

# NEW FRONTIERS OF LIGHTING



## DOE SSL WORKSHOP

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# Move Beyond Legacy Form Factors



**LED Packages**



**Light Fixtures**

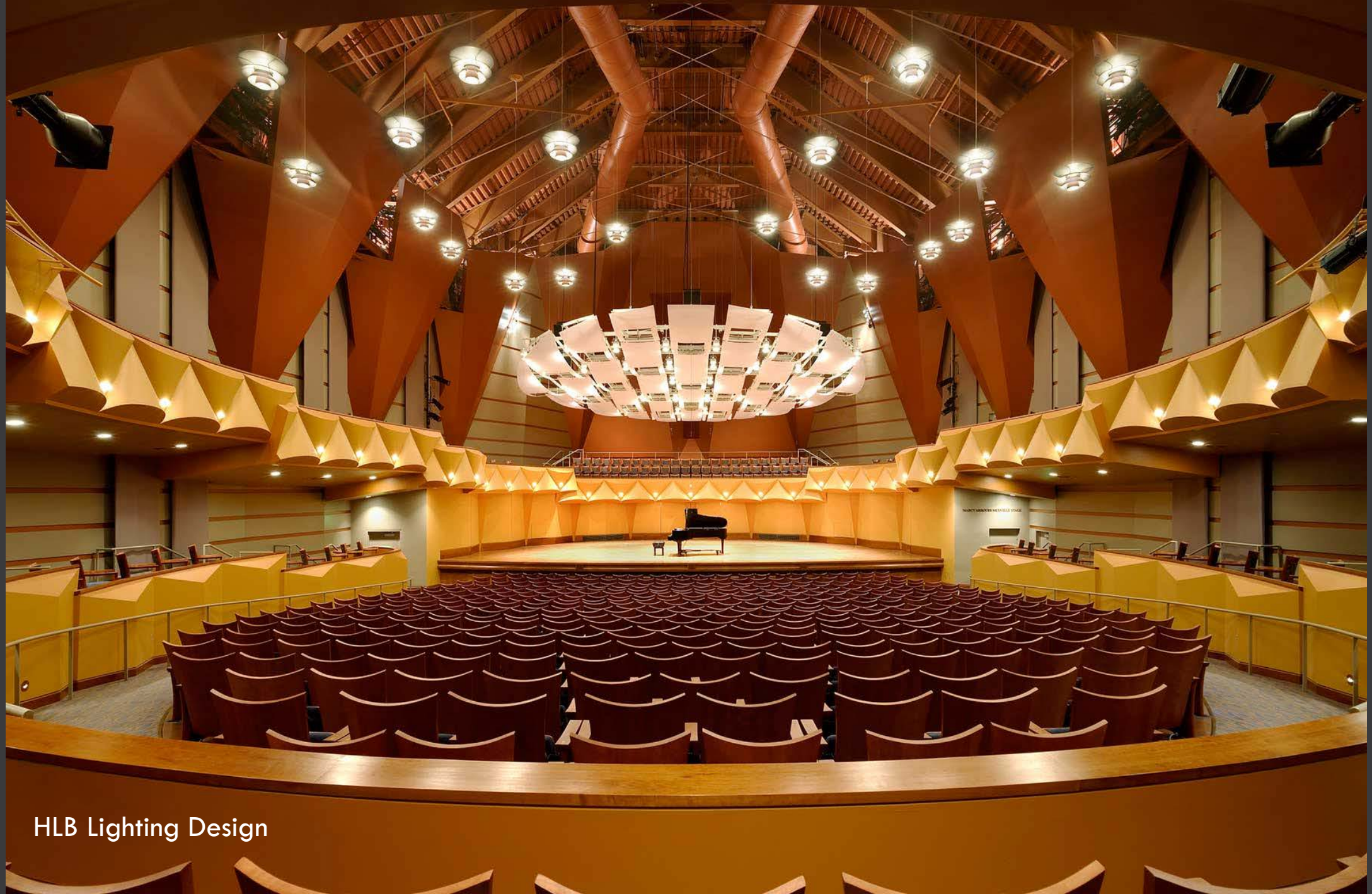


**Installations**



ROI

Coolidge



HLB Lighting Design



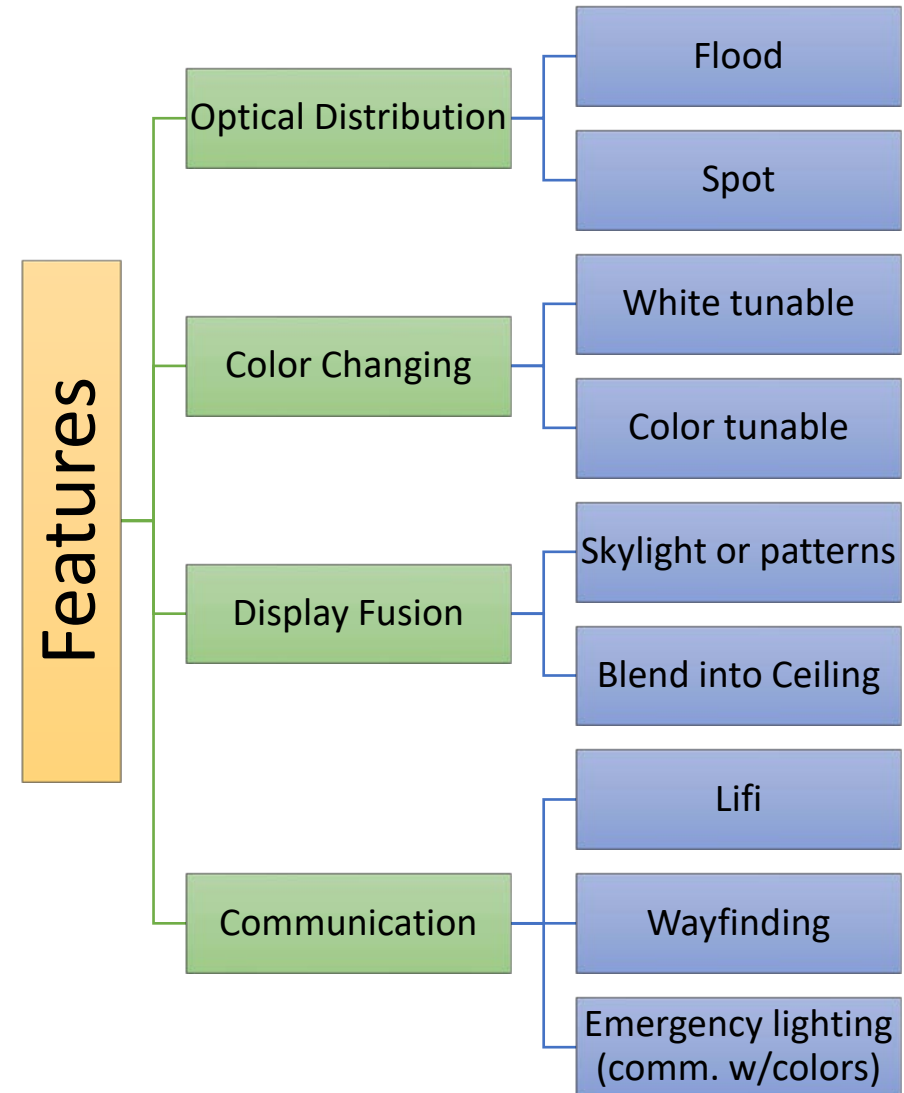
Glamox



Acuity Brands

# Mass Customization

- Customize the lighting products for the needs of the space
  - Create lighting by the lighting requirements not by combining legacy product form factors to reach this performance level.



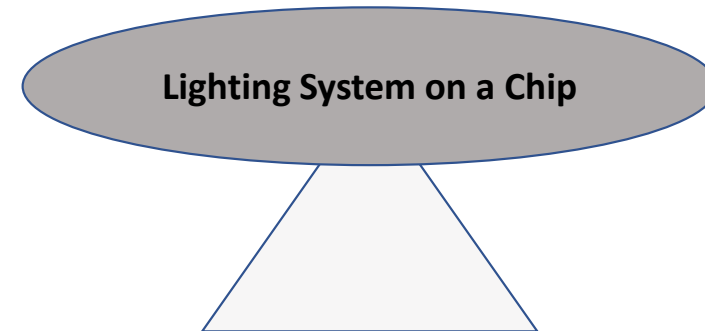


Acuity Brands



# New Lighting Approach

- A lighting photonic integrated circuit (PIC) can create a 'lighting system on a chip' for integration into buildings
- “Print on demand” model must be amenable to create configurable semiconductors



## Photonic Integrated Circuit for Lighting

*A semiconductor foundry model:*

Scalable: 300mm silicon

Low cost: automated wafer fab

Reliability: integrated semiconductor devices

# Lighting PIC Technology



## Technology Elements

Optical/Electrical  
Integration

Pixelated Light  
Source

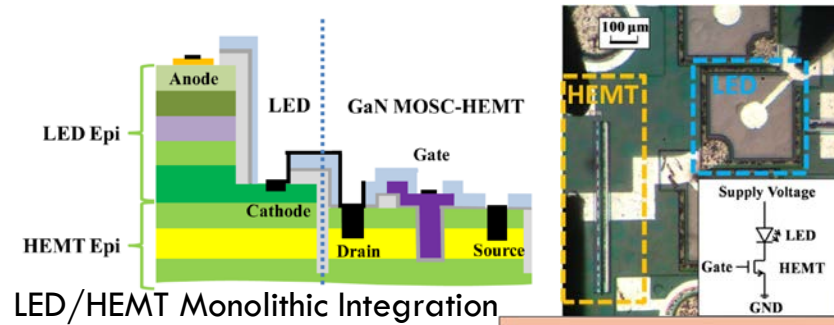
Optical Control

Communication  
& Sensors

Full Color  
Tunable  
Spectrum

Package  
Innovation

# Potential Technologies

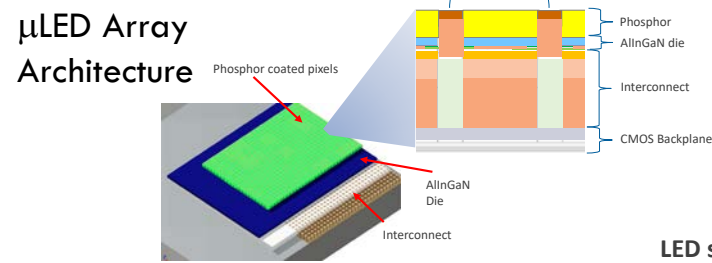


Planar Magnetics

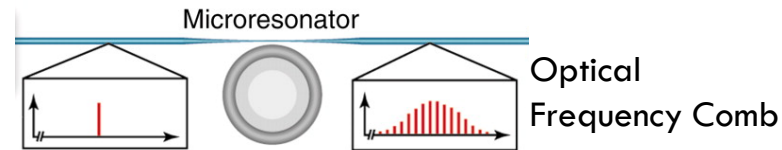
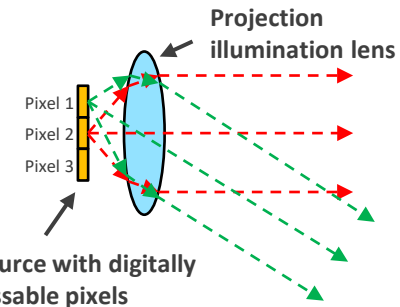


## Optical-Electrical Integration

Driver & LEDs: GaN power electronics + InGaN LEDs integrated on chip, planar magnetics



LED source with digitally addressable pixels



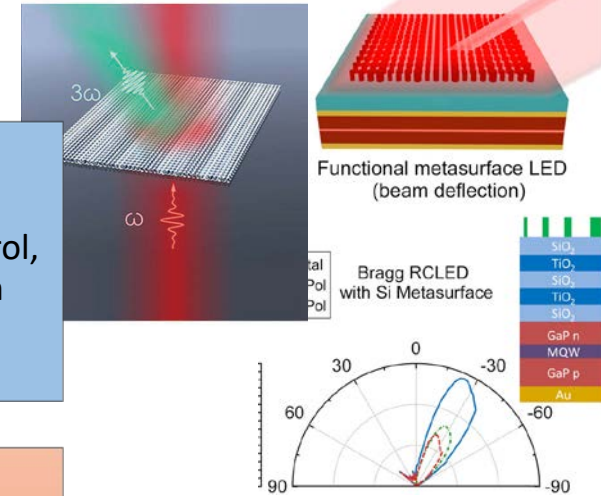
## Pixelated Light Source

Micro/mini-LEDs integration with CMOS, spatial distribution of optical frequency combs

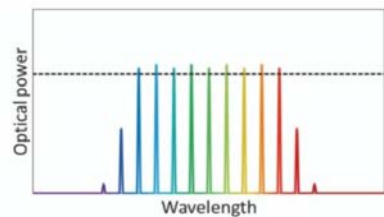
## Optical Control

Diffusers and beam control, metasurfaces for beam steering

## Metasurfaces



## Optical Frequency Comb



## Communication & Sensors

Lifi, sensor integration at chip/package scale, optical multiplexing

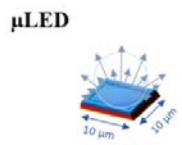
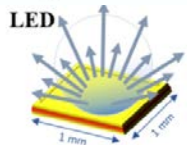
## Full Color Tunable Spectrum

Micro/mini compatible phosphors or QDs, optical frequency combs

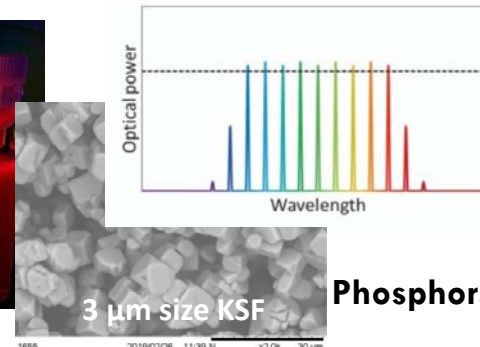
## Package Innovation

3D package integration or chiplets, silicon photonics approaches

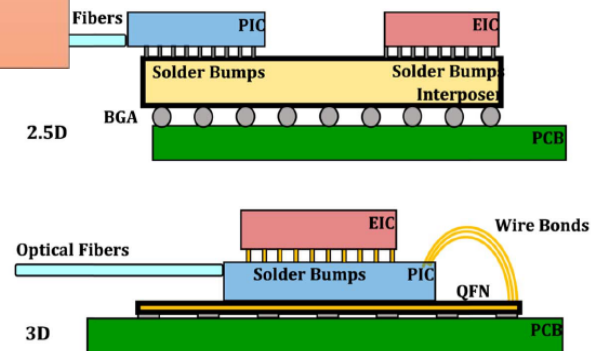
## Lifi



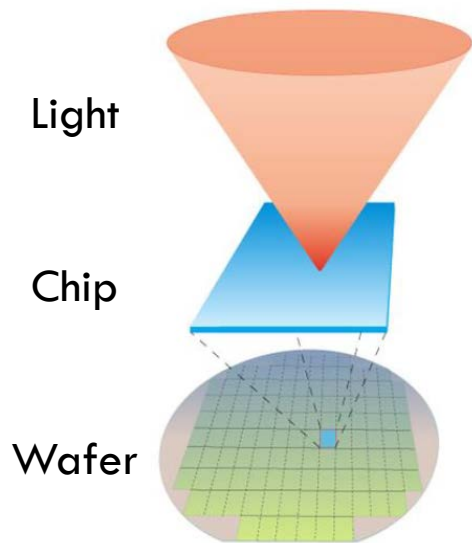
Area	0.1~1mm <sup>2</sup>	<0.01mm <sup>2</sup>
Limiting factor	$\tau_{RC}(\sim 1 \text{ ns})$	$\tau_{carrier}(\sim 0.1 \text{ ns})$
Bandwidth	~10 MHz	<1.5 GHz



## Phosphors



# Lighting PIC Wafer Fabs



NEWS

## NXP Opens New Advanced GaN Fab in Arizona

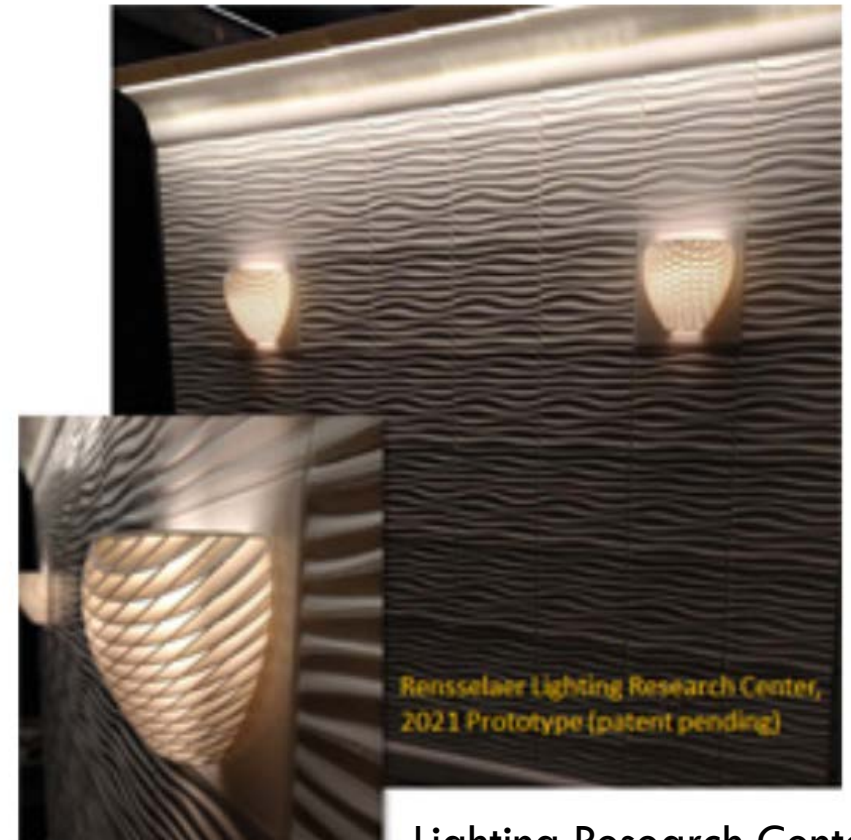


## Cree, NY State Form \$1B Partnership To Create World's Largest Silicon Carbide Device Facility

*More than 600 Cree jobs will be created at the Marcy Nanocenter on SUNY Poly Campus in collaboration with the New York Power Electronics Manufacturing Consortium.*

# Print on Demand

- Additive manufacturing can be leveraged for integrating the lighting system on a chip into building materials



Lighting Research Center

# Sustainable Manufacturing



- Make every component of a lighting system recyclable, reusable, and free of harmful chemicals
  - Eco-friendly designs with low-embodied energy materials, recycled materials, or bioderived materials.
  - Design for deconstruction to disassemble and recycle.
  - Provide materials transparency through certification bodies.



## Circular Economy

