DOE - SSL R&D Summit

Changing architecture to incorporate LED lighting

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- 10 years Theatrical Lighting Design
- 20 years Architectural Lighting Design
- 13 years Product Design
- Currently EVP LF Illumination

How do we change Architecture to take advantage of Solid State Lighting?

architecture is designed for **P**eople.

lighting is designed for the **P**eople within the **a**rchitecture.

What are the unique qualities of Solid State Lighting and how can they be optimized within the architecture to create a better visual and subjective human experience?

Light is Light

The physical properties of light

- Intensity
- Color
- Direction
- Form
- Movement

Human Factors

Design based on subjective impressions is unaffected by the source.

- Visual Clarity
- Spaciousness
- Relaxation
- Social Interaction
- Complexity

Metrics of Quality

- Color Rendering
- Contrast Ratios
- Visual Acuity
- Glare Indices
- Visual Comfort

Unique qualities of Solid State Sources

- Size
- Digital
- Extended color range
- Unidirectional
- Low voltage
- Low heat

Unique qualities of Solid State Sources

- Size
  - Smaller luminaires
  - New form factors
  - more precise optics
  - Lower wattage options
- Digital
- Extended color range
- Unidirectional
- Low voltage
- Low heat

Unique qualities of Solid State Sources

- Size
- Digital
  - More discrete control options
  - LiFi using light for more than just vision
- Extended color range
- Unidirectional
- Low voltage
- Low heat

Unique qualities of Solid State Sources

- Size
- Digital
- Extended color range
  - Phosphor tuning for circadian rhythm
  - Extended and optimized color pallets
  - Signaling using light for more than just vision
- Unidirectional
- Low voltage
- Low heat

Unique qualities of Solid State Sources

- Size
- Digital
- Extended color range
- Unidirectional
  - Well suited for recessed and directional luminaires
  - Allow shallow recessing depths
- Low voltage
- Low heat

Unique qualities of Solid State Sources

- Size
- Digital
- Extended color range
- Unidirectional
- Low voltage
  - Smaller control gear
  - Class 2 solutions
- Low heat

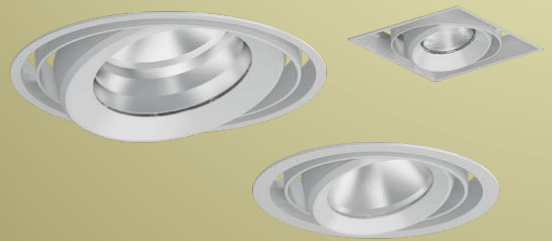
Unique qualities of Solid State Sources

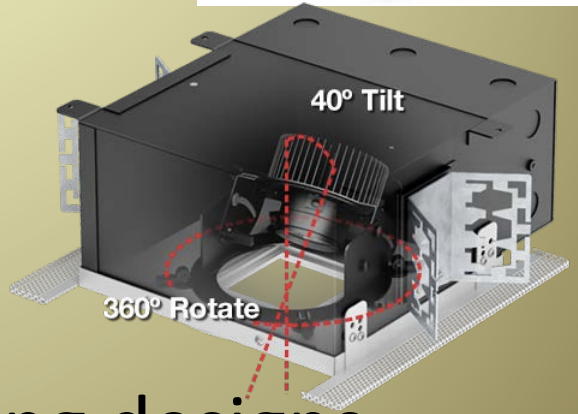
- Size
- Digital
- Extended color range
- Unidirectional
- Low Voltage
- Low heat
  - Greater architectural integration
  - New materials offer more optical possibilities
  - Greater variety of housing materials

Evolution of the Solid State Luminaire

Phase 1 - Show the source

Evolution of the Solid State Luminaire





Phase 2 - Adapt to pre-existing designs

Evolution of the Solid State Luminaire

Phase 3 - Create new design unique to the source

The source has changed but the human eye has not.

Size - Smaller is better?

- LED sources permit smaller luminaires
- More discrete
- Smaller apertures
- Minimize the impact on the architecture

Glare

Source	Luminance
White Illuminated Cloud	10 kcd/m^2
Fluorescent Lamp	12 kcd/m^2
Frosted Incandescent Lamp	130 kcd/m^2
Solar Disk at Horizon	600 kcd/m^2
Chip On Board	1.5 Mcd/m^2
Clear Incandescent Lamp Filament	7 Mcd/m^2
Possible Retinal Damage	100 Mcd/m^2
Solar Disk at Noon	1.6 Gcd/m^2

Beware Glare

- Energy codes set minimum efficiencies in Lumens per Watt
- Efficiency - Optical control = Glare

Glare Considerations

- Smaller source permits more effective optics for a given size of luminaire
- Reflectors (legacy solution) are efficient but not precise. Good for wide distributions.
- Refractors and lenses offer more precise control at the cost of efficiency
- Efficiency should consider lumens reaching the task, not lumens exiting the fixture.

Digital Control

- Drivers in each luminaire are an opportunity to distribute the control system throughout the project.
- Control over more than just intensity. Color and color temperature are now able to be easily addressed.
- Existing infrastructure and lighting grid is offers ideal placement for replacement solutions.
- Bidirectional communication and integration of sensors into the luminaire with minimal impact on fixture cost.

Digital Control Consideration

Flicker

- When the current stops the LED stops producing light. Unintended disruptions in the power to the LED can cause visual disturbance.
- Flicker Index
- Percent flicker

Digital - Control

Luminaires can do more than just provide illumination

- Bidirectional communication and integration of sensors into the luminaire with minimal impact on fixture cost.
- Lights can communicate information visually with Color
- Lights can communicate non visually with Lifi

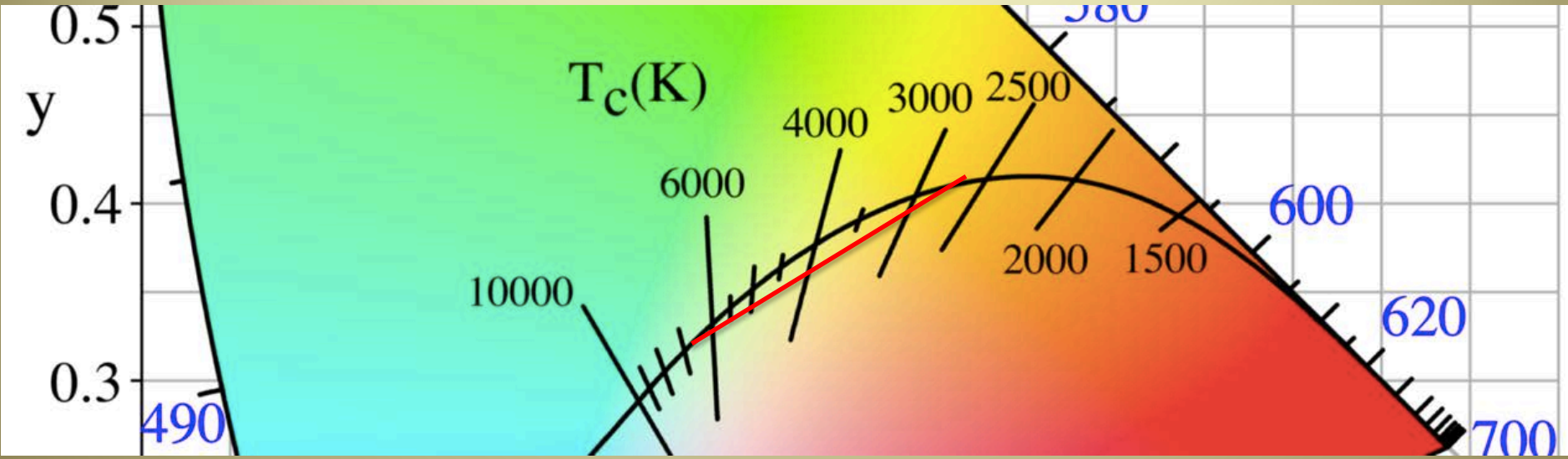
Color – Tuneable White

- Ability to tune he color temperature along the Black Body Locus.
- Reinforce Circadian rhythm
- Match electric light to available daylight

Color Tuning Considerations

- Effects on health are still being determined and debated.
- Cost effective systems take a shortcut across the BBL.

Color Tuning Considerations



Enhanced Color Palletes

- Spectral Power Distributions can be tailored to precise needs
- Enhance skintone
- Accentuate colors
- Whiter whites
- Make food more appealing

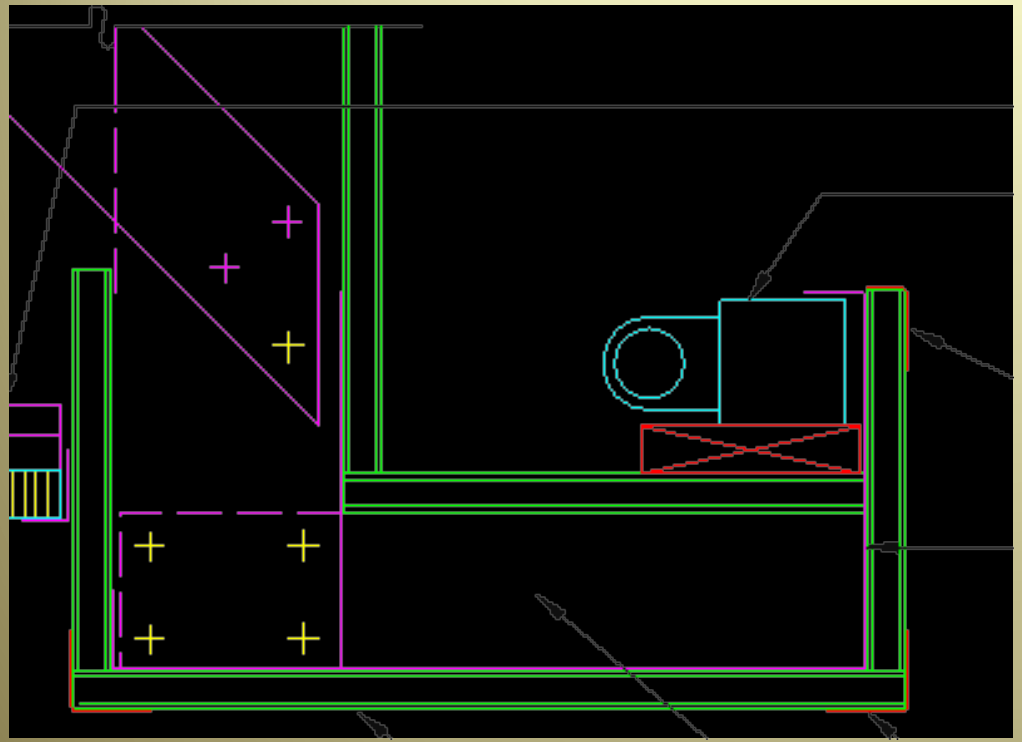
Color - Architectural Considerations

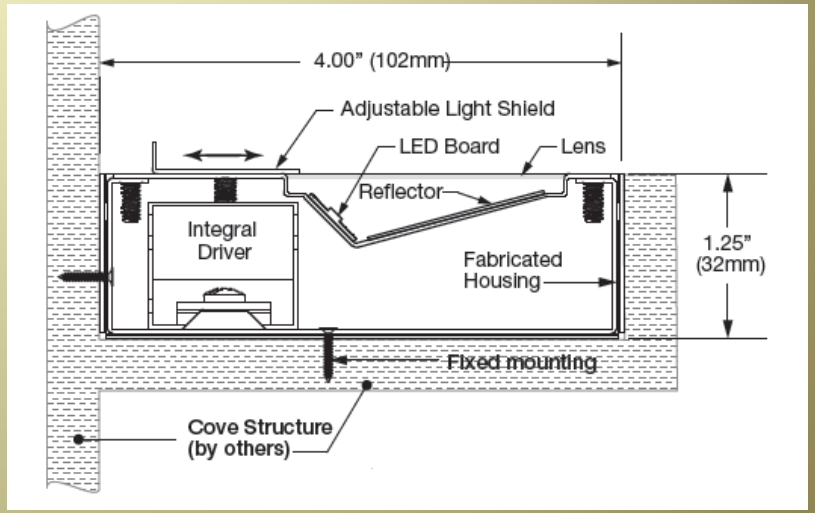
- Pallet of surface materials must be evaluated underneath the same spectrum as it will be seen.

Unidirectional

- Easy to conceal the luminaire within architecture as the majority of light is already vectored to exit fixture.

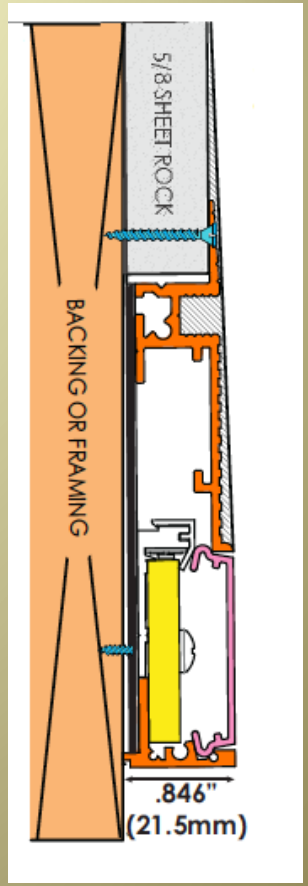
Unidirectional





Unidirectional

- Shallow luminaires can be created that work within the thickness of the wall construction.



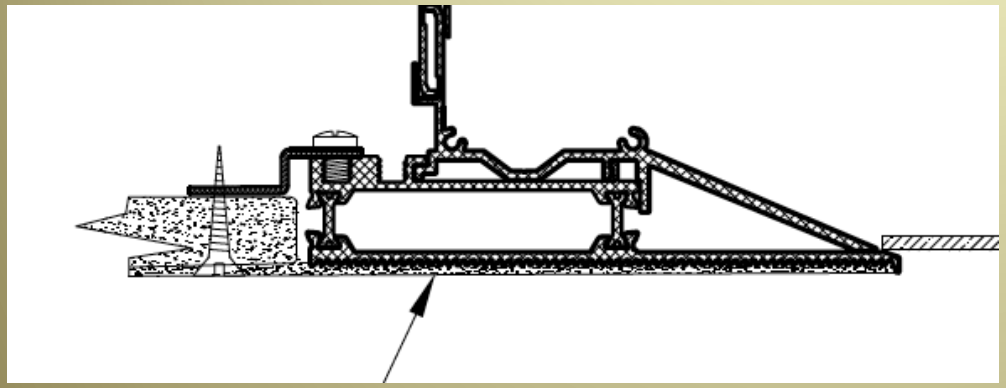
Low Voltage

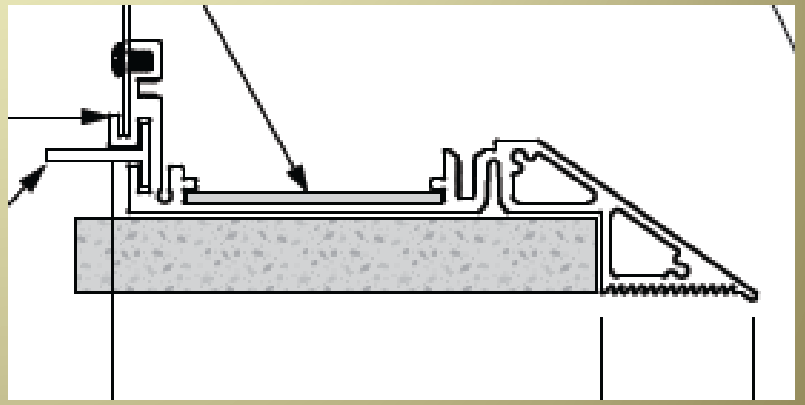
- Low voltage distribution options
- Potential for less stringent wiring requirements.

Low Heat

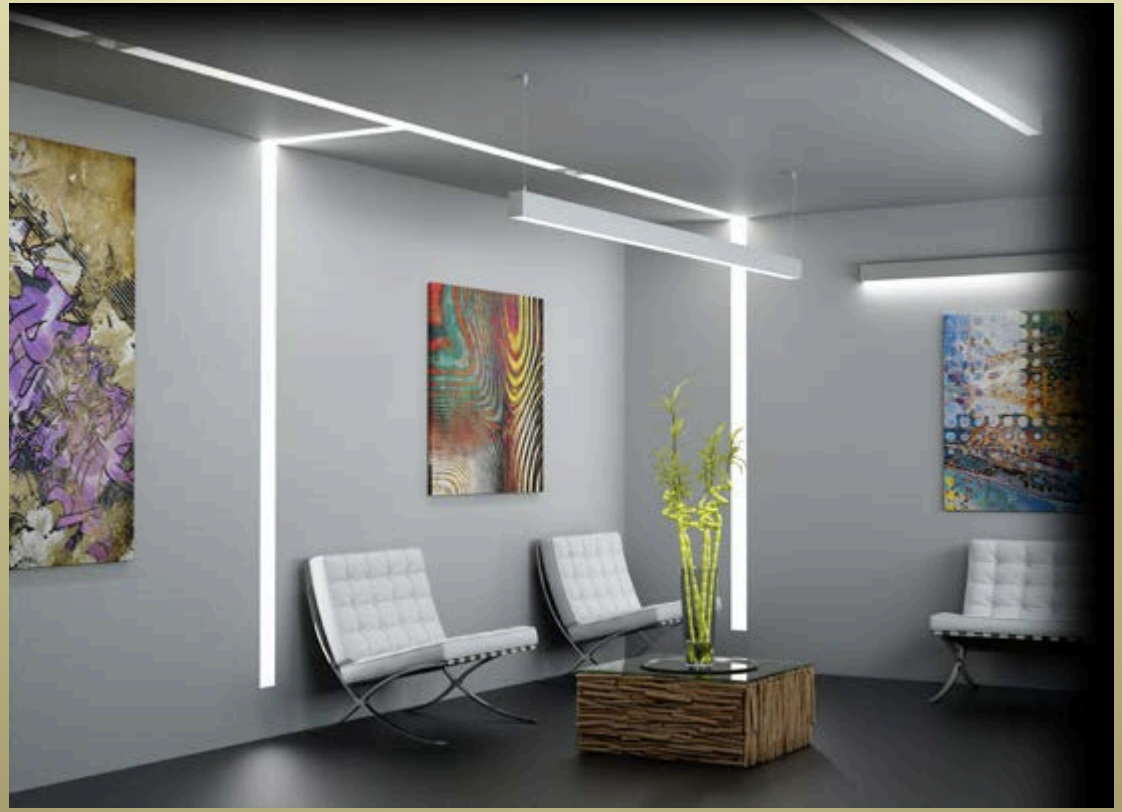
- LED Luminaires permit integration with sheetrock with little need to compensate for thermal expansion.

Trimless details





Lines of Light



Linear Integrations

Building Systems Integrations