

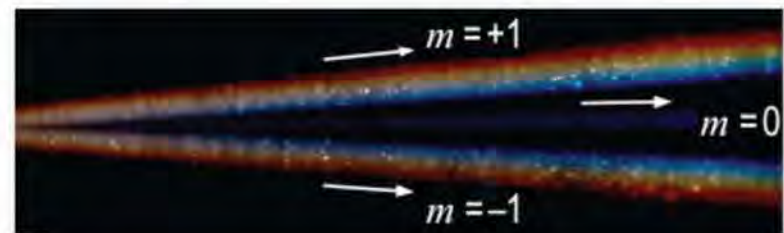
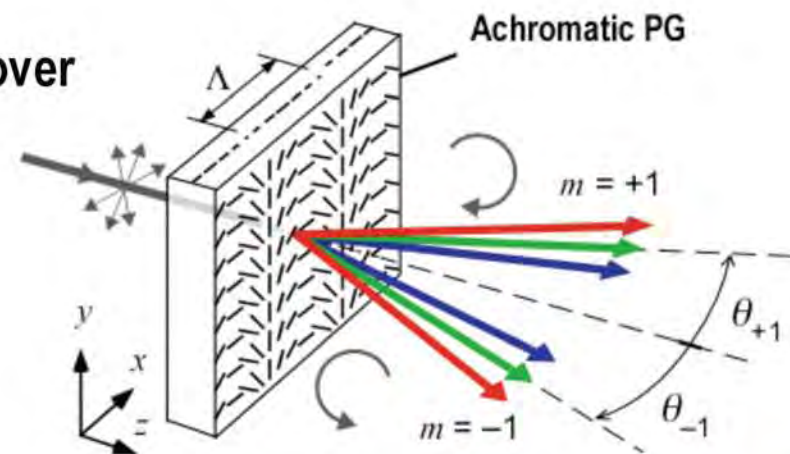
Polarization-Independent Modulation using Standard LCDs and Polymer Gratings

**Chulwoo Oh, Ravi Komanduri, Brandon Conover
& Michael J. Escuti**

Electrical & Computer Engineering
North Carolina State University

coh@ncsu.edu

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IDRC 2008 @ UCF, Orlando



Overview

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- **Motivation – Polarizer-free LCDs**
- **Polarization Grating** as Diffractive Beam Splitters
- ***Our Concept: Polymer-PG LCDs***
- **Operation Principles** as modulator
- **Prototype Projection Display**
- **Conclusions**

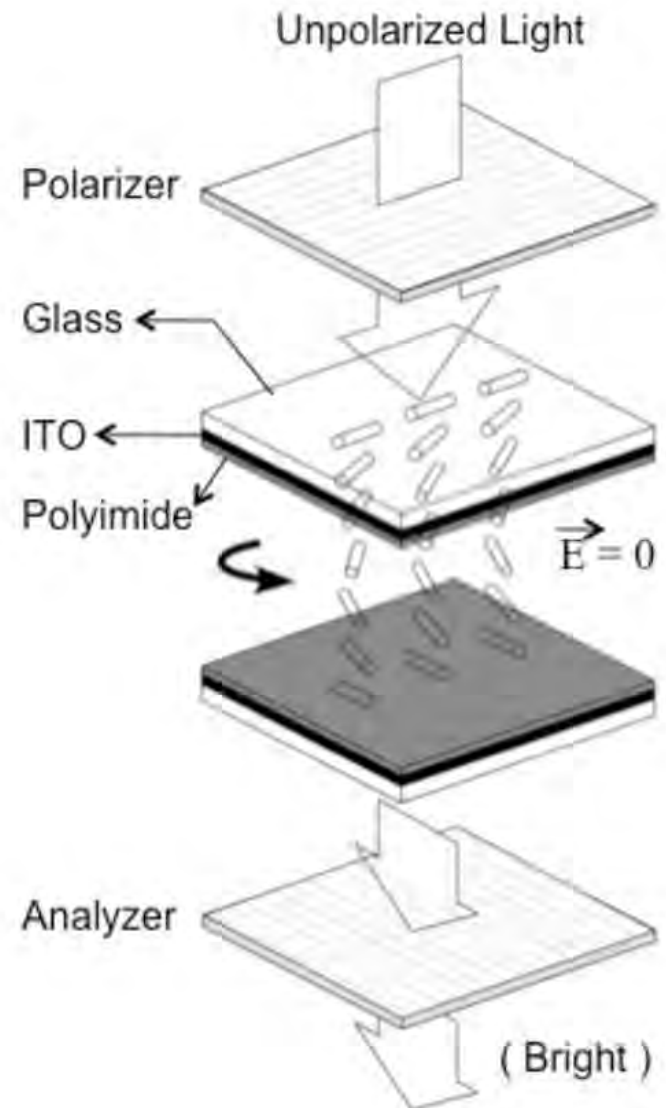
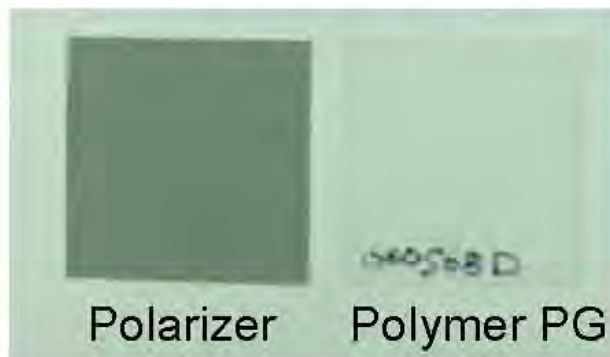
Motivation – Polarizer-Free LCDs

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Theme of IDRC 2008
Energy Efficient Displays

- Light efficiency of LCDs is usually ~10-20%
- Polarizers: >55% reduction

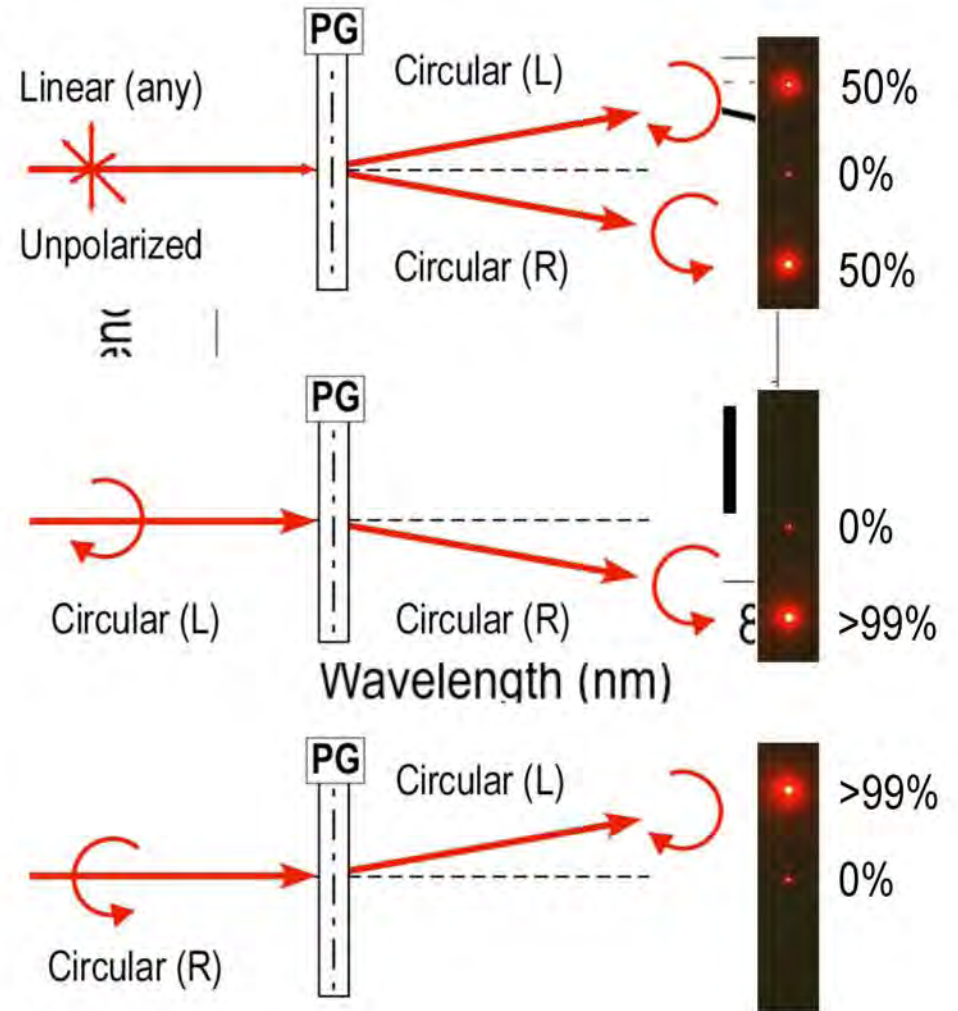
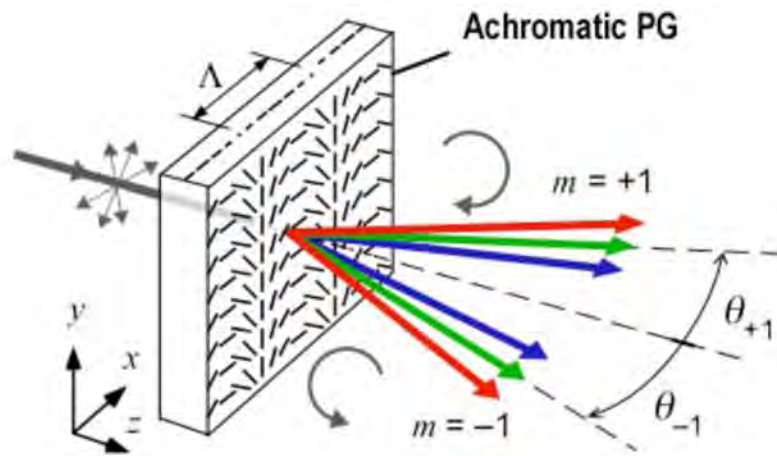
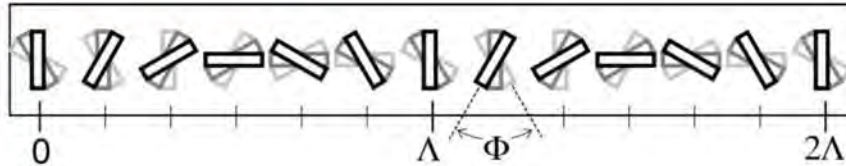
We suggest to replace polarizers with transparent thin-film polymer grating



Polarization Gratings

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Nikolova et al., *Optica Acta* **31**, 579-588 (1984)
 Oh and Escuti, *Opt. Lett.* **33**, 2287-2289 (2008)



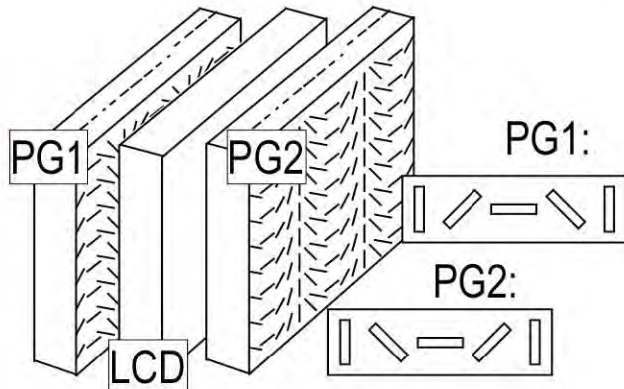
Polarization Gratings

- **birefringent** diffraction gratings
- nearly 100% 1st order efficiency proven
- 1st orders individually *polarization sensitive*

Polarization-Independent Modulation

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using Standard LCDs & Polymer PGs

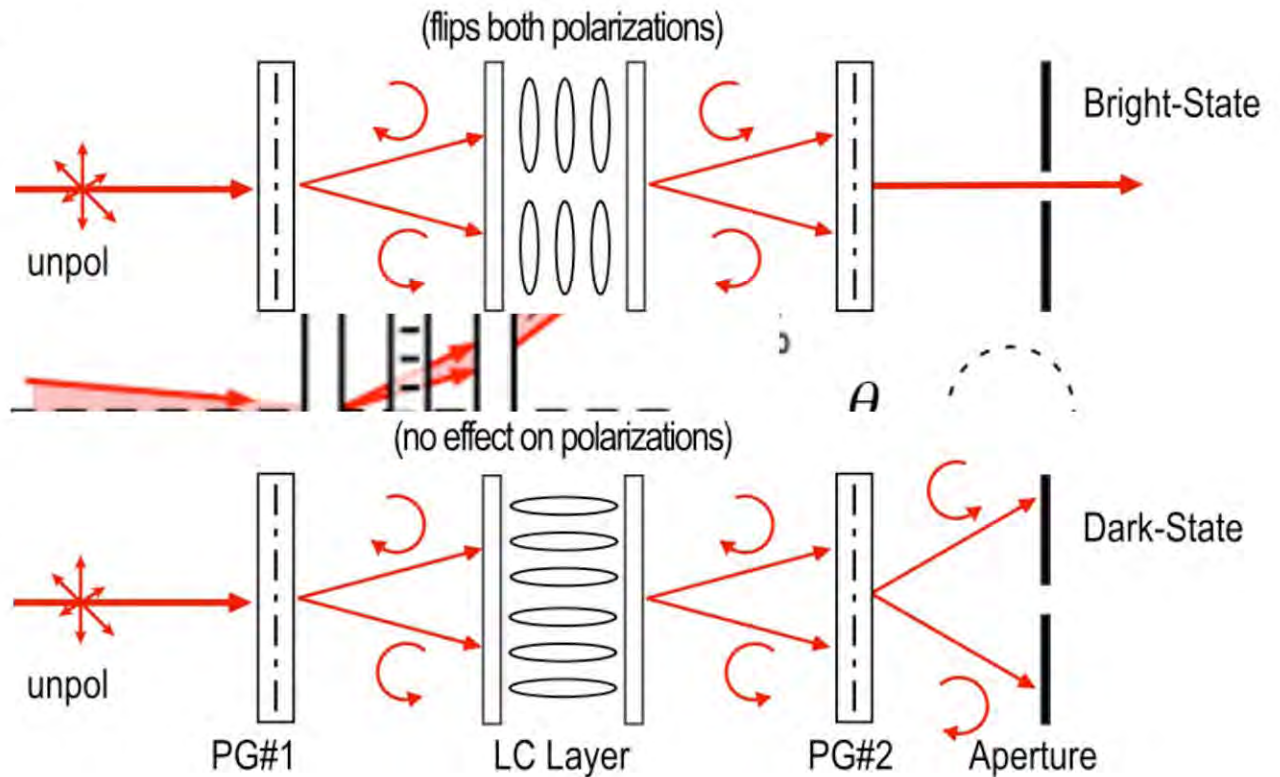


Anti-Parallel PG configuration

Suitable for most conventional LC modes

No Polarizers!!!

Potential for ×2 brightness

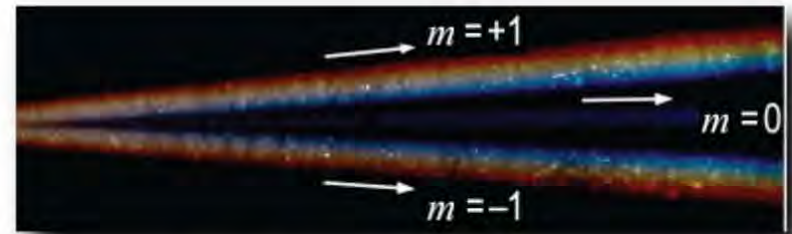
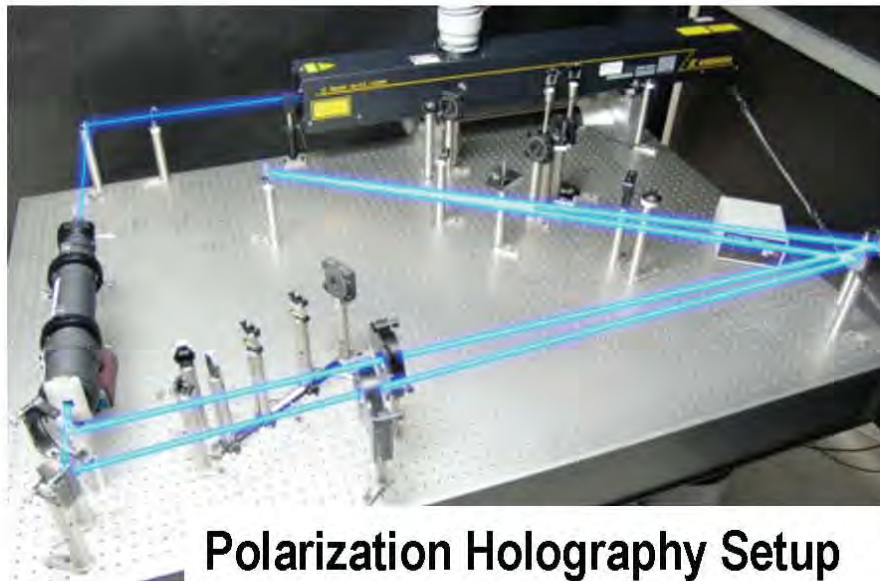
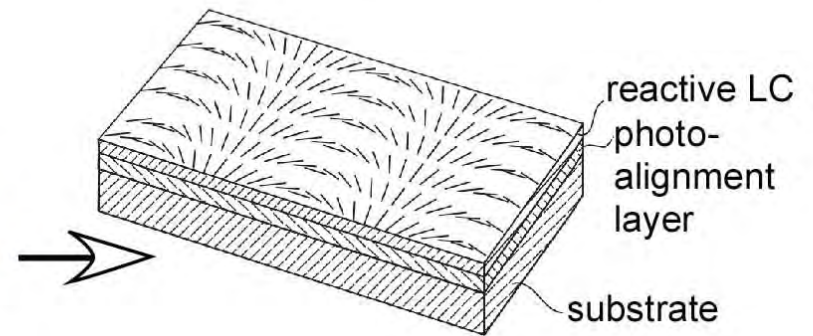
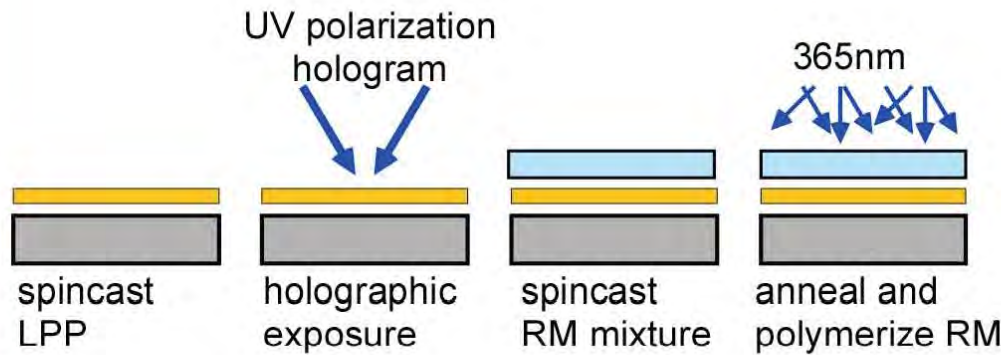


Polymer Polarization Gratings

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LPP – ROP103/2CP (Rolic)
RM – RMS03-001C (Merck)

Crawford et al., *J. Appl. Phys.* **98**, 123102 (2005)
Escuti et al., *Proc. SPIE* **6302**, 632614 (2006)



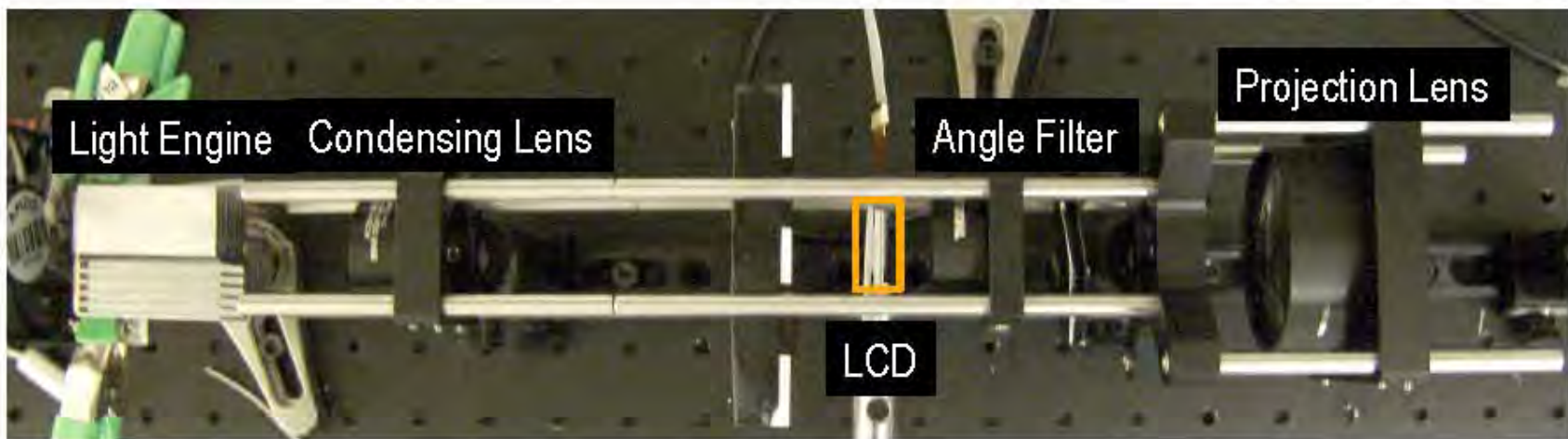
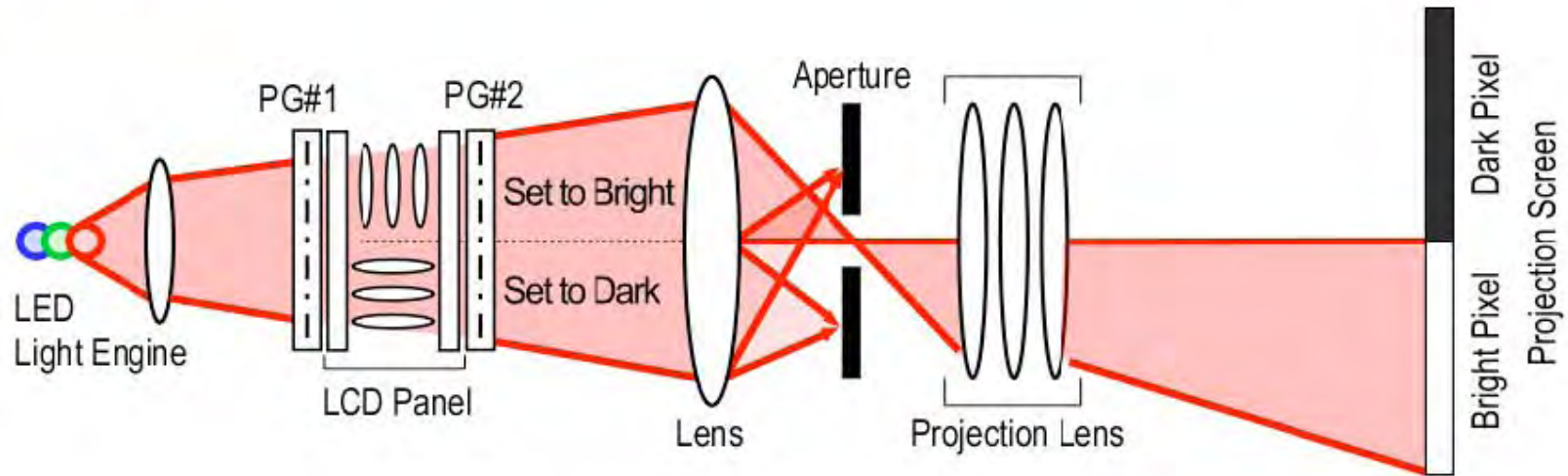
Polymer PGs

- highly efficient LC gratings
- thin polymer films
- ⇒ stable, easily integrated
- simple processing at low cost

Proof of Concept Projector

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Projection using Standard LCD

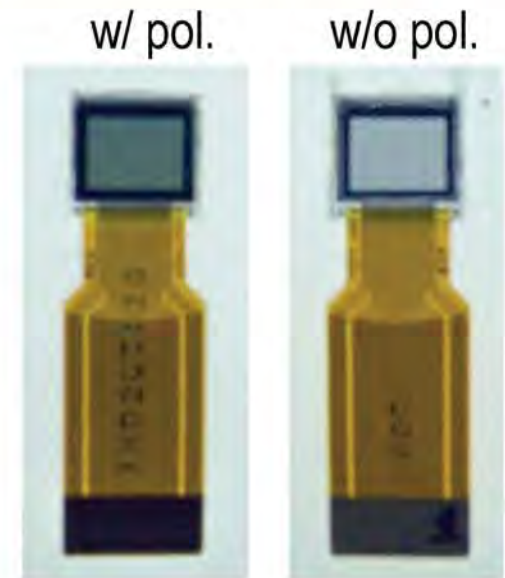
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LC Microdisplay

- size: 8mm×6mm
- resolution: 640×480
- ECB mode
- field sequential light

System

- acceptance angle: $\pm 6^\circ$
- lens F/# = 2.6
- PG period: 2.5 μm

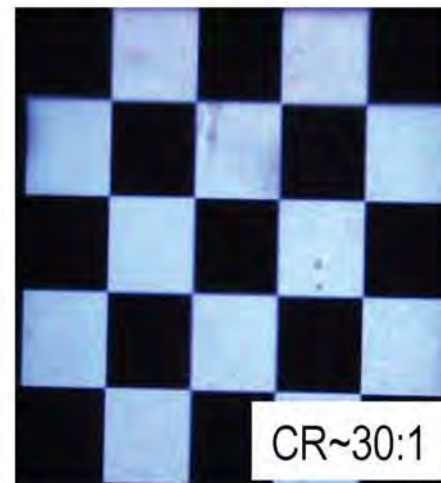


Polymer-PG LCD Projector

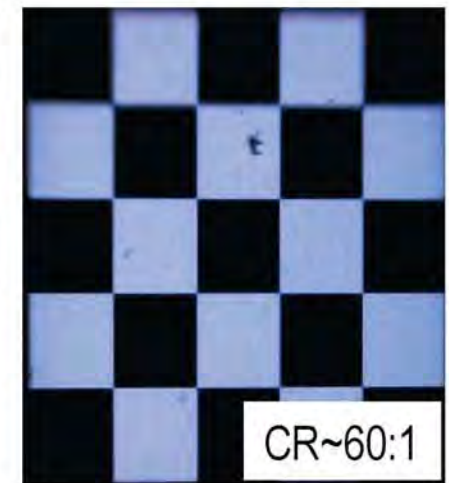
Achievement: **x1.8 brighter**

Challenge: $\frac{1}{2}$ contrast ratios

Additional work on compensation films to increase CRs



Polymer-PG LCD



unmodified LCD

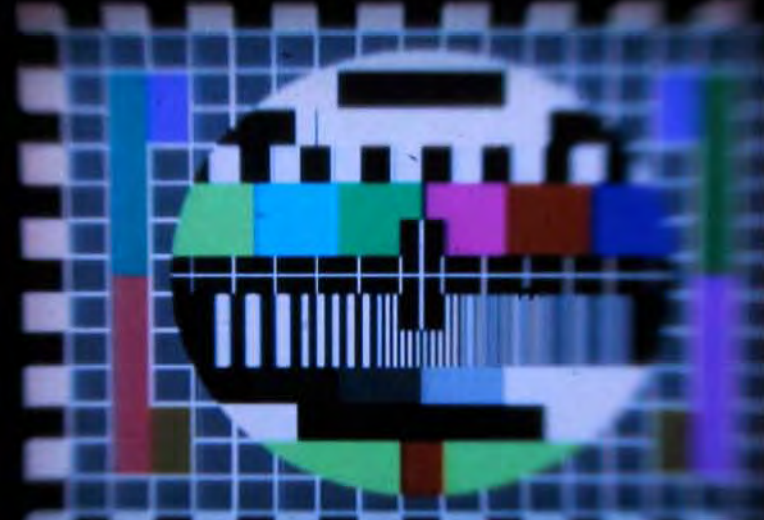
Polymer PG LCD



Polarizer-based LCD



From "Ratatouille," Copyright by Disney/Pixar



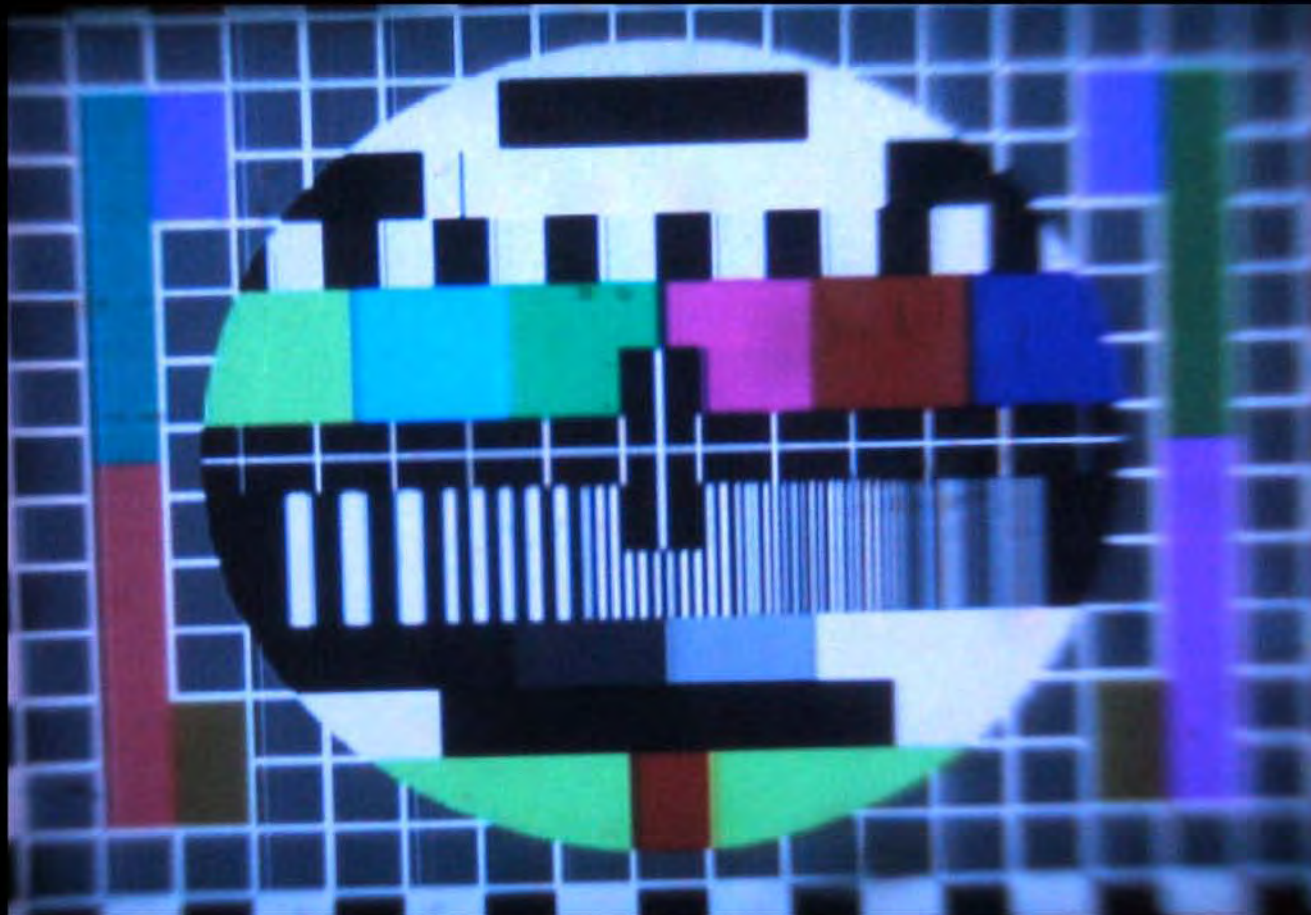
NTSC Standard

Projected Images by Polymer-PG LCD



From "Ratatouille"
Copyright by Disney/Pixar

Projected Images by Polymer-PG LCD



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Projected Images by Polymer-PG LCD



From "Kung Fu Panda"
Copyright by DreamWorks/Paramount

Movie from Polymer-PG LCD



From "Kung Fu Panda"
Copyright by DreamWorks/Paramount

Conclusions / Summary

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- Polymer PG-LCDs
 - Achieved brightness enhancement factor of $\sim x2$, fundamental contrasts $>100:1$
 - Via conventional LC displays (all pixel modes possible) + external polymer films
 - Polarizer-free, birefringent grating approach modulating unpolarized light
- Prototype projection system
 - Proved imaging qualities are preserved
 - Current contrast limitations are solved by retardation film optimization

(#16.2) Polarization-Independent Modulation using Standard LCDs & Polymer Polarization Gratings



**NC STATE
UNIVERSITY**

Chulwoo Oh, Ravi Komanduri, BL Conover, MJ Escuti
< www.ece.ncsu.edu/oleg >

- Demo of proper nano-projector targeted for **CES** (Jan09), with development partner Jabil Circuit (FL)
- Technology licensed to ImagineOptix Corp (NC), actively engaging manufacturing/development partners
- Hope you will consider this PolymerPG LCD approach as the viable alternative to conventional polarizers for many display applications!

• Acknowledgements/Funding

- National Science Foundation (grant #0621906)
- ImagineOptix Corp (grant #528991)



National Science Foundation
WHERE DISCOVERIES BEGIN



NC STATE UNIVERSITY

Opto-electronics &
Lightwave Engineering Group



Fabrication Details