Shaping and Directing Light to Improve Efficiency

Paul A. Magill

Brian Richardson

January 30 2013
Overview

• Call to arms

• Light directioning

• Applied with optics to an LED example

• Applied with micro-lenses to an OLED example

• Summary
Call to arms

• LED market forecasting explosive growth for the next 3-4 years

• Displacing an embedded technology is difficult

• DOW example
Light Directioning

- Light directioning offers immediate improvement in effective efficiency

- Several methods are available for altering the shape/distribution of emitted light

- The light distribution can be altered by modifying the reflecting surfaces

- The light distribution can be modified by changing the shape of the scattering pattern or by modifying the shape of the individual scattering sites.
To illuminate the yellow area at 2 ft cdls (21 Lux) it takes 11,348 lumens. With 80 L/W LEDs it takes 141 watts.
Solid reflectors are the key to improved performance:

- Create tightly-controlled light output
- Deliver more light to task
- Enable highly-compact optics
- Significantly improve system efficiency
- Adjustable light emission
SolidCore™ reflector vs. Conventional reflector

- Smaller reflector for the same beam angle
- Major reduction in size and cost
- Up to 75%
SolidCore™ reflector as a light guide

- Effectively directs the desired amount of light to task
- Light can accurately be placed up or down the road
Example: Directing Light Output

To illuminate the yellow area at 2 ft cdl's (21 Lux) it takes only 3,440 lumens. With 80 L/W LEDs it takes only 43 watts.
# Example: Directing Light Output

<table>
<thead>
<tr>
<th></th>
<th>SolidCore™ street light</th>
<th>Conventional street light</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Output</strong></td>
<td><img src="image" alt="SolidCore™" /></td>
<td><img src="image" alt="Conventional" /></td>
</tr>
<tr>
<td><strong>Required Power</strong></td>
<td>43 Watts</td>
<td>141 Watts</td>
</tr>
<tr>
<td><strong>Light Output</strong></td>
<td>2 ft. candles</td>
<td>2 ft. candles</td>
</tr>
</tbody>
</table>
Surface Lens Setup

- Polar detector
- Optic and LED
- Rear glass with mirror surface
- Optic on surface
- Front glass RI 1.5
- Close-up of optic and OLED

Analysis Setup
Without any Optic

Flat surface
No optic

Close-up of OLED panel

Polar Output
With a Hemispherical Lens

Close-up of OLED panel and optical element

Small hemispherical lens on the output surface

.28 Tall x .5 dia.

Larger hemispherical lens on the output surface

.35 Tall x .5 dia.

Polar Output

Graphs showing luminous intensity distribution.
A CAD model of an office was created for optical analysis. The light at the work surface was compared for different outputs of the lighting fixtures. All surfaces were assigned a reflectance of 80%.
The amount of light delivered to one of the work surfaces was analyzed with a lambertian output to be 45 ft. cdls.

The output increased to 56 ft. cdls. when ray angle control was added to the fixture. All other conditions were kept the same.
Summary

• Applying light directioning control reduces glare

• For the example provided light directioning increased the light delivered to the work surface by 25%

• Controlling the light direction improves the effective efficiency

• Controlling the directionality improves the cost and competitiveness against the installed base.

• Developments in this area would be broadly applicable