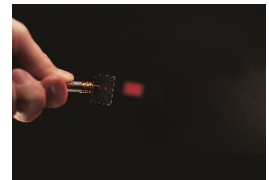


New Manufacturing Methods for Light Shaping

DOE R&D Conference, 2017
Long Beach, CA



Outline

- Introduction to Luminitt
- Refractive Optics – Light Shaping Diffusers
 - Roll-to-Roll (and -Sheet) Manufacturing
 - Injection Molding - Flat and Curved
- Diffractive Optics – CGH & HOE
- Conclusions



Luminit's Background

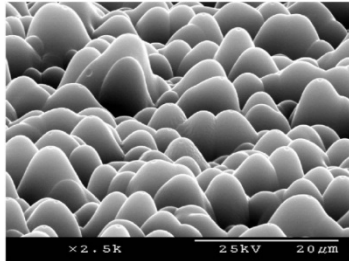
Founded in 2006, Luminit is a global provider of innovative light management solutions for the lighting, display, automotive, aerospace, biomedical, and machine vision industries.

- Privately held, profitable small business
- 70 employees, U.S. manufacturing
 - Experiencing rapid growth in the next 12 months!
- Diversity in both customers and market segments
- Differentiated high performance products

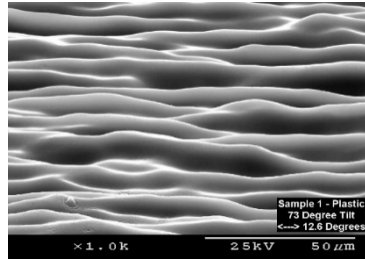


First Application of Holography to Lighting and Displays

Light Shaping Diffusers (LSD)



80°



60x1°

Mimic Diffuser Function with Surface Relief

Holographic Recording:

- Creates pseudo-random pattern
- Can be symmetrical or asymmetrical

Surface Relief:

- No loss from scattering sites
- No particles = no wavelength dependence

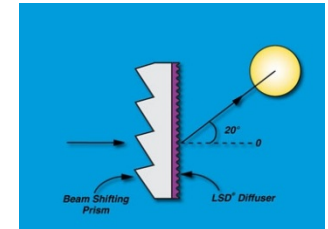
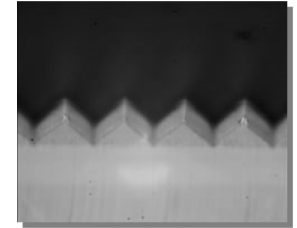
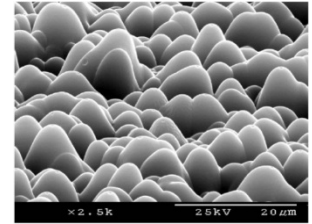
Commercial Products

Surface Relief Components:

- Light Shaping Diffusers®
- Round Tip Display Film
- Direction Turning Film
- Edge-lit Uniformity Tape
- Custom Prismatic Films
- ***Monolithic Glass LSD***
- ***Crystal Screens***
- ***Volumetric LSD***

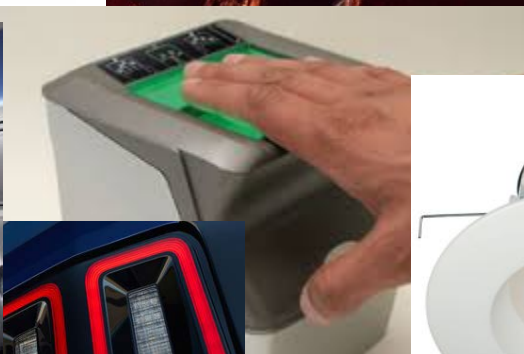
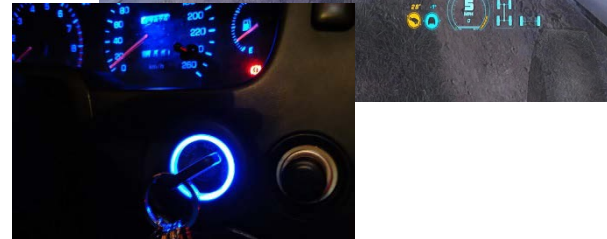
Available in Diverse Form Factors:

- Film
- Rigid Flats
- Plastic
- Sol-gel
- Glass
- Tape
- Injection Molded
- Curved IM



Largest market is LED lighting – Shaping Light As Needed!

Holography and LSD is Pervasive



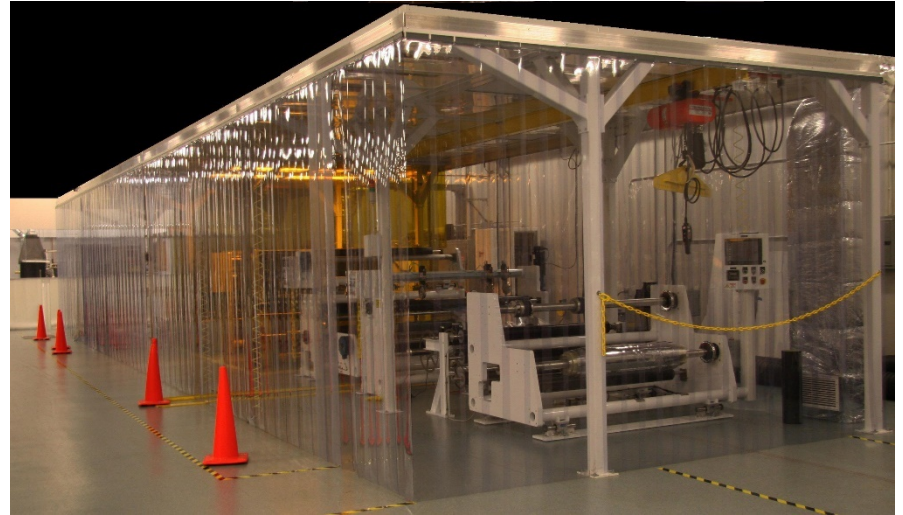
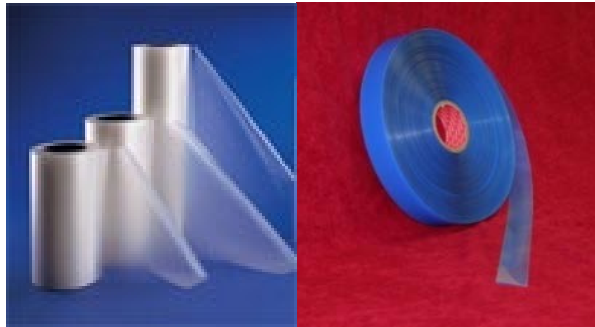
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LSD is Manufactured Roll-to-Roll

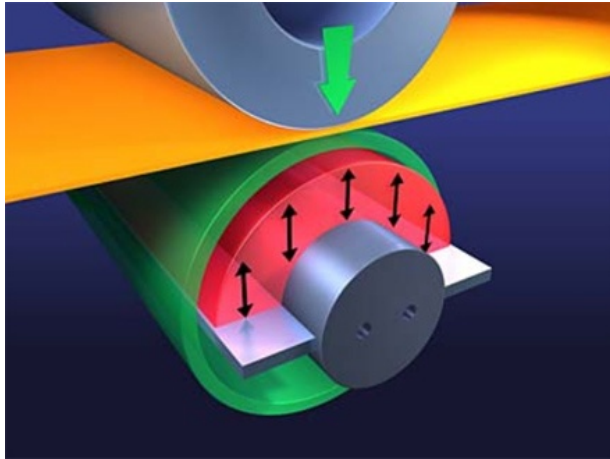
- Shipping >100k R2R linear ft/month
- Class 100 operation
- Existing US manufacturing facility
- UV embossing process
- Holographic mastering



Ideal for Large Area, Flexible,
and Uniform Products

LSD is Manufactured Roll-to-Sheet

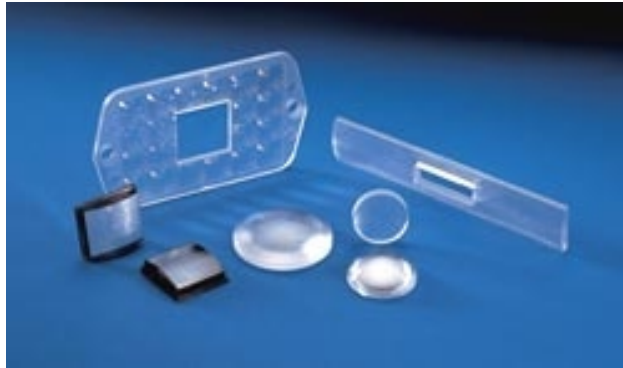
- 10,000 rigid panels/month capacity
- Existing US manufacturing facility
- Similar UV embossing process
- Similar holographic mastering process



Enables Rigid Parts without
Additional Lamination Process

LSD is Manufactured by Injection Molding

- Leverages existing infrastructure in Asia
- Similar holographic mastering process
- Eliminates UV embossing
- Monolithic part – PC, Acrylic, Urethane



Enables Complex Parts,
without Conversion Processes

Now Introducing Curved Injection Molding

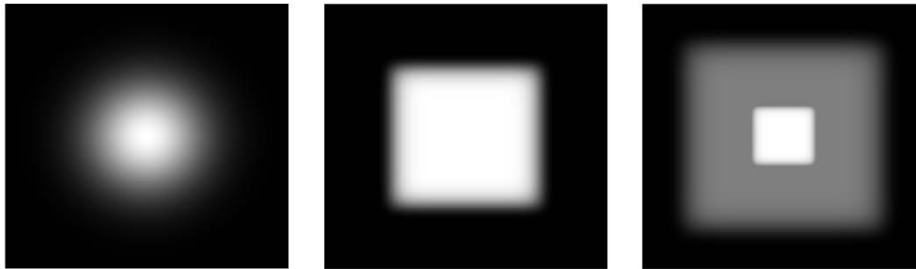
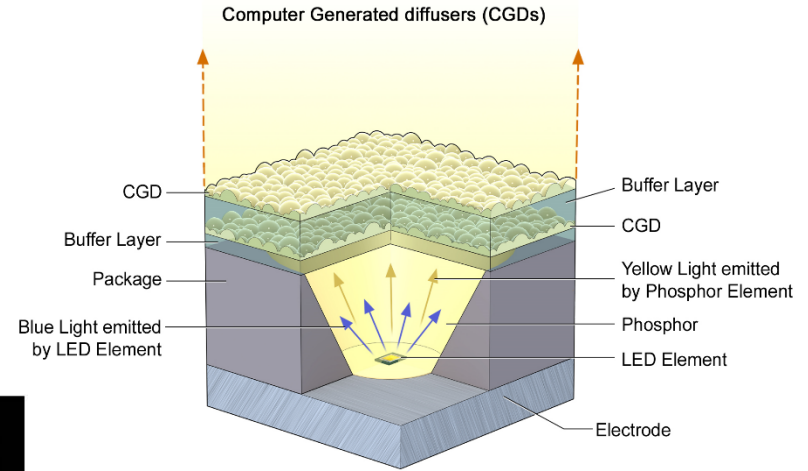
- Complex holographic mastering
- All processes must be curved
- Same benefits of IM process, costs
- LSD can be inside or outside surface



Enables Automotive Market
Monolithic Parts

How can we apply Light Shaping to LEDs?

- ✓ As secondary lens
- At package output?
- On phosphor layer?



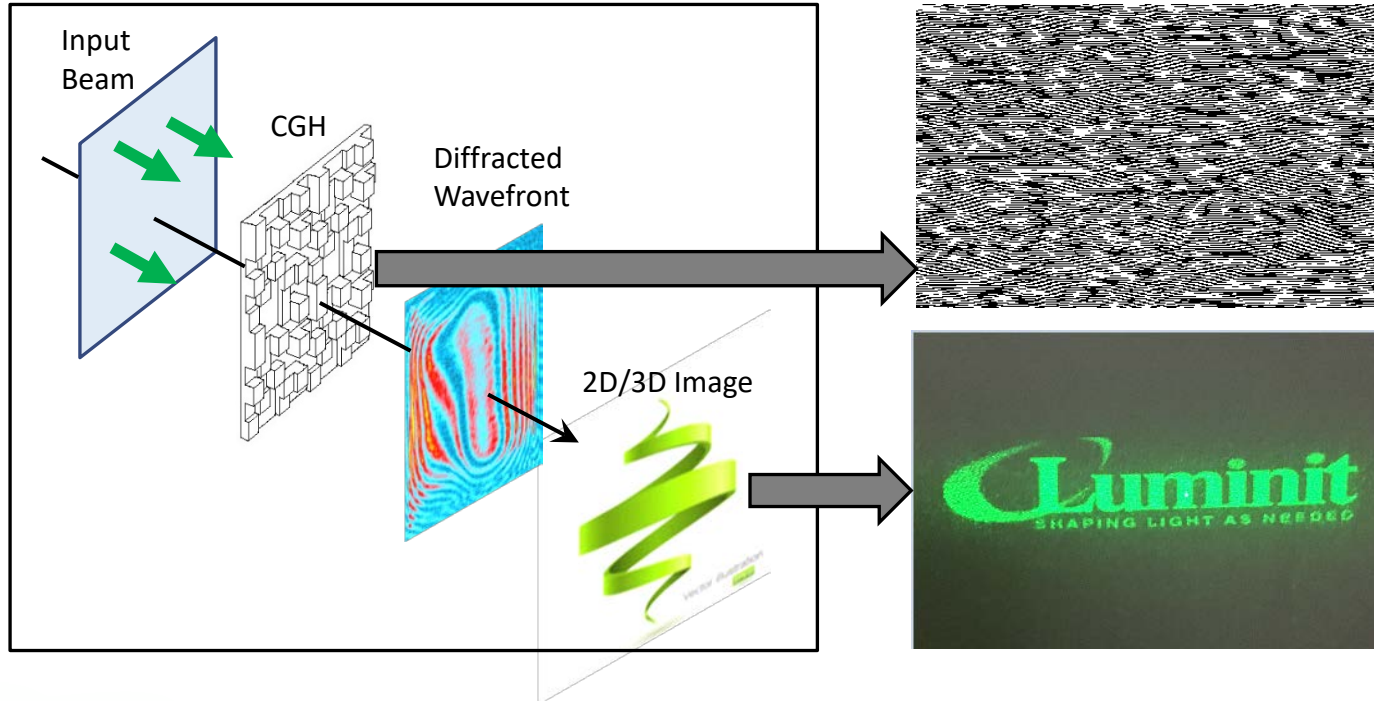
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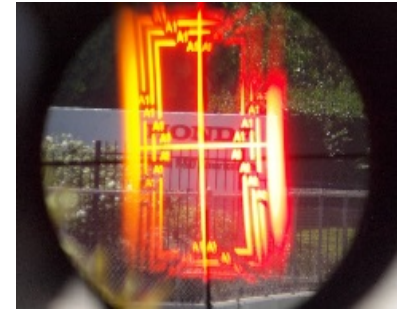
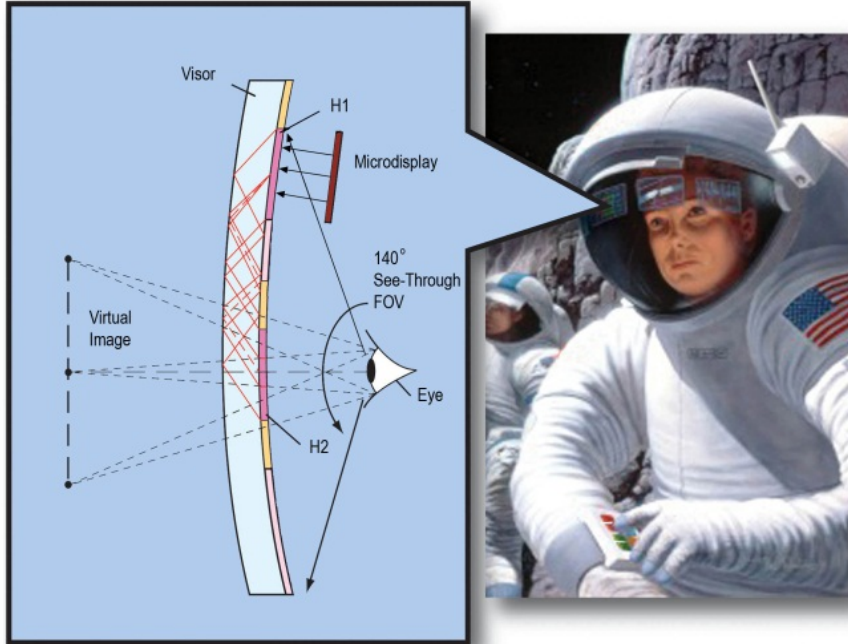


Computer Generated Holography (CGH)

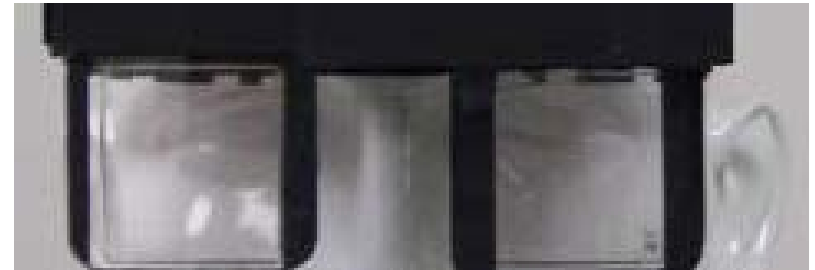
CGH Example: Auto Welcome Mat Lighting



HOE for Augmented Reality

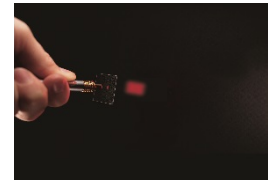


Transparent, thin, near-to-eye displays using DLP (above), OLED (below), or any other microdisplay technology.



HOE Mass Production

- HOE mass production capability worldwide is negligible today
- Luminet is currently ramping up capacity to meet AR industry's needs
 - PP capacity (1,000-20,000 units/mo) in 1H17
 - MP capacity (1,000's of m²/mo) in 2H17
- Luminet is only company with right-sized, roll-to-roll manufacturing capability, with needed holographic expertise to meet AR industry's needs



Conclusions

- Light Shaping with designed refractive optics is already a critical part of the LED ecosystem
- For cost and efficiency reasons, Light Shaping will get pushed closer to the chip
- New manufacturing methods can help bring light shaping to LED chips and packages
- Luminitt has the market position, balance sheet, personnel, manufacturing and technology to help meet these DOE goals.

