ORGANIC ELECTRONICS AND OPTOELECTRONICS: CURRENT TRENDS AND FUTURE DIRECTIONS

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San Jose, California

Directions in Organic Optoelectronics

Organics in Communications

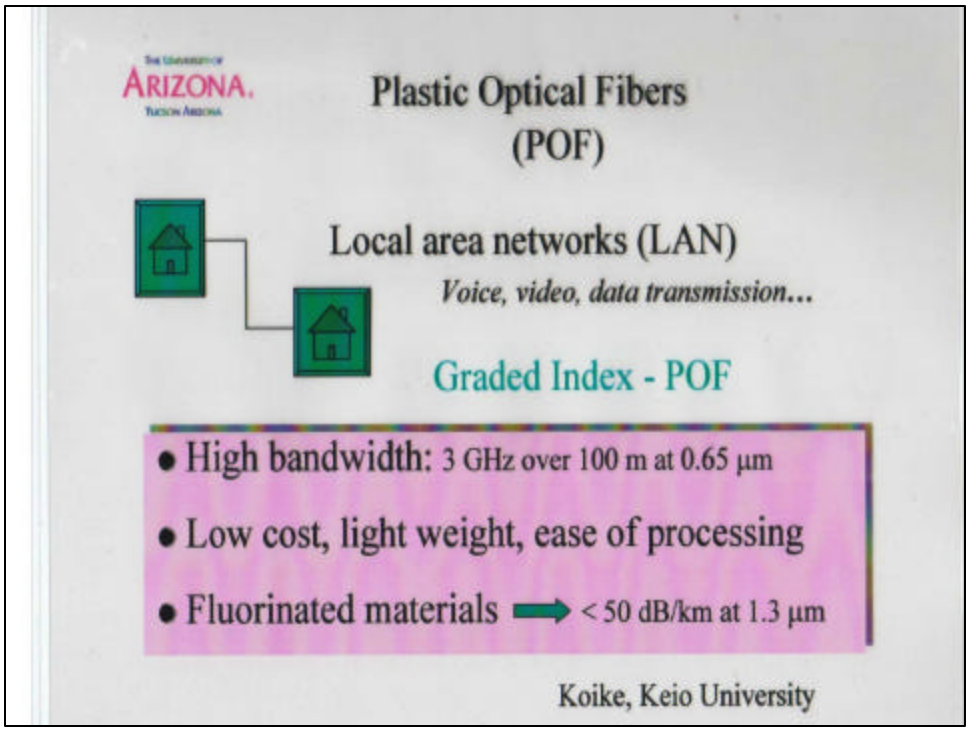
- polymer optical fibers
- polymer components for WDM
- NLO polymers for modulators and switches

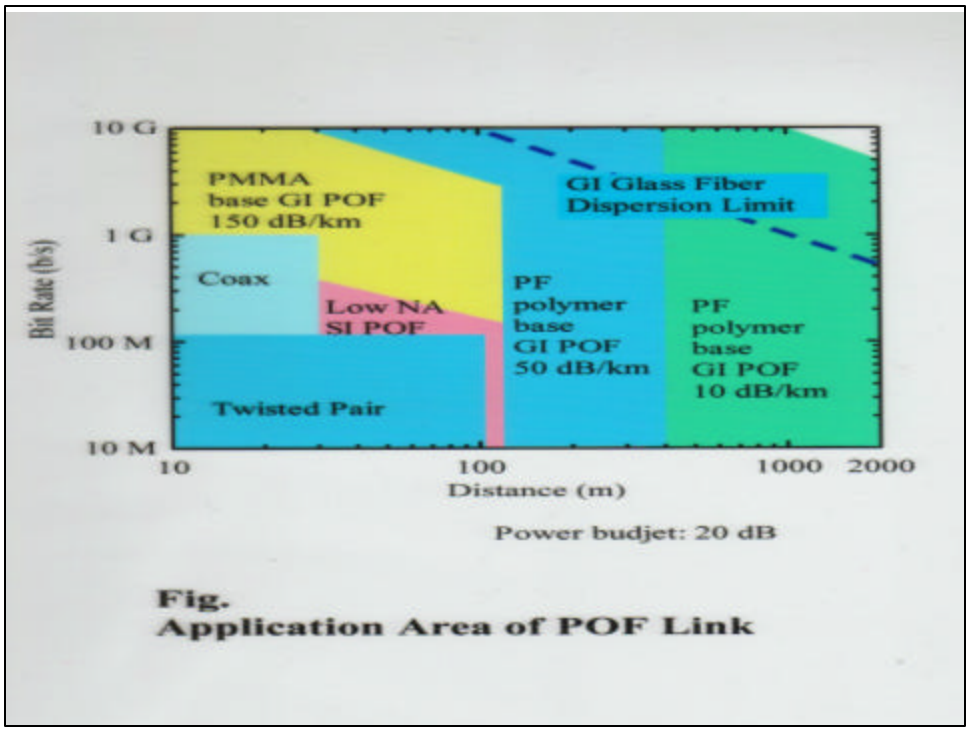
Organics in Optical Storage and Security

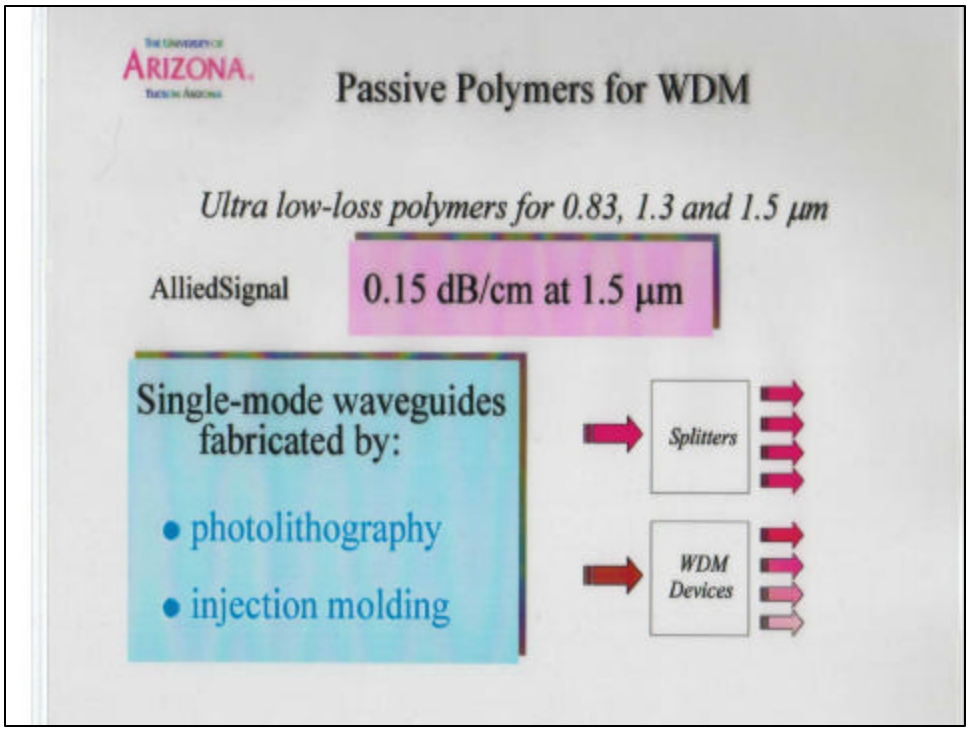
- photo polymers
- photorefractive polymers

Organic Displays and Light Emission

- OLEDs
- polymer lasers
- organic transistors

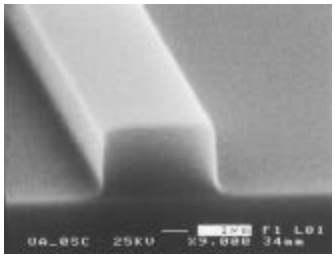

ARIZONA.
Plastic Optical Fibers
(POF)
Local area networks (LAN)
Voice, video, data transmission...
Graded Index - POF
• High bandwidth: 3 GHz over 100 m at 0.65 μm
• Low cost, light weight, ease of processing
• Fluorinated materials → < 50 dB/km at 1.3 μm
Koike, Keio University


10 G
1 G
100 M
10 M
Bit Rate (b/s)
PMMA
base GI POF
150 dB/km
GI Glass Fiber
Dispersion Limit
Coax
Low NA
SI POF
PF
polymer
base
GI POF
50 dB/km
PF
polymer
base
GI POF
10 dB/km
Twisted Pair
10
100
1000
2000
Distance (m)
Power budjet: 20 dB
Fig.
Application Area of POF Link



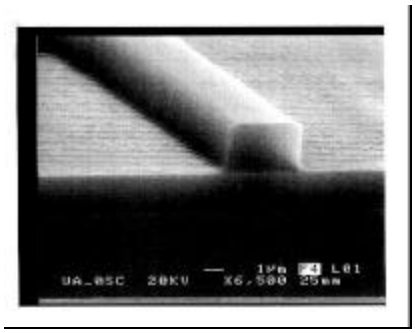
SC

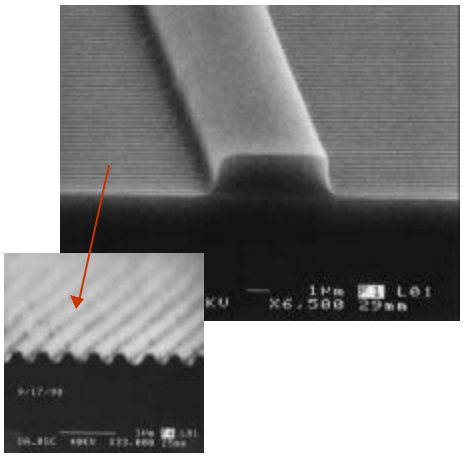
Sol-Gel Waveguide for Integrated Optics



SC

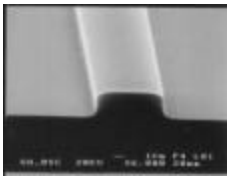
Bragg Grating and Sol-Gel Waveguide

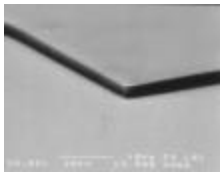


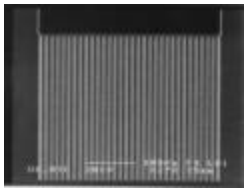


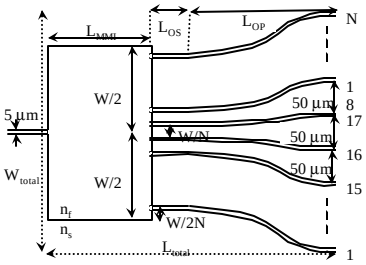
SC

1-N Sol-Gel MMI Splitter







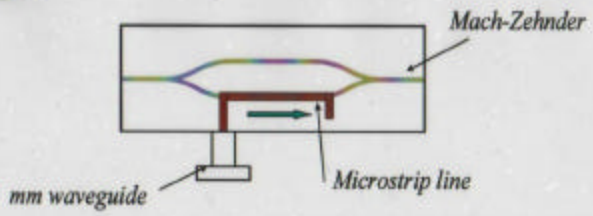


1x32 MMI output

Electro-optic modulators

$$\frac{n^3 r}{\varepsilon}$$

Low dielectric constant of polymers and large electro-optic coefficient

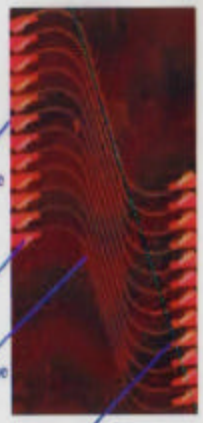


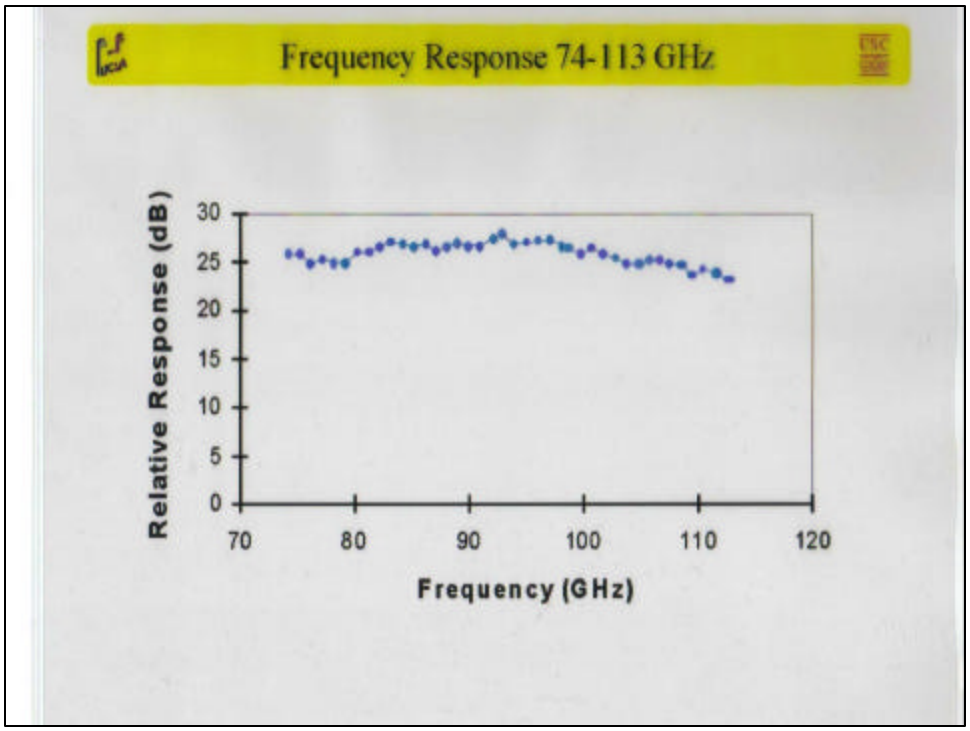
High bandwidth: > 110 GHz

Fetterman, Steier, Dalton (UCLA, USC)

Polymer Modulator on Mylar substrate

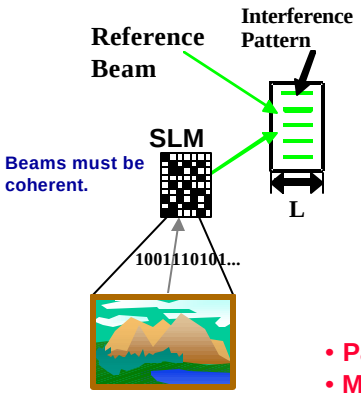
Finline to Waveguide Transition



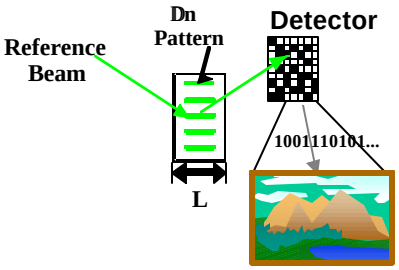


Introduction to Holography

Recording



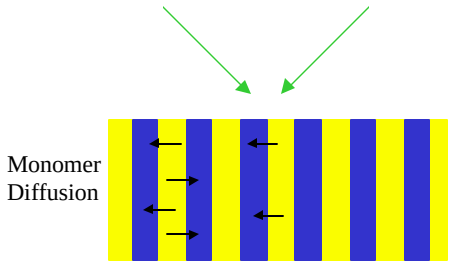
Readout



- Parallel readout of data - fast rates
- Multiplexing - much greater density

Low T_g Materials

Hologram Formation



Local Photoinitiated Polymerization

New Approach

- Large Δn with minimal shrinkage.

=> Large dynamic range

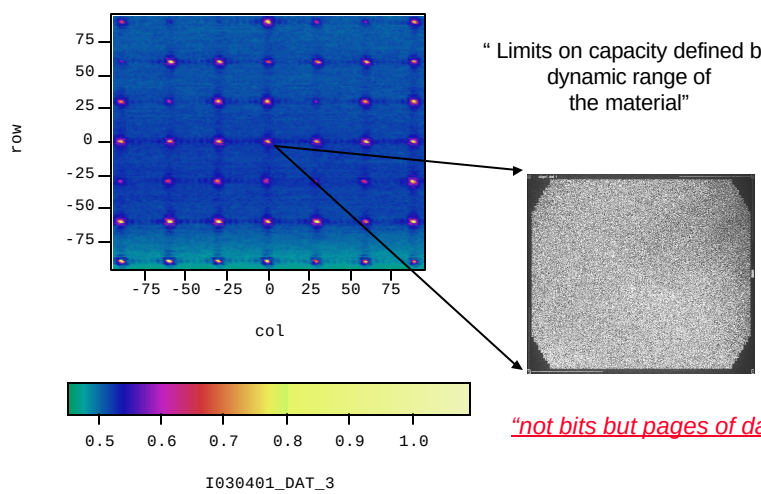
- Inherently permanent
- WORM Applications

- High Sensitivity
- Large Δn changes
- Low Cost
- Excellent Optical Quality

Lucent Technologies Inc. – Proprietary

Lucent Technologies
Bell Labs Innovations

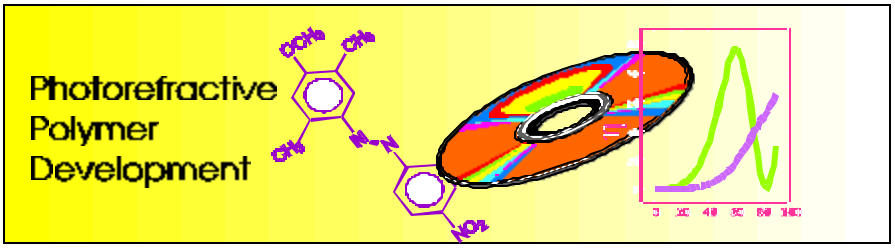
High Density Storage



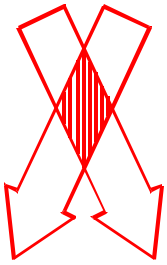
" Limits on capacity defined by dynamic range of the material"

"not bits but pages of data"

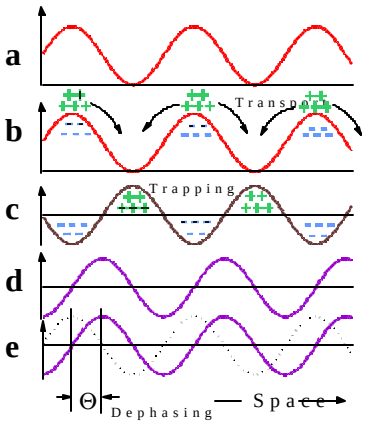
Photorefractive Polymers



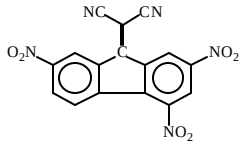
The photorefractive effect



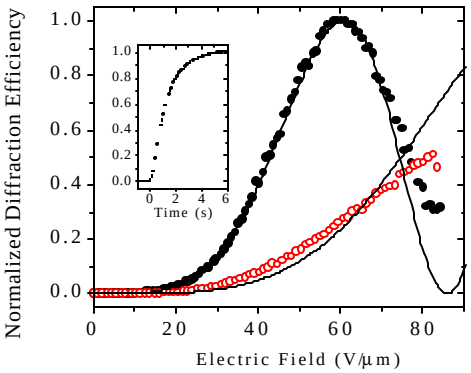
Convert an intensity distribution into a refractive index distribution



Near IR sensitivity



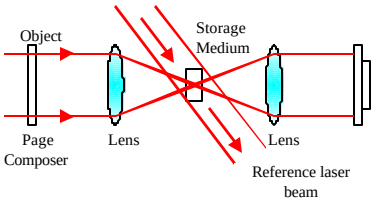
Science, 279, 54 (1998)



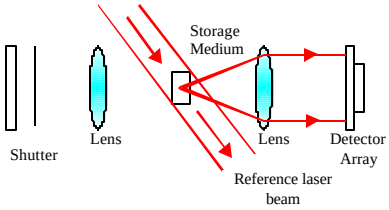
DHADCMPN:PVK:ECZ:TNFDM (25:49:24:2 % wt.)

Photorefractive Polymers for Holographic Storage

1) Recording



2) Reconstruction



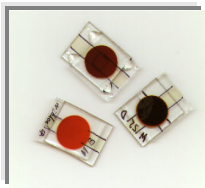
Three-dimensional image of a penny retrieved from holographic storage in a photorefractive polymer composite prepared at the University of Arizona. The red color reflects the 675 nm wavelength of the low power semiconductor laser diode used for the recording and the reconstruction of the hologram

K. Meerholz et al., *Nature* 371, 497 (1994)

Polymeric Optical Correlator for Security Verification

Table-top demonstration of principle

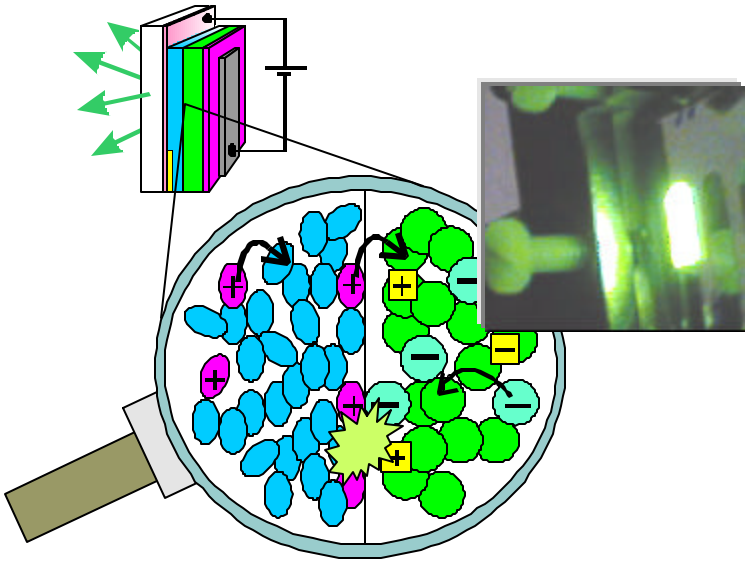
Portable compact version



Photorefractive polymer samples

B. Volodin et al., *Nature* 383, 58 (1996)

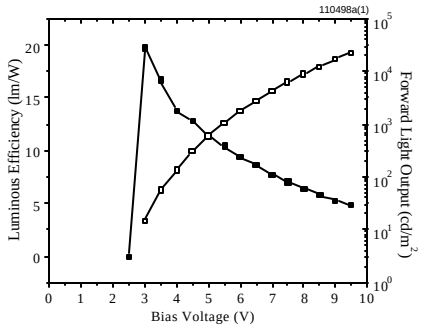
Organic light-emitting diodes

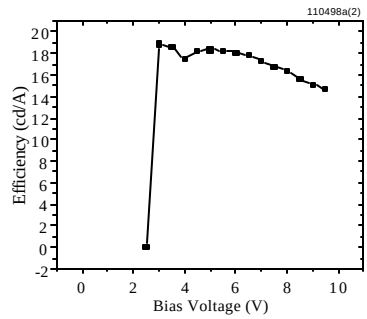


Device Efficiency

$$lm/W = \frac{I\,(cd/m^2)\,\times\,\pi}{V_{bias}\,\times\,i\,(mA/cm^2)\,\times\,10}$$

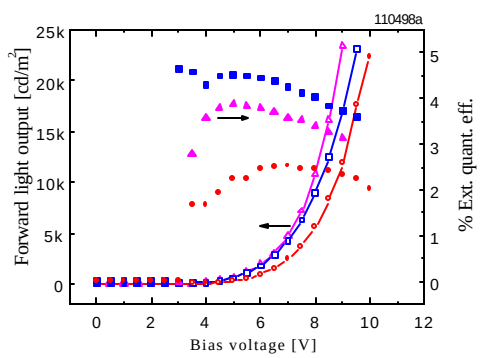
$$cd/A = \frac{I\,(cd/m^2)}{10\,\times\,i\,(mA/cm^2)}$$

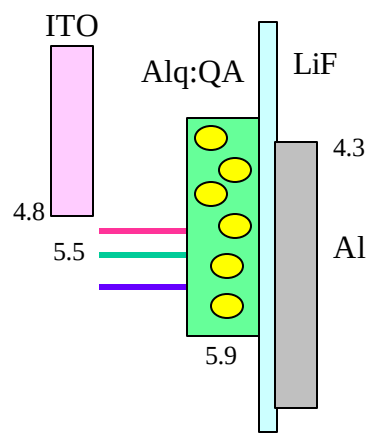




Al-based cathode

Doped devices

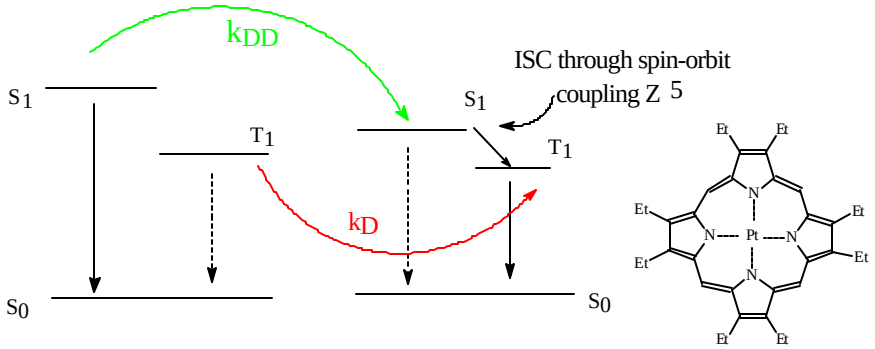




4.6 % external quantum efficiency

From fluorescence towards phosphorescence

Collect all the singlets and triplets: 100% efficiency

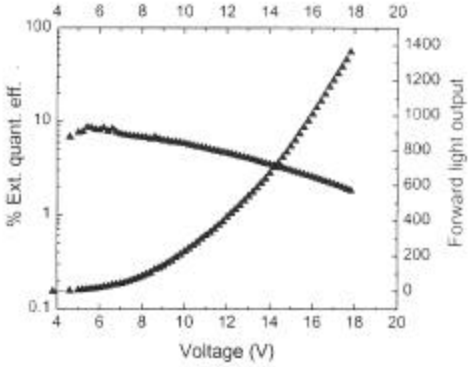


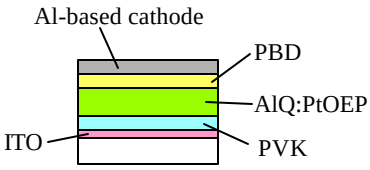
k_{DD} : dipole-dipole (Forster) long range 1/R 6

k_D : Dexter transfer, short range exp(- b r)

Baldo et al., Nature 395, 151 (1998)

Red electrophosphorescent device with 8.7 % external efficiency (45% internal efficiency)



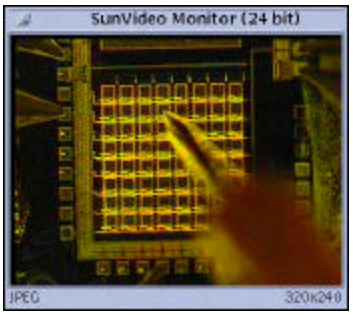


- h = 8.7 % at 14 cd/m²
- h = 4 % at 540 cd/m²

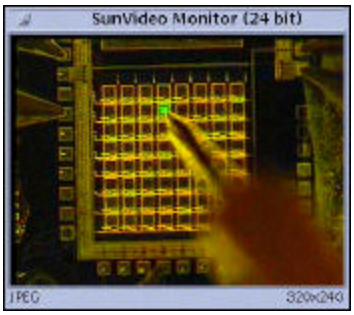
Baldo et al. 4% at < 1 cd/m²

OLED/CMOS Test

Pixel Off

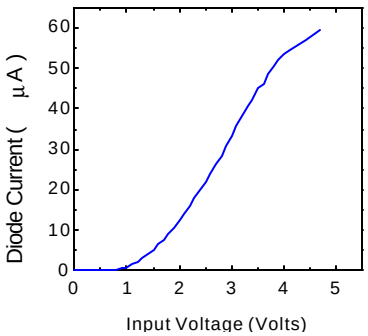


Pixel On

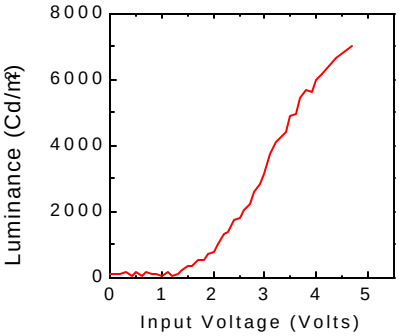


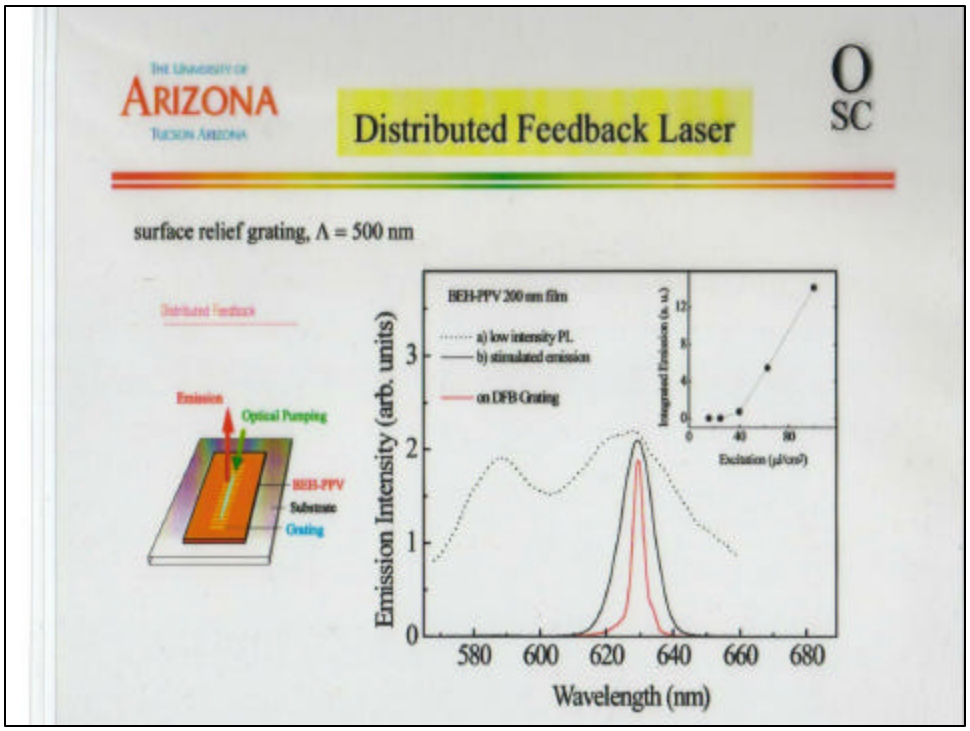
OLED/CMOS Test

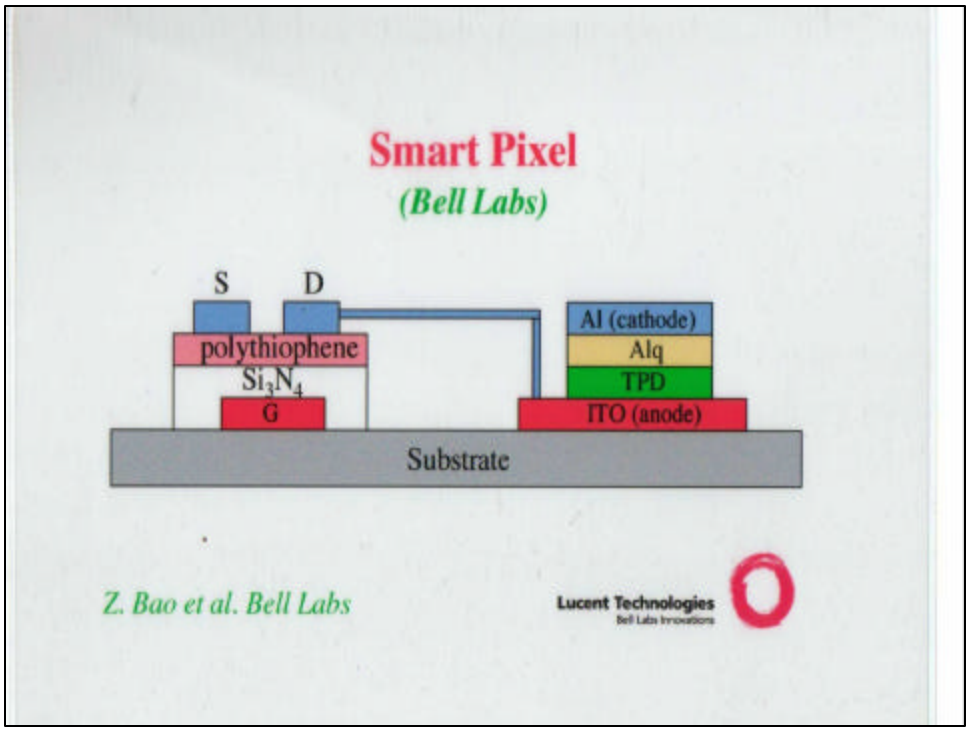
OLED Current

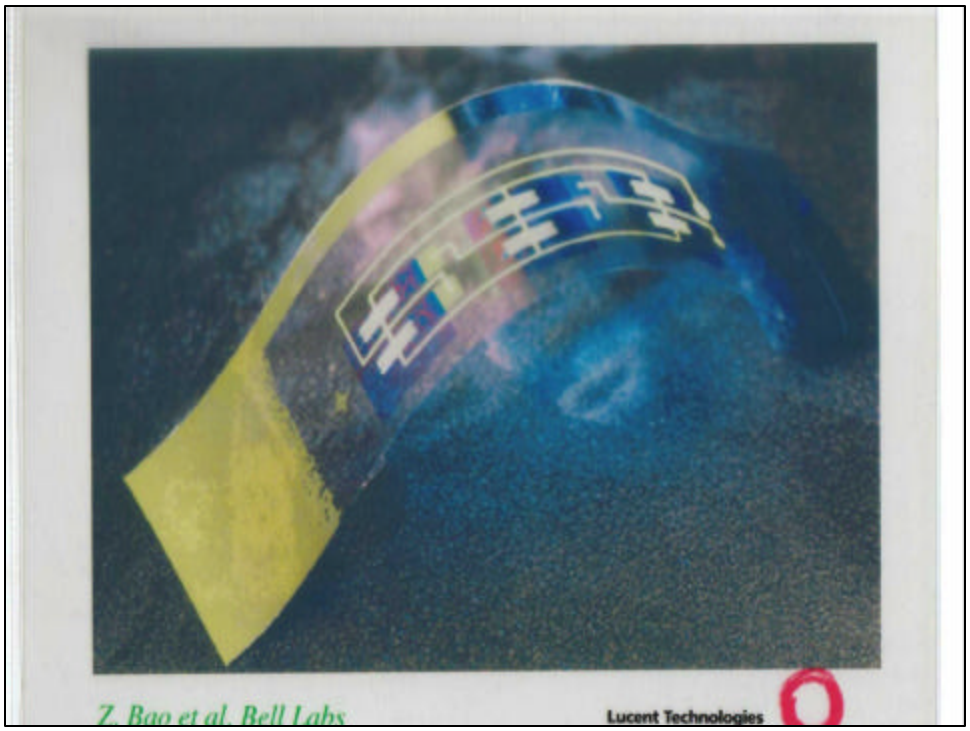


OLED Light




THE UNIVERSITY OF
ARIZONA
TUCSON ARIZONA
Distributed Feedback Laser
O
SC
surface relief grating, Λ = 500 nm
Distributed Feedback
Emission
Optical Pumping
BEH-PPV
Substrate
Grating
BEH-PPV 200 nm film
a) low intensity PL
b) stimulated emission
on DFB Grating
Emission Intensity (arb. units)
Wavelength (nm)
Integrated Emission (a. u.)
Excitation (μJ/cm²)


Smart Pixel
(Bell Labs)
S
D
polythiophene
Si_3N_4
G
Al (cathode)
Alq
TPD
ITO (anode)
Substrate
Z. Bao et al. Bell Labs
Lucent Technologies
Bell Labs Innovations


Z. Bao et al. Bell Labs
Lucent Technologies