Founded in 2006, Luminit is a global provider of innovative light management solutions for the lighting, display, automotive, aerospace, biomedical, and machine vision SDF.

Micro and nano structure creation

Transparent Holographic Components in Augmented Reality Applications

Display Week 2019 Booth 1633
Outline

☼ Introduction to Luminit
☼ Light Shaping Diffusers
☼ Transparent Holographic Components
☼ Conclusions
Luminit’s Background

Spun out of Physical Optics Corp in 2006, Luminit is a global provider of innovative light management solutions for the lighting, display, automotive, aerospace, biomedical, and machine vision industries.

- Privately held, profitable business
- >$100M in cumulative revenue
- ~100 employees, US manufacturing
- Diversity in both customers and markets
- Differentiated high performance product
- Holography is our core technology

“Luminit wants to solve your most challenging light management problems!”
Light Shaping Diffusers (LSDs®) Enhance and Improve Light Sources
LSD Diffuses Light in a Single Pass

Mimic Diffuser Function with Surface Relief

- Light is refracted by lenslets
  - All light goes ‘forward’
  - Transmission >>90%

- No loss from scattering sites
- No wavelength dependence
- Gaussian output profiles
LSD Is Manufactured by Four Methodologies

1. Hand Replication
   • Low volume, custom, development

2. Roll to Roll
   • High volume, thin film, largest area

3. Sheet to Sheet
   • Rigid parts, LCD fab-like capacity

4. Injection Molding
   • Highest volume, small 3D parts
   • Monolithic plastic

All Manufacturing Methods Start with Seamless Holographic Mastering
What Is Holographic Mastering?

High Volume replication requires creation of an original ‘master’ pattern on a hard surface.

Luminit creates these masters at very large area with very low cost using our patented Holographic Recording:

- Interference of multiple optical wavefronts creates pseudo-random intensity profile
- Intensity profile is mapped into surface relief
- Spot size can be <1mm or >>1cm
- Can use conventional optics to ‘stretch’ pattern
  - Symmetrical or asymmetrical
  - Fine grain or coarse grain
- Directly written onto large area, and even curved, surfaces
LSD Outperforms All Other Diffuser Technologies

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Bulk Diffuser</th>
<th>Mechanically Roughened</th>
<th>Light Shaping Diffuser®</th>
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<tbody>
<tr>
<td>Circular Small Angle</td>
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<tr>
<td>Circular Large Angle</td>
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<td>Elliptical Diffuser</td>
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The Need for Diffuse Light – in Displays

🌞 The need for diffuse displays has always existed.
🌞 LCD backlights made it a necessary and separate component.
Light Shaping Can’t Always Tolerate Haze – See-Through Optics

Augmented Reality, Smart Glasses, and Head-Up Displays require truly transparent optics:

- Need unobstructed view of reality
- Conventional optics too bulky
- Surface relief micro-optics too hazy
- Nano-optics too costly to manufacture at consumer volumes or prices

Solution

Requires a diffractive optic with lower index contrast and higher thickness

Transparent Holographic Components (THC)

Photo courtesy of REYDER
THCs Are Volumetric, Index Modulated, Polymer Films

Periodic index modulation(s) creates distributed Bragg gratings.

- No surface relief
- Highly efficient Holographic Optical Elements direct light beams without the need for conventional optics
- Recorded on thin (10-30 micron) holographic photopolymer film
- The holograms have thick Bragg properties that are wavelength and angle selective
- Very low scattering, low haze
- Transparency above 90%
- Diffraction efficiency above 90% at peak
- Can form linear gratings
- Can form ‘lenses’ with optical power

One example of a waveguide design using THC.
THC Has the Best Trade-offs

- High transparency with high efficiency (diffractive)
- Thin (10’s of micron active layer) and lightweight
- Thermoformable – photopolymer based
- Roll-to-roll manufacturable
- RGB performance in a single component/layer

Transparent Holographic Components (THCs) from Luminit address these problems

- Requires expensive tools/lasers
- Requires extensive customization
- No manufacturing capacity in the world
Replication allows for lower cost, less vibration sensitive, rapid recording of optical copies of a pristine master.

Replication is compatible with roll-to-roll manufacturing techniques.

Only Luminit has installed and operating capacity of roll-to-roll holographic replication machines.

Active material ‘learns’ the function you write into it.
**THC Mass Production**

- Worldwide capability to mass produce volume HOEs was negligible until today
- Luminit is currently manufacturing THCs to meet AR industry’s needs:
  - Current capacity 50,000 AR units/mo.
  - Mfg. Plan to support >5M units/year
  - R2R thermal and optical post-processing
  - R2R in-line barcoding and inspection

Combined expertise in roll-to-roll manufacturing and holography are required.
THC Outperforms All Other Combiner Technologies

<table>
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<tr>
<th>Attribute</th>
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<th>H-PDLC (WG)</th>
<th>THC (Reflective)</th>
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<td>Price Potential</td>
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But we could also compare FoV, large-area compatible, stray light reflections, etc.
Conclusions

☼ **Light Shaping Diffuser** is an industry standard wherever Gaussian light distribution is required

☼ **Transparent Holographic Components** are appearing on the market now in Augmented Reality applications and wherever high transparency is a requirement

Visit us at booth 1633 to talk to us about your unique thin-optic challenges or email us at sales@luminitco.com