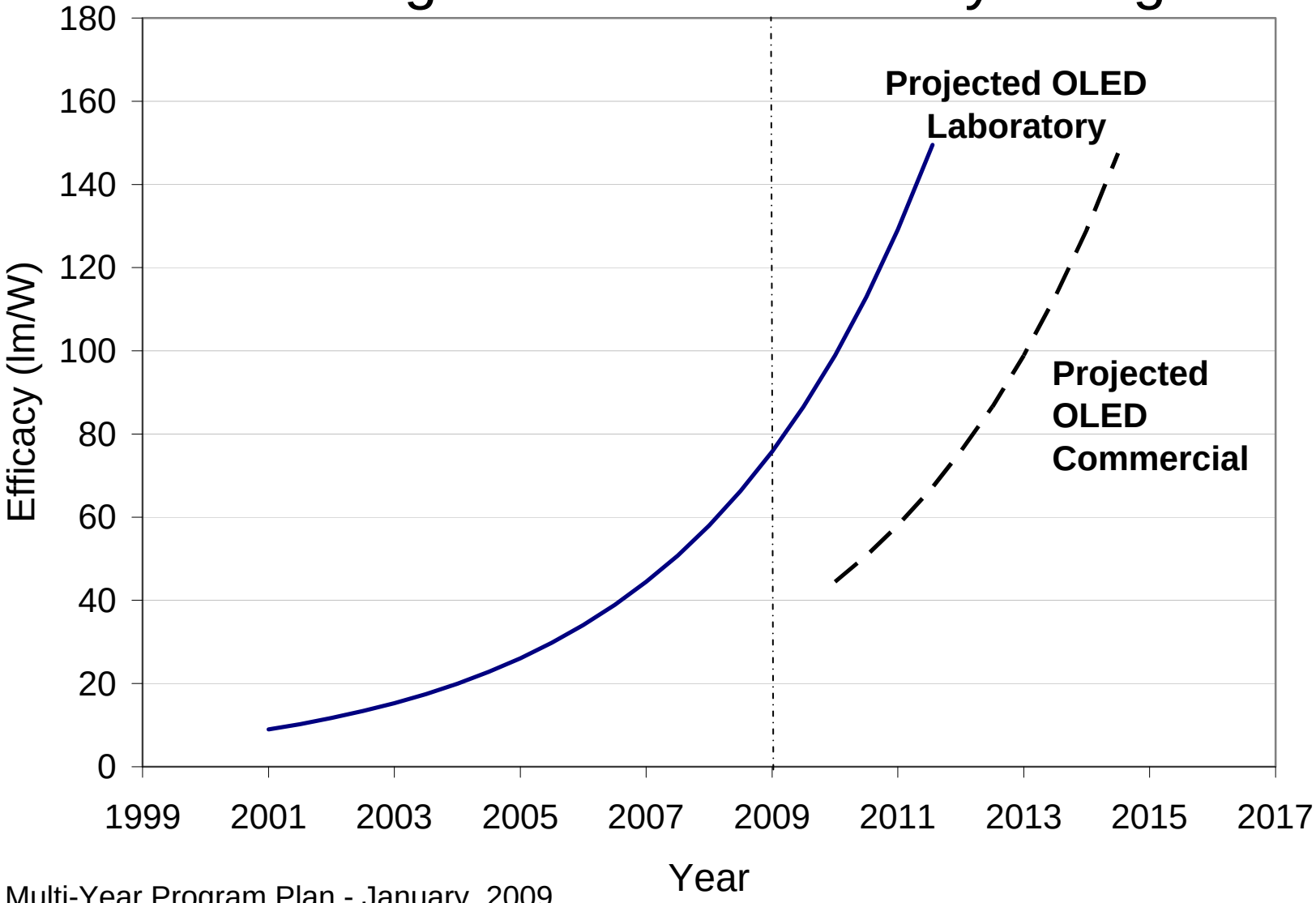
Goal

By 2025, develop advanced SSL 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.

White-Light LED Efficacy Targets



White-Light OLED Efficacy Targets



SSL Multi-Year Program Plan - January, 2009.

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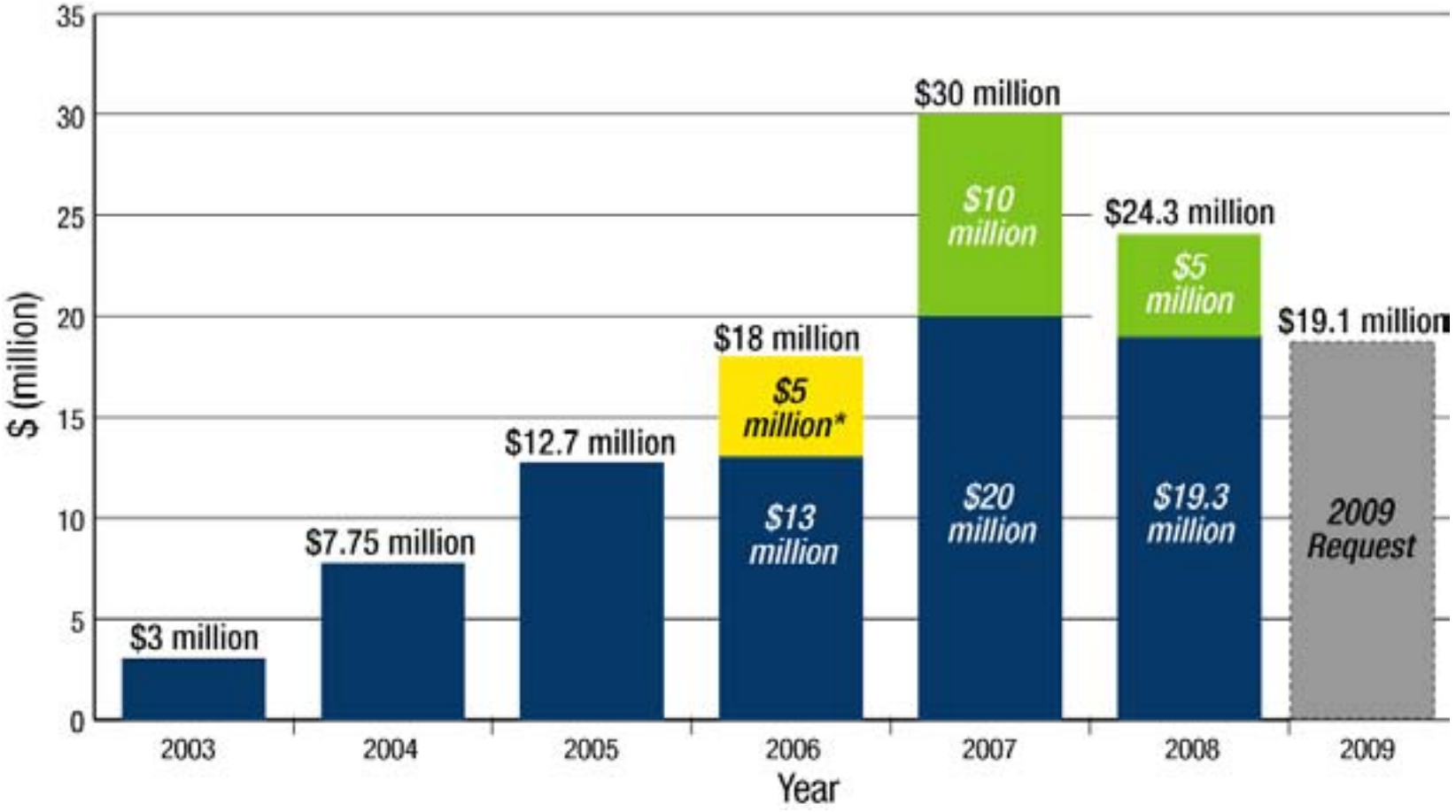
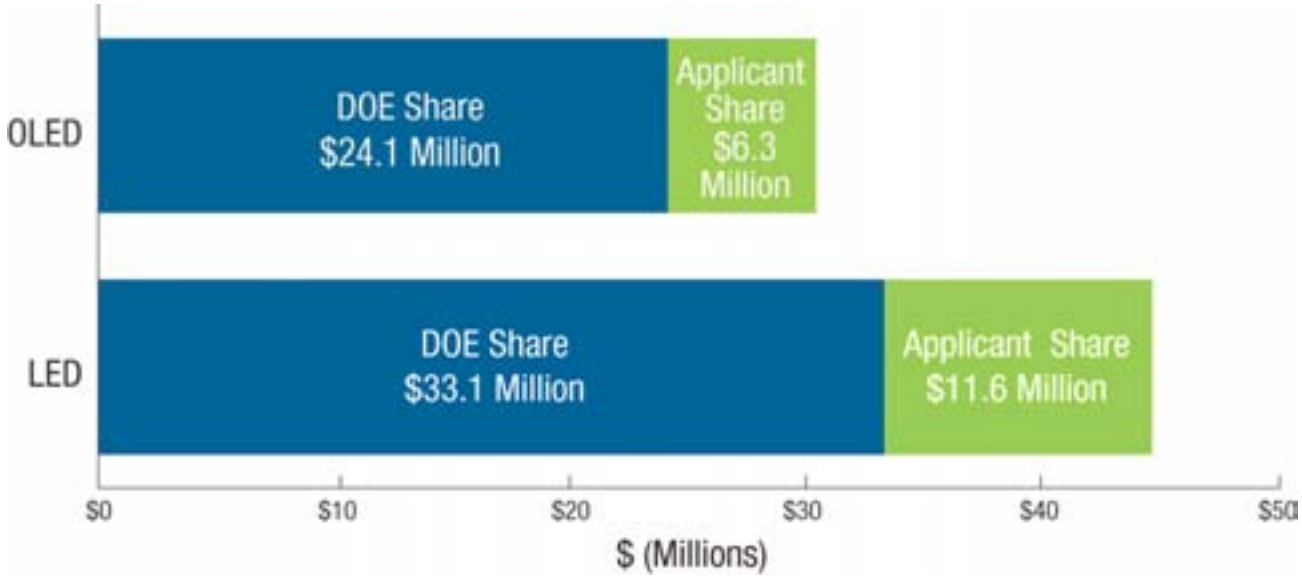
Congressional Appropriations



*Congressional Directive

SSL R&D Project Funding



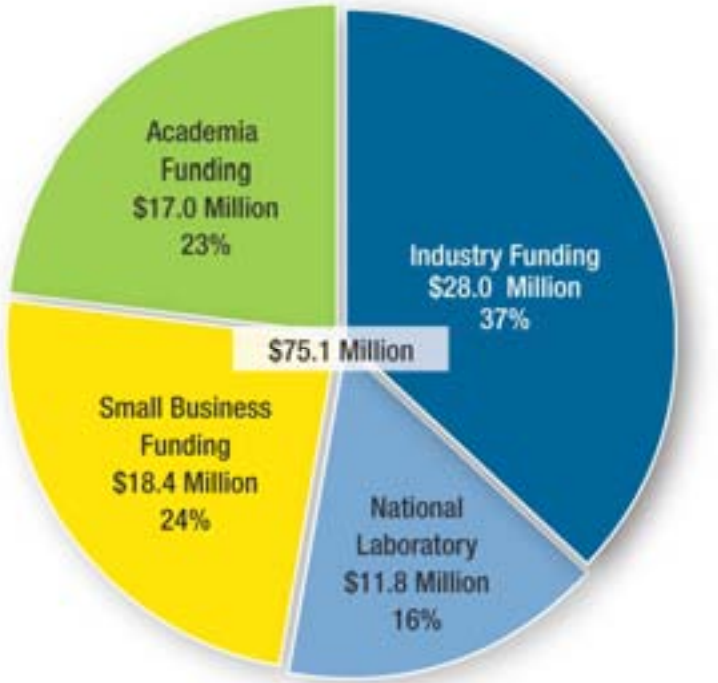
Total Contract Value of Projects: $75.1 million* (44 projects)

- OLED: $30.4 million (18 projects)
- LED: $44.7 million (26 projects)

* The total contract value includes DOE funding ($57.2 million) and applicant cost-share ($17.9 million).

Who's Getting the R&D Money?

- DOE funds SSL research in partnership with:
  - Industry
  - Academia
  - National labs



Total Portfolio: LED Core Technology

	# of Projects	Funding ($ million)
Light-Emitting Diode Core Technology		
Large-area substrates, buffer layers, and wafer research	3	$3.3
High-efficiency semiconductor materials	9	$14.0
Reliability and defect physics for improved emitter lifetime and efficiency	1	$1.3
Strategies for improved light extraction and manipulation	1	$2.5
Phosphors and conversion materials	2	$3.7
Total	**16**	**$24.8 million**

Total Portfolio: OLED Core Technology

	# of Projects	Funding ($ million)
Organic Light-Emitting Diode Core Technology		
Novel materials and device architectures	3	$5.8
Improved contact materials and surface modification techniques to improve charge injection	3	$4.1
Applied research in OLED devices	1	$0.8
Novel strategies for improved light extraction	1	$0.1
Research on low-cost transparent electrodes	2	$2.9
Investigation (theoretical and experimental) of low-cost fabrication and patterning techniques and tools	1	$4.0
Total	**11**	**$17.7 million**

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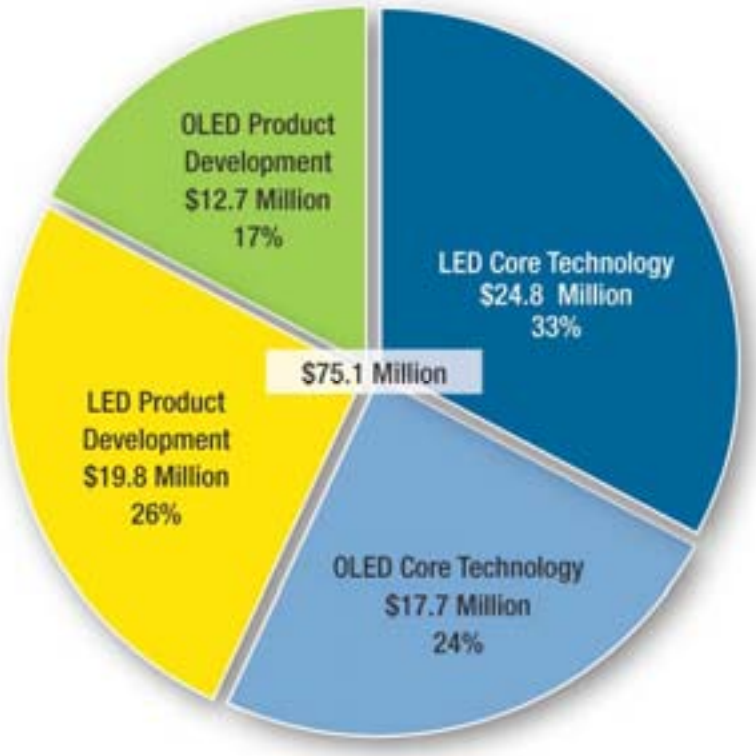
Total Portfolio: Product Development

	# of Projects	Funding ($ million)
Light-Emitting Diode		
Manufactured materials	1	$3.8
LED packages and packaging materials	6	$9.8
Optical coupling and modeling	2	$3.3
Thermal design	1	$2.9
Organic Light-Emitting Diode		
Practical implementation of materials and device architectures	2	$3.4
Practical application of light-extraction technology	3	$6.6
OLED encapsulation packaging for lighting applications	2	$2.7
Total	**17**	**$32.6 million**

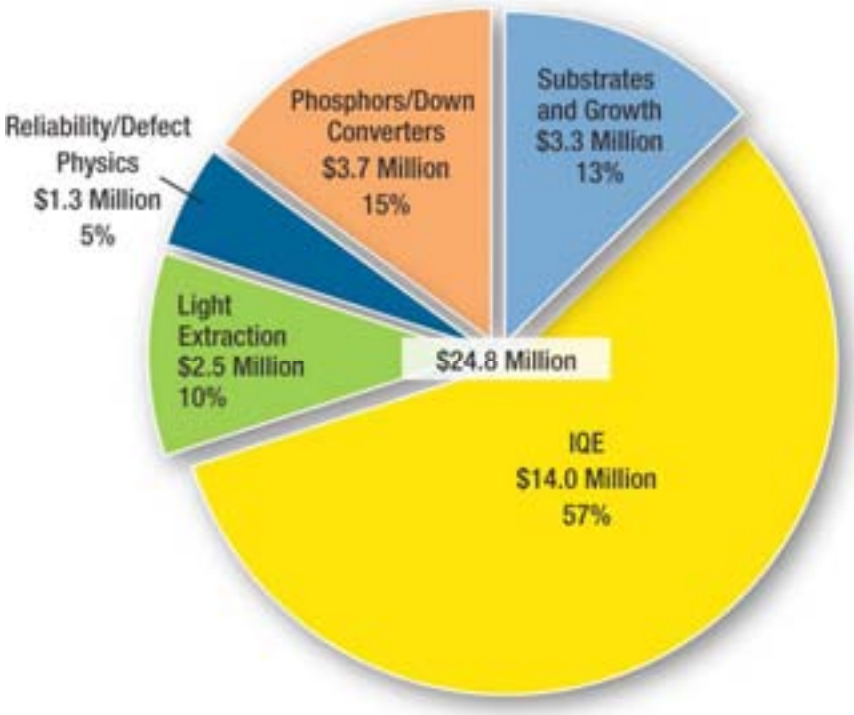
LED and OLED Core and Product Research

- Of 44 total projects:
  - 16 are LED core research
  - 10 are LED product development
  - 11 are OLED core research
  - 7 are OLED product development



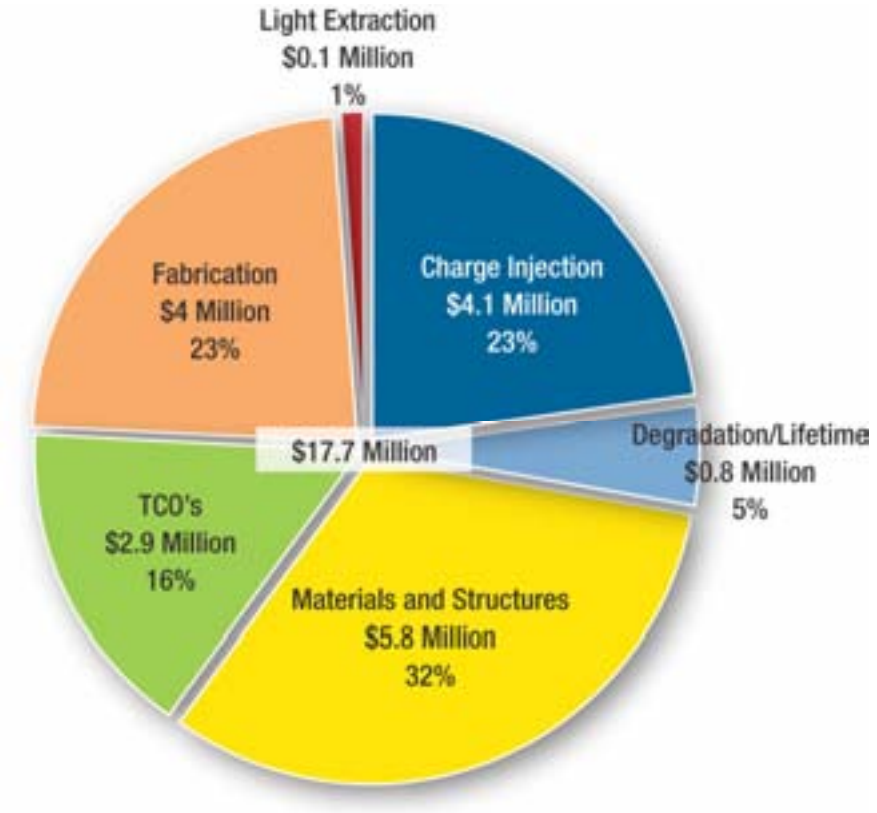
LED Core Research

- Of 16 total projects:
  - 10 are researching LED IQE
  - 3 are researching substrates and growth
  - 2 are studying phosphors/down converters
  - 1 is studying light extraction



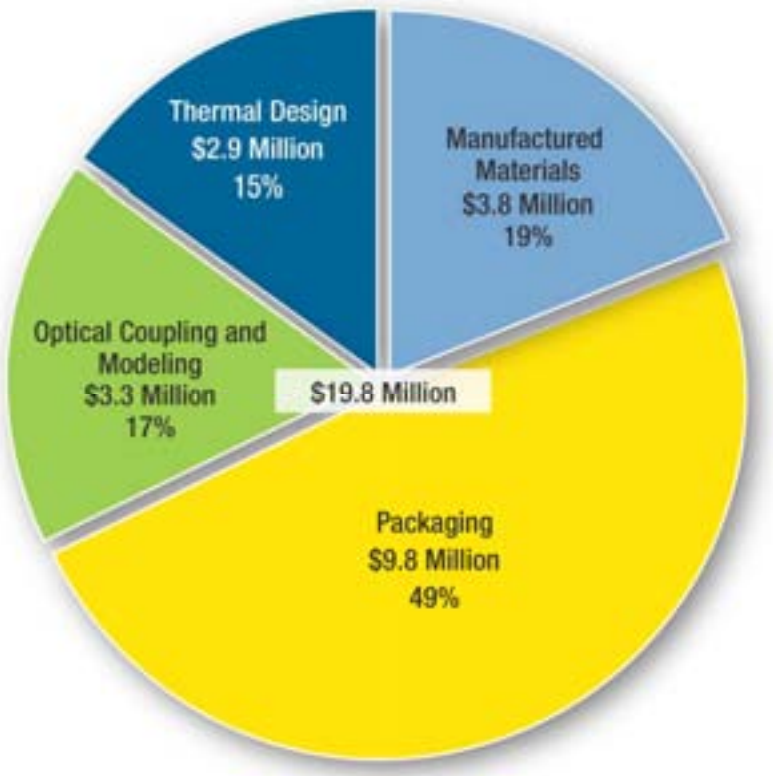
OLED Core Research

- Of 11 total projects:
  - 3 are studying charge injection
  - 3 are researching OLED materials and structures
  - 2 are researching transparent conductive oxides
  - 1 is studying OLED fabrication
  - 1 is studying degradation/lifetime
  - 1 is studying light extraction



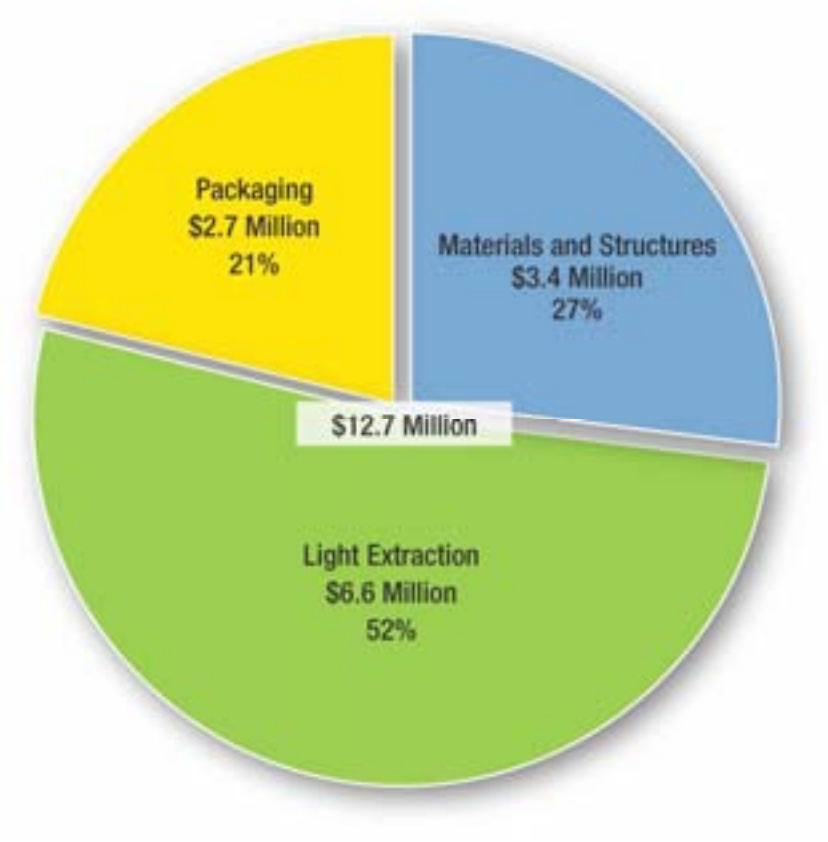
LED Product Research

- Of 10 total projects:
  - 6 are researching packaging
  - 2 are researching optical coupling and modeling
  - 1 is studying thermal design
  - 1 is studying manufactured materials

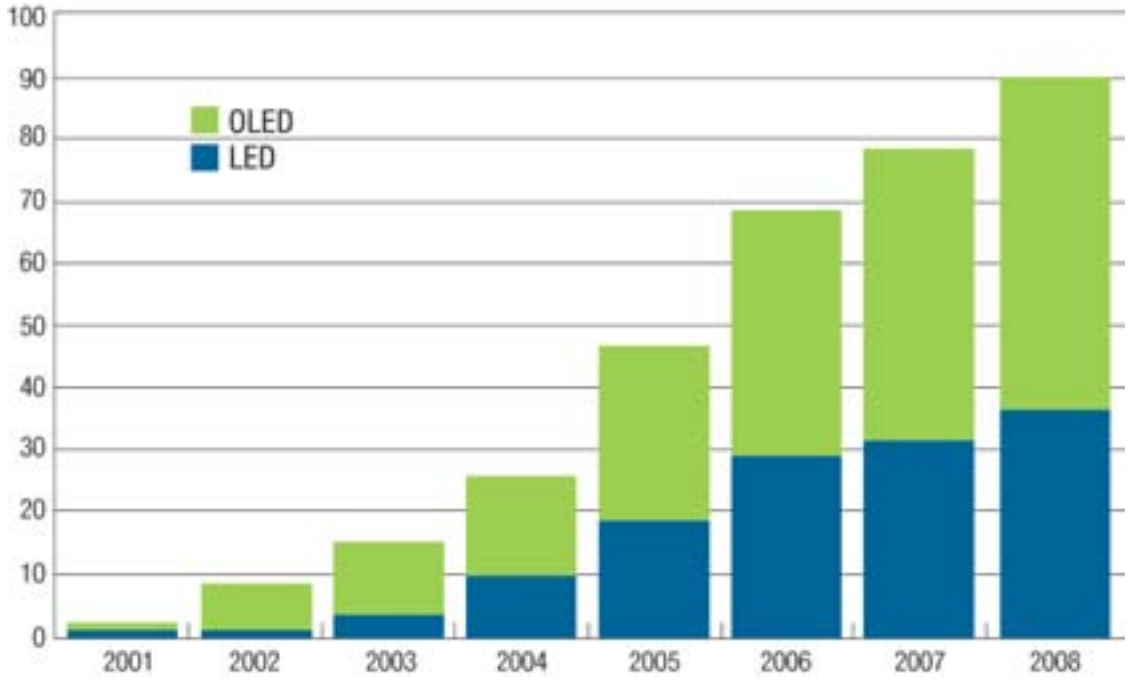


OLED Product Research

- Of 7 total projects:
  - 3 are studying light extraction
  - 2 are researching packaging
  - 2 are researching materials and structures



SSL R&D Intellectual Property, Cumulative Patent Applications by Year



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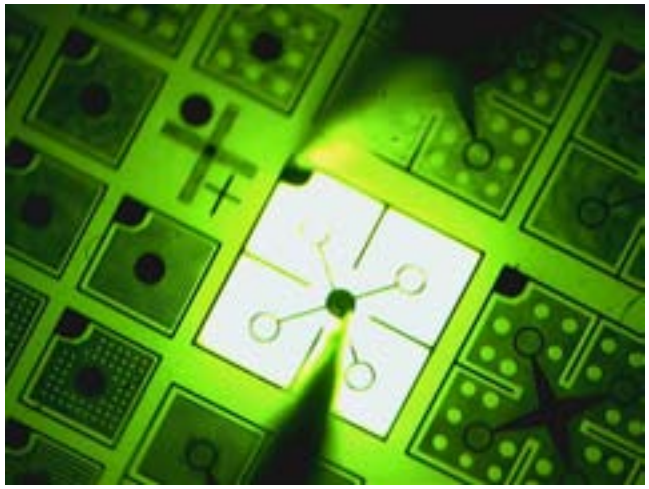
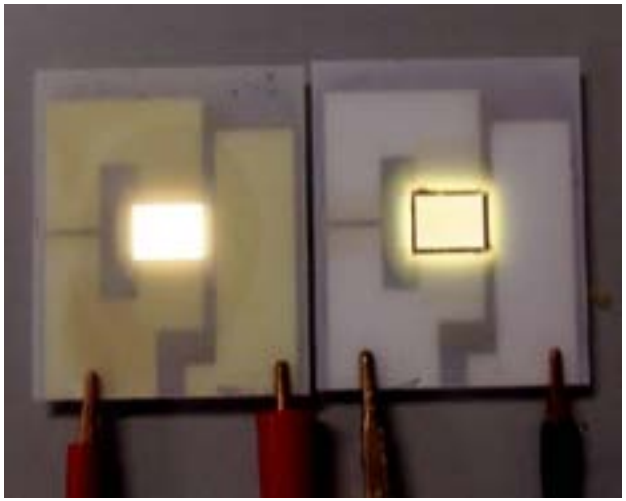
RPI Improves Efficiency of Deep Green LED Epitaxial Materials

- Demonstrated 555 nm deep green electroluminescence
- Exhibited 8 mW of output at 100 A/cm^2
- Reduced defects in active region of LED



Eastman Kodak Demonstrates Breakthrough Efficacy

- 56 lm/W hybrid OLED
- Unique architecture
  - Fluorescent blue emitter
  - Phosphorescent emitter with yellow and red emitting layers
- High efficiency achieved within SSL ENERGY STAR® color coordinates

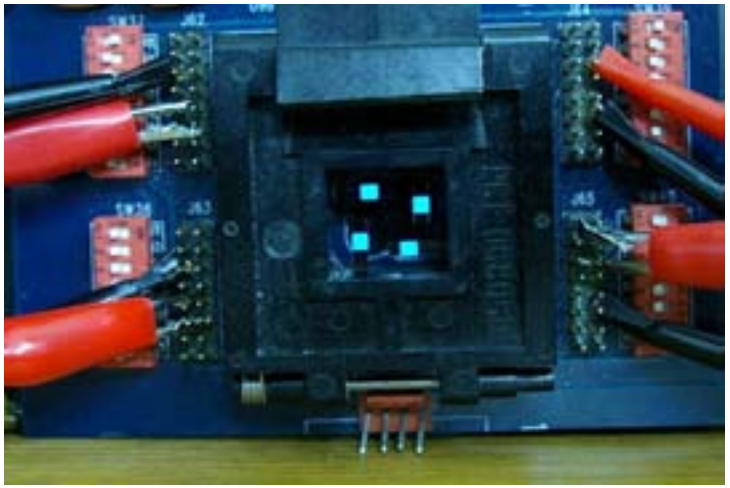


GE Global Research Increases Efficiency of Phosphor-Based LED Lamps

- Exploring new phosphor compositions to achieve warm, efficient LEDs
- Utilizing combinations of crystal chemistry, inorganic luminescence spectroscopy, ceramic processing

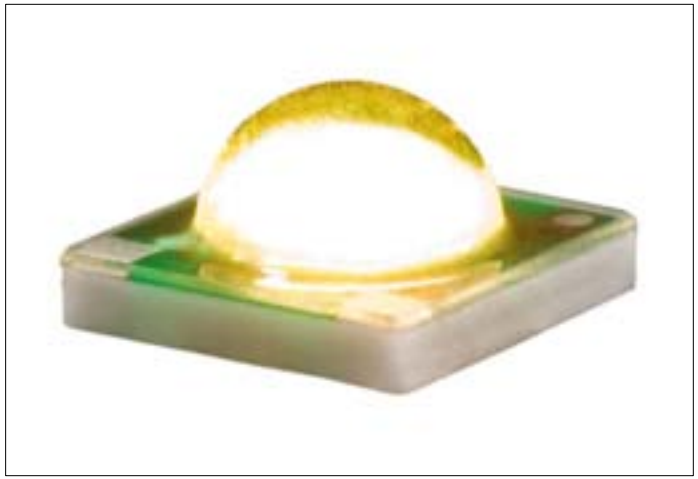
University of Florida Achieves Record Blue OLED Efficiency

- Wall plug efficiency (W/W):
  - 17% at 100 cd/m^2
  - 14% at 1,000 cd/m^2
- Peak external quantum efficiency: 20%
- Believed to be the world record in blue OLED efficiency



Cree Improves Cool White LED Prototype

- Multi-chip prototype: 107 lm/W at 350 mA
- CCT: 5500K; CRI: 73
- Based on EZBright® chip technology platform, with prototype packaging technology



UDC Breaks World Record in White OLED Performance

- Power efficacy of 102 lm/W at 1,000 cd/m^2
- Achieved through combination of
  - Phosphorescence internal quantum efficiency of nearly 100%
  - Novel outcoupling efficiency enhancements
  - Low voltage operation through highly conductive transport layers and device engineering

Philips Color Kinetics Improves Warm-White LED PAR Prototype

- Greater efficiency than comparable lamps on market
- Multi-chip prototype: 69 lm/W
- CCT: 2716K; CRI: 91
- Advanced packaging; novel driver and optical arrangement

There are no speed limits on the road to excellence.

– David W. Johnson