Dynamic Optics for Lighting

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What it is

Dynamic Control of **beam shape** in the palm of your hand

Without Moving Parts

https://vimeo.com/199243790
Dissection

Heat sink & Housing

Light engine + LVS3
Adding Adaptive Optics

Standard Light Engine
Tight Spot Lens

Driver IC or PCB
Interconnect

LVS3
Lens Array- “metasurface”

- Adaptive Optic
- LC Cell
- Adaptive Optic
- PCB Interconnect
Technology: Micro LC Lens

- Transparent electrode Structure
- Glass Substrate
- Liquid Crystal (LC) Molecules
Light Propagation in LC Molecules

Treat the two resolved polarizations separately

- Slow axis: Higher Refractive Index $n_1$
- Fast axis: Lower Refractive Index $n_2$

Gradient of Refractive index

Light
Electric Field Controls Orientation

No Electric Field

Activated Electric Field
Molecular Action

Zero optical power (Diopters)

Maximum optical power (Diopters)
Recap: How does it work?

• Solid-state control of light using liquid crystals
  – Molecular orientation changes are obtained by changing electric field profiles hence inducing a corresponding gradient of refractive index.

• Properties of Liquid Crystals
  – Birefringence
    • Aligned nematic LC’s are uniaxially birefringent. 
      No – Ne can be >0.2
      (calcite is 0.17, quartz is 0.01)
  – Self-organizing
    • LC molecules tend to align with each other.
  – Rotated by E-field
    • Applying an E-field torques the molecules, rotating the birefringent axis.
Recap: Liquid Crystal Cell

• Alignment layers orient the molecules initially
• Applying an E-field rotates them
• $n_{\text{effective}}$ is tuned
A Gradient E-field

• Stronger at the edges than at the center, the effective index is lower at the edge than in the center, creating a positive GRIN lens
Gradient Birefringent Lens

• Optical power is proportional to OPD variation:
  – LC cell thickness
  – LC birefringence

• And inversely proportional to \((\text{clear aperture})^2\)

• Practical limits to LC cell thickness are imposed by response time and optical parameters.
Practical Considerations

• Optical Transmission 78 to 90 %
  – Losses primarily due to scattering, absorption less than 5%
• Power consumption single digit mW
• Expected lifetime 10,000’s hours
  – Simpler device than LCD TV same materials
• Competitively priced
The Future

- Complete control of beam shape
  - Micro lens addressing
- Beam Steering
- BATWINGS!???
Thank You!

LensVector

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