

# New Lighting Concepts

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# What Will the Products of the Future Look Like?

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- New Form Factors
- Smaller Volumetrically / Lighter Weight
  - With Illumination Performance Improvements; Brightness Control, etc.
- Less LED Material at Higher Power???
- More LED Material at Lower Power???
  - Cheaper and Better LEDs
  - Less Heat...
- More Housing Material Options
  - Plastics... Low Environmental Impact Options
- As Close to One Highly Reliable Circuit Board as Possible
  - Fully Populated for all Possible Functionality (Less SKUs)
    - Programmed at Factory or During Installation (Commissioning)
  - Populated as Needed (More SKUs, More Inventory Challenges)

# Component and Process Consolidation for Greater Overall Value

- Fewer Electronic Components and Circuit Boards
- Fewer Manufacturing Process Steps and Associated Risk (Higher Reliability)
- Full Function Solutions With Flexibility to Configure/Reconfigure as Needed (programmable?)
- Less Electrical Compatibility Conflicts
- Higher Energy Performance Possibilities
- Lowest Average Product Cost
- Greater Possibilities for Highly Reliable Solutions

**Do they need to be "serviceable"???**

# Overcoming Resistance to the “Non-Serviceable” Solution

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- High Reliability
- Long Warranty Periods
- Acceptance of Non-traditional Form-factors
- Acceptance of Non-traditional Materials and Manufacturing Processes
- Etc...

# Light Source Common Categories

Point



Line

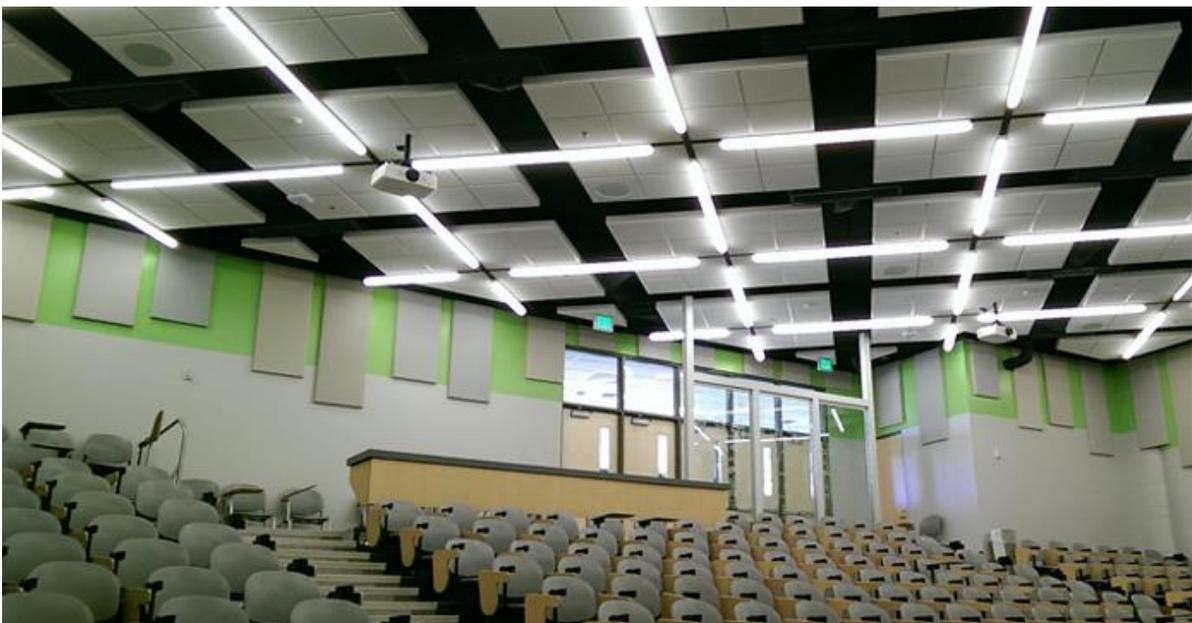


Area



Point is the Most Flexible

All Other Forms can be Reasonably Replicated or Improved



Spots-and-Dots



Giga-Nits???



Glare

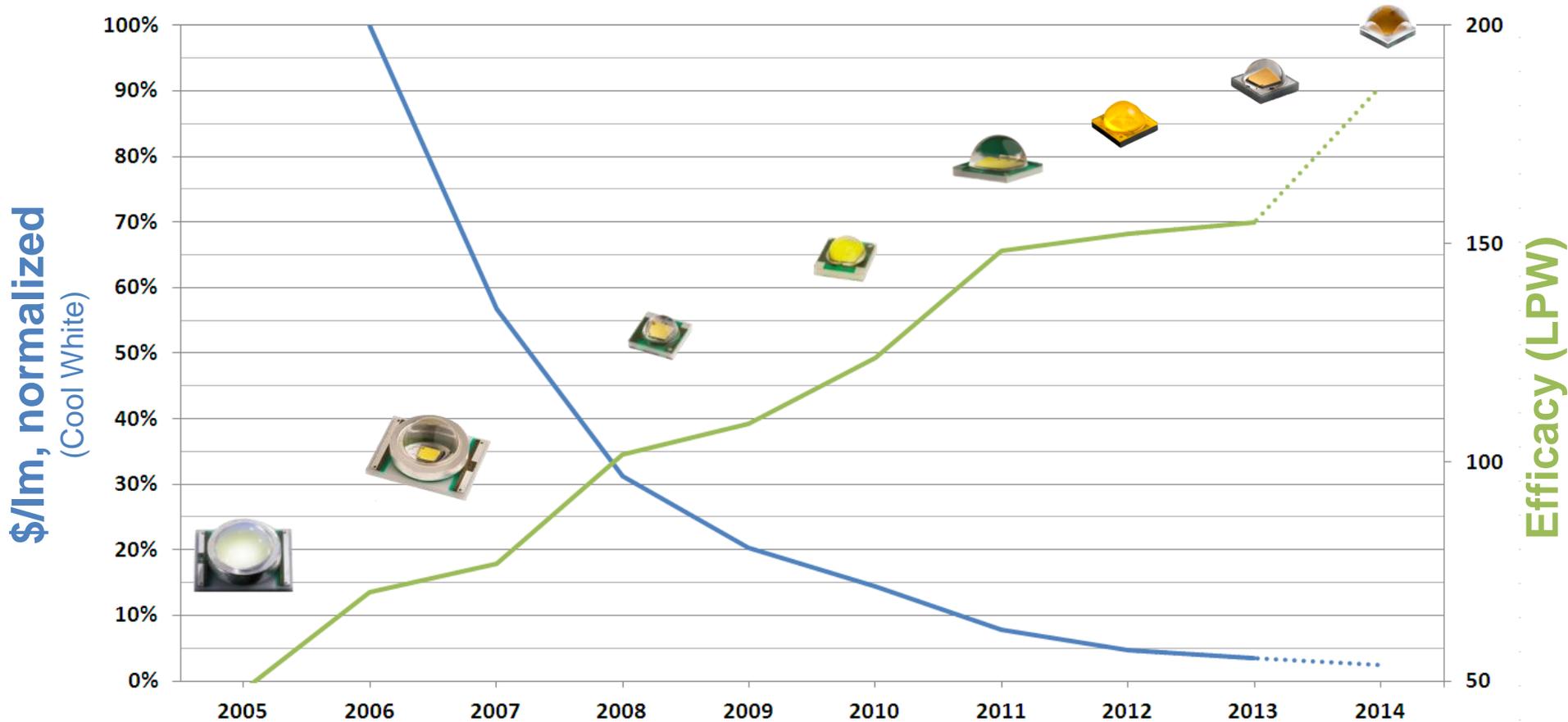
Discomfort Glare  
Disability Glare  
Annoyance Glare???



Efficiency, Control, Comfort... (Pick 2???)

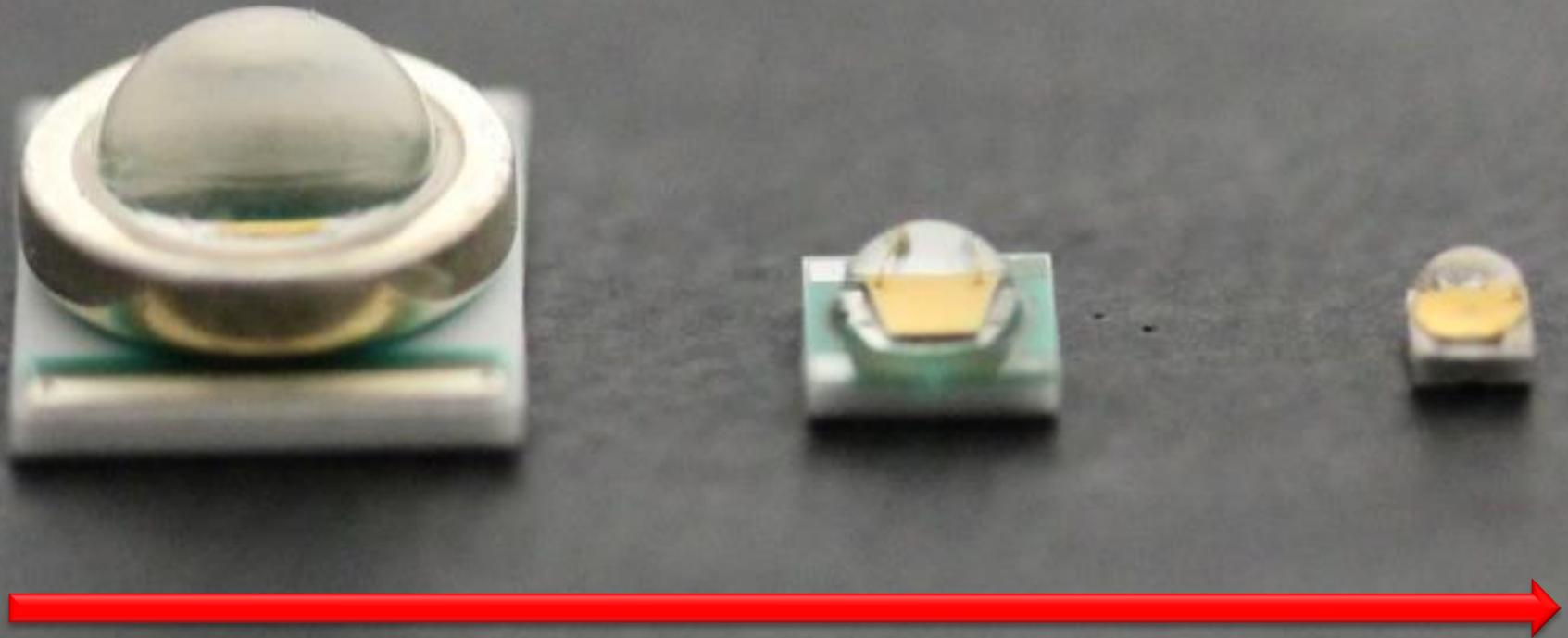
Solutions Should be Comfortable and Attractive as Well as High Performance

# Packaged LED Value Evolution



| Annual Improvement in \$/lm @ 100 LPW | 43% | 45% | 35% | 29% | 45% | 40% | 27% |
|---------------------------------------|-----|-----|-----|-----|-----|-----|-----|
|---------------------------------------|-----|-----|-----|-----|-----|-----|-----|

# Different Die and Package, Same Performance <sub>9</sub>

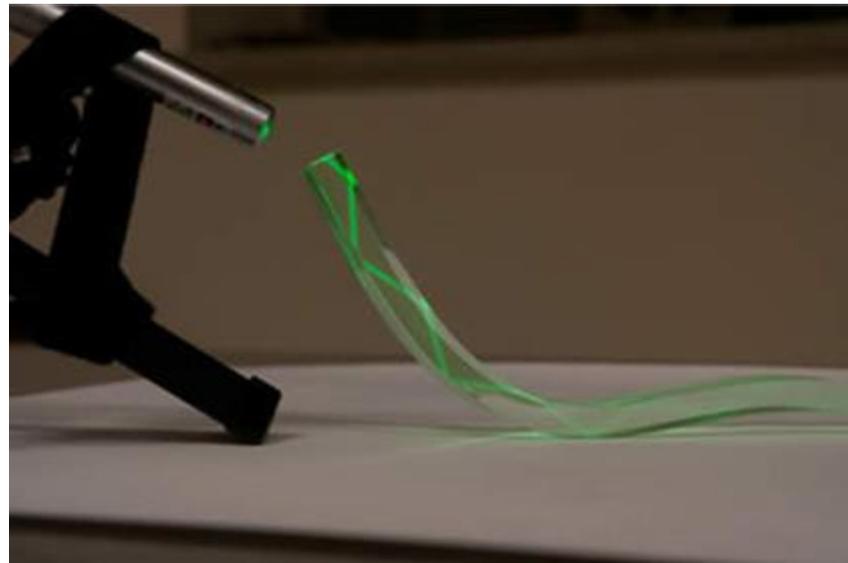
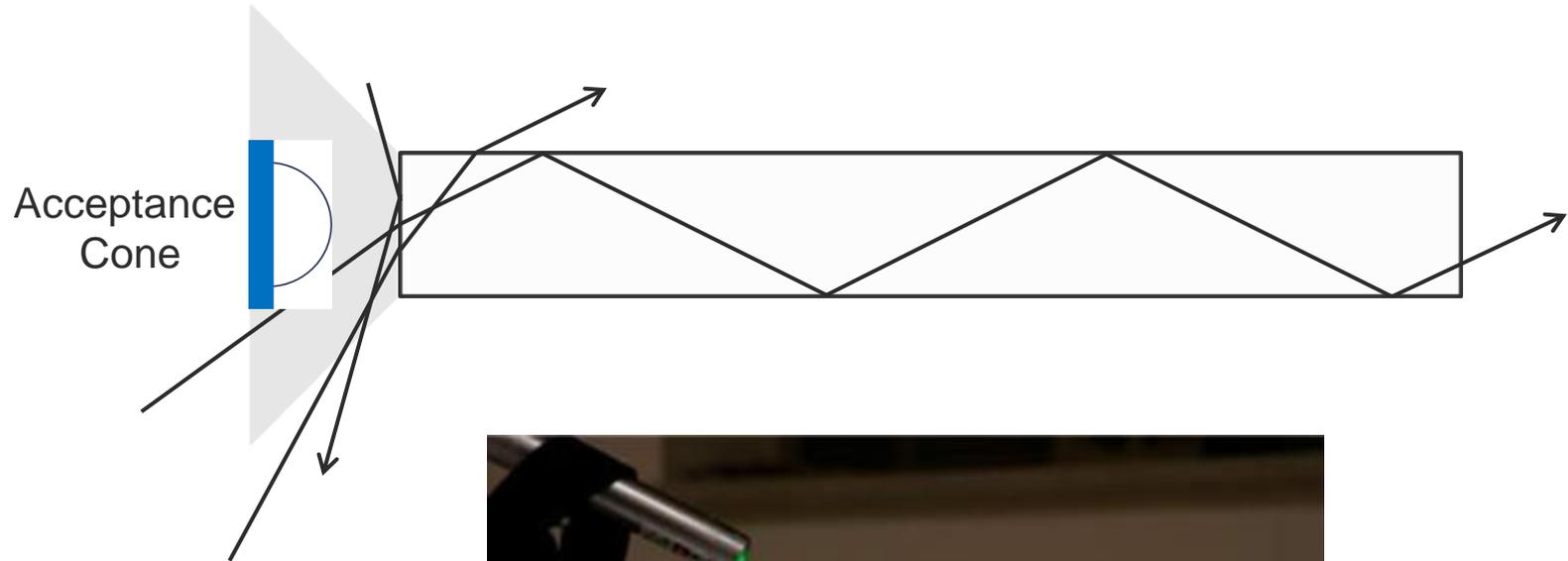


**96% Reduction in Size (volume)**

# Wave Guides

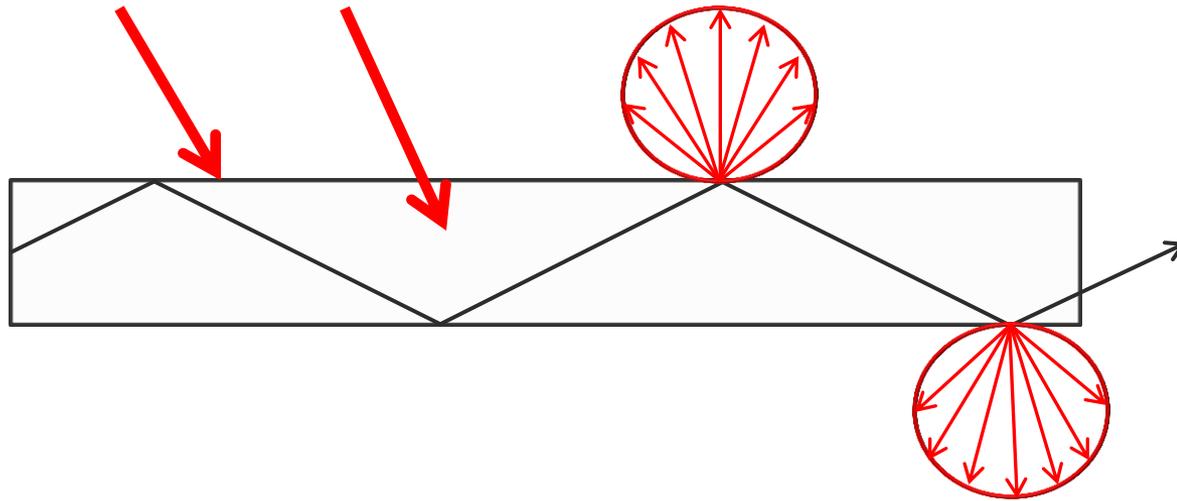
# Optical Coupling and Extraction

- Total Internal Reflection (TIR) Example



# Simple Extraction

**Roughen / Diffuse to Extract and Distribute Light**

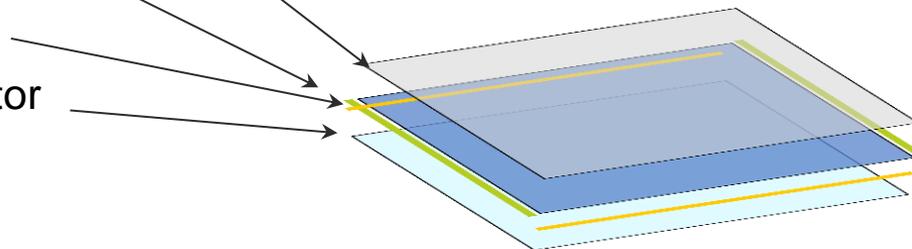


## Edge Coupled Side Emission

- Core Technology from Display Backlighting
- Optical Coupling Losses
- Often Requires Addition of Reflectors, Etc..., to Recycle Light Not Efficiently Extracted
- Usually Around 80% Optical Efficiency (Not All Light is Extracted Before Opposite Edge is Reached)
- Typically Limited Optical Control Possibilities

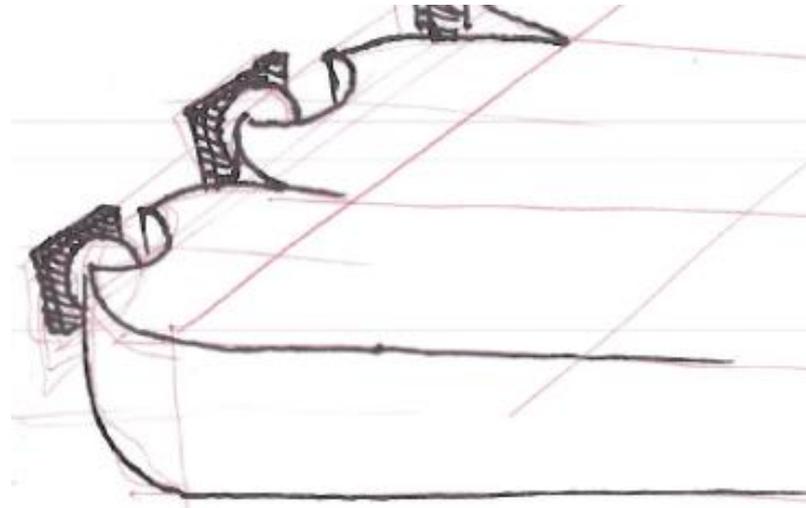
### Typical “Simple” Waveguide :

- 1) Room-Side Diffuser
- 2) Side Reflectors
- 3) Waveguide
- 4) Back Reflector

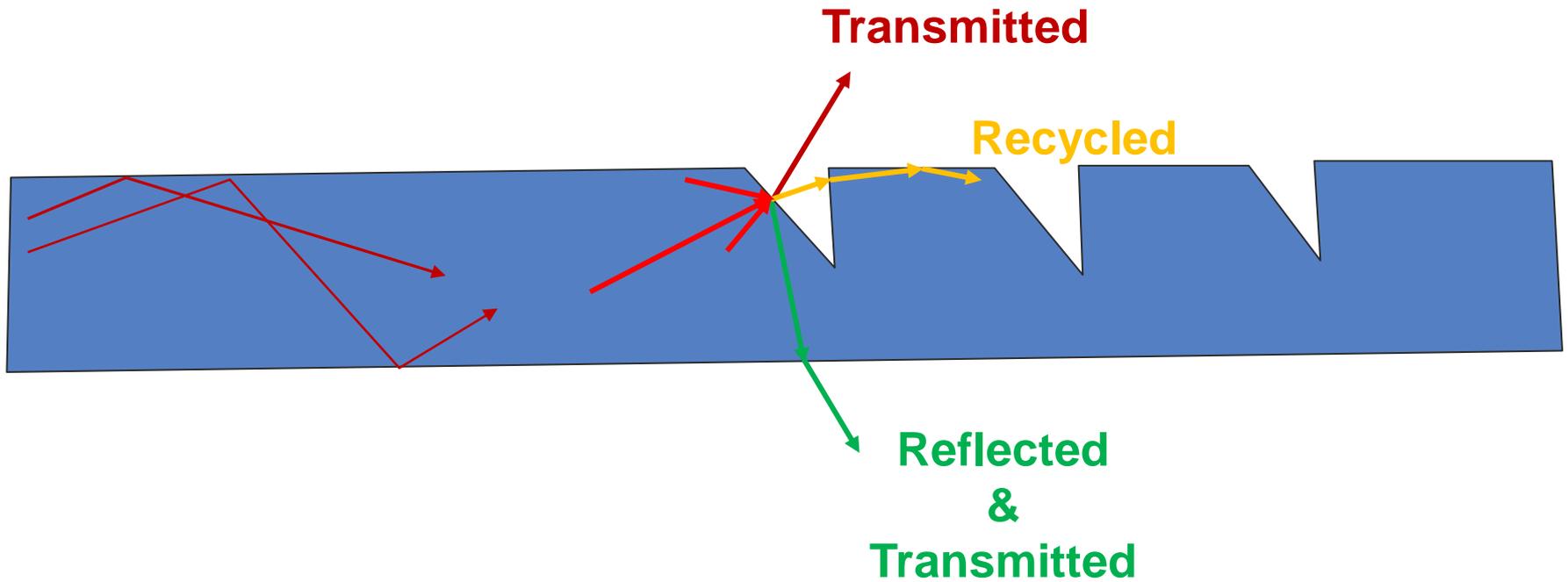


# Maximizing Optical Coupling

The coupling surface is designed to maximize the amount of light entering the wave guide from the source



# Precise Light Extraction Features



# Features Can Be Very Small

Feature size required  
could be 80 microns

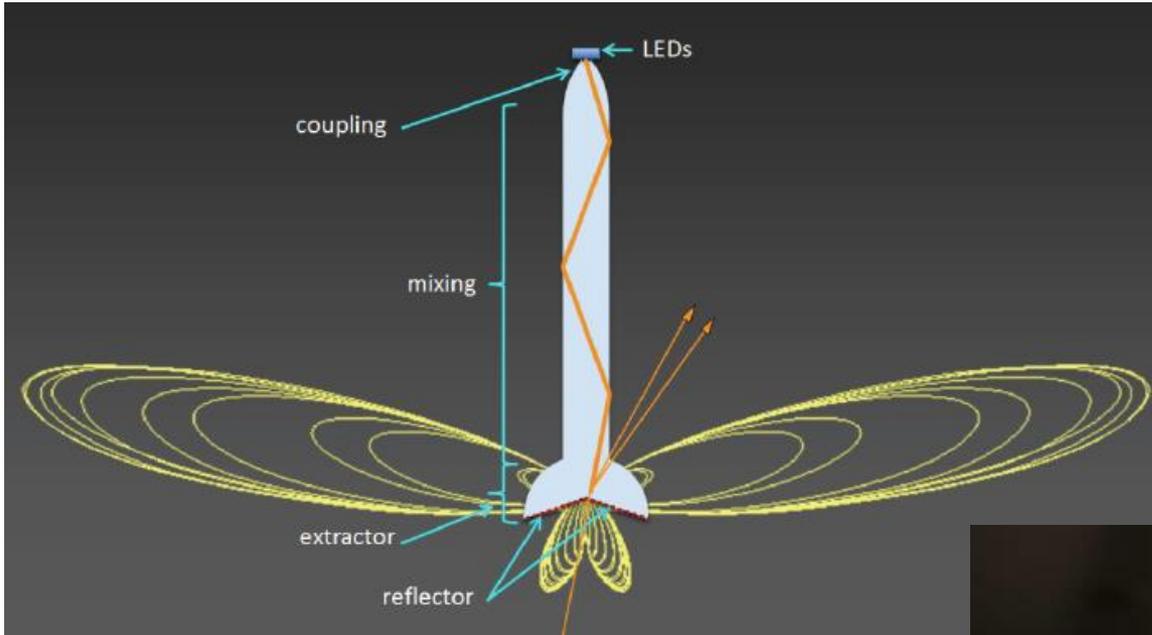
$$\underline{80\mu = \sim 0.003 \text{ in}}$$



Maximum allowable surface  
“roughness”

$$\underline{0.0000015 \text{ in?}}$$





**Credit - QuarkStar**



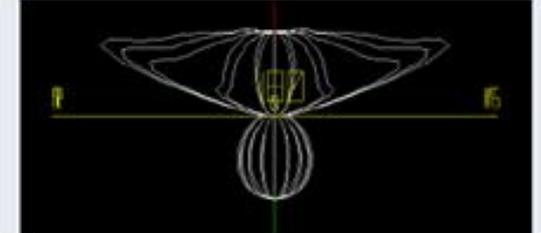
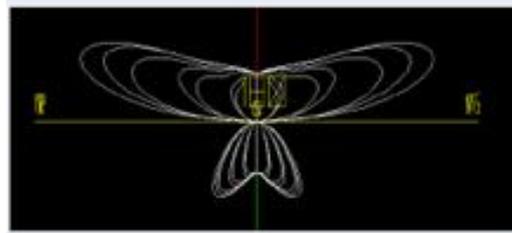
## Ceiling Uniformity Improvement Example



**High Performance  
LED Wave Guide**

**Edge Coupled  
Side Emission LED**

**Specification Grade  
T5 HO**



# Material Related Challenges Affecting Waveguide Performance

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Better Optical Performance Sometimes Requires Longer Optical Path Lengths

Small Changes in Optical Clarity Can Result in Significant Changes in Optical Performance

“Lighting Grade” Acrylics Have Lower Transmissivity Properties Than Many “Non-Lighting Grade” Acrylics (i.e. PMMA used as Fiber Optic Cable)

Many “Lighting Grade” Acrylics are Formulated to Withstand Heat, UV and Other Elements at Levels Well Beyond What LED Systems Will be Exposed to

Thank you for your  
Kind attention

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