Plastic Display Research at HP

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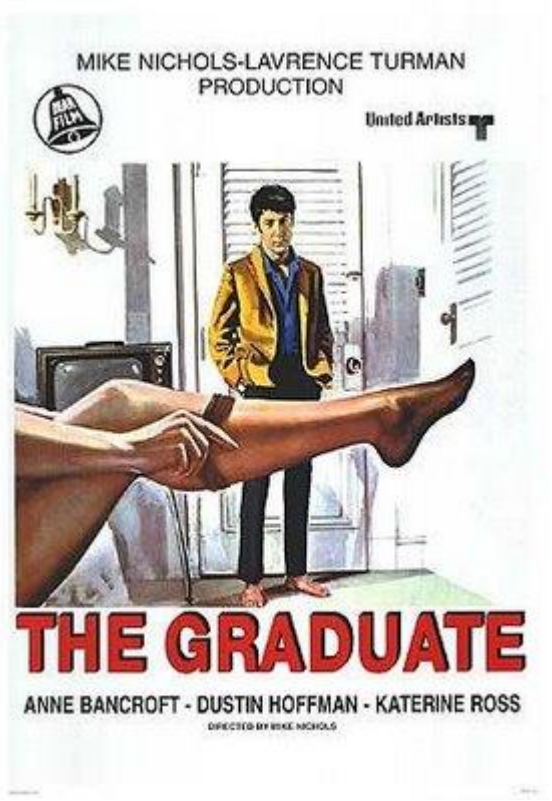
Director Information Surfaces Lab

Displays are in virtually every product HP sells

Last year we sold 70 million

What will be the next big change in displays?

"Just one word: plastic."



Career advice given to the Graduate by Mr. Robinson;
more true today than it was in 1967

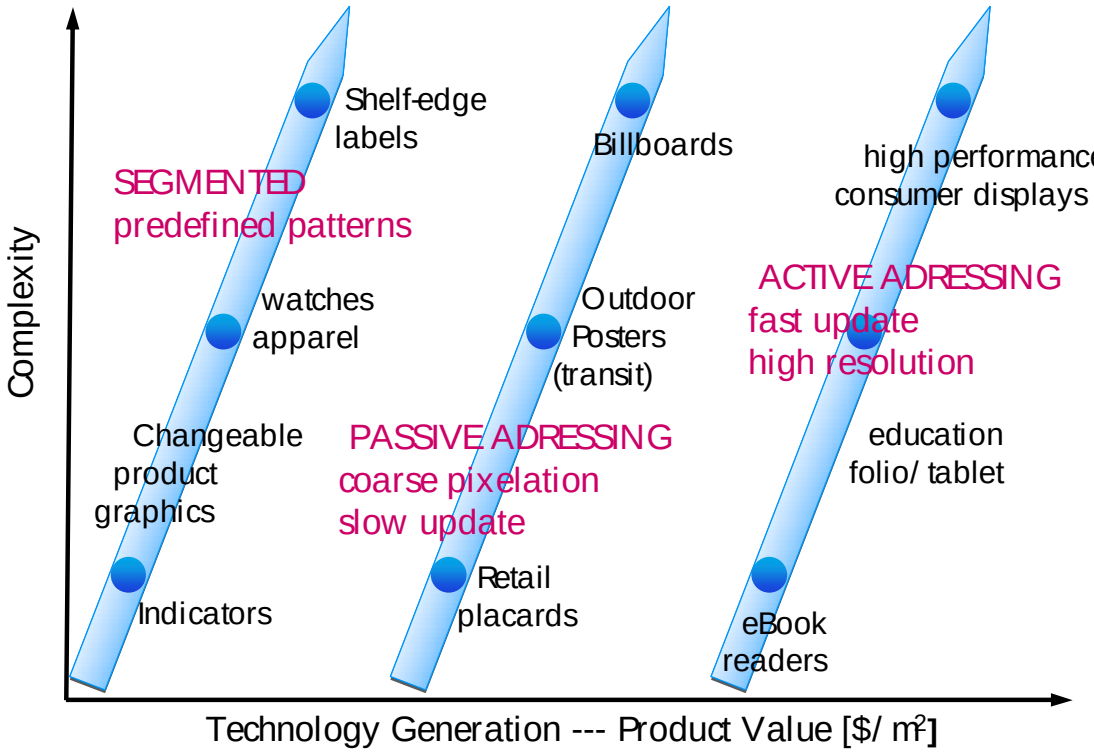
Plastics Will Revolutionize the Display Industry

- Lower cost: roll-to-roll manufacturing
- Not Glass
  - Lightweight
  - Unbreakable
  - Conformable
- Compatible with Emerging Display Technologies
  - OLED brighter, cheaper, more efficient alternative to LCD
  - Ultra low power displays
    - Reflective
    - Bi-stable
  - Mobile displays
    - Reflective
    - Mixed-mode: transflective, remissive

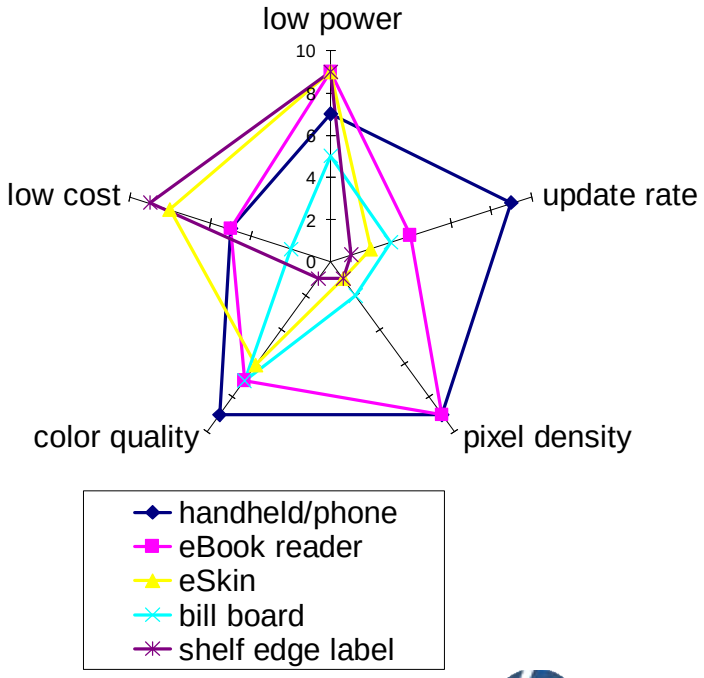

Apparel, Fashion
eBook Readers, Education
eSkins, Packaging
Flexible reflective displays
have many other applications
Military, Civil
Signage
PC’s, Phones

Flexible Display Roadmap

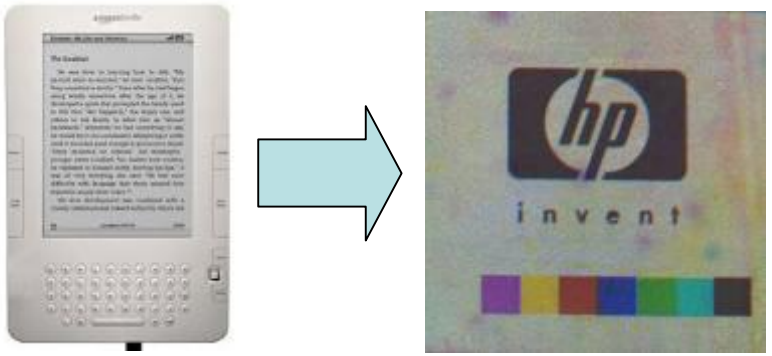
Technology roadmap for plastic display technology



Technical difficulty comparison for selected applications



The Big Technical Hurdles We Face

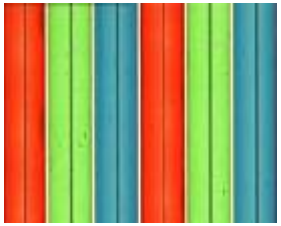


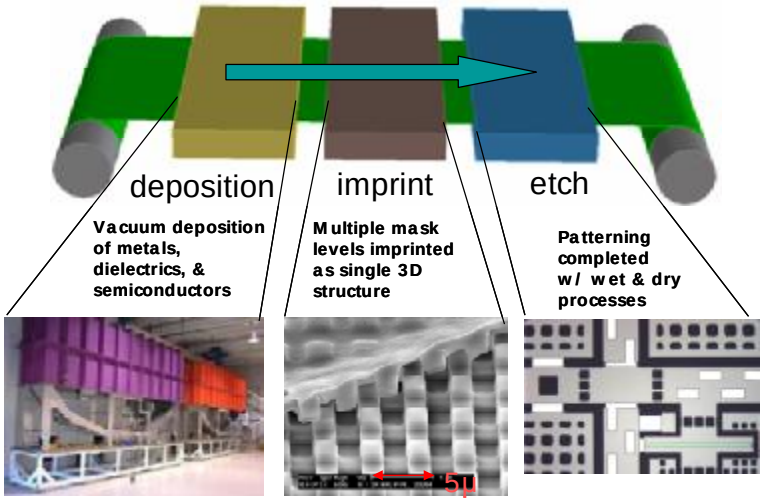
e Ink Displays are Great!

- Super low power
- Readable in bright light
- Wide viewing angle

But…..

- Update is slow
- Quality COLOR unreachable?





Roll-to-Roll built Electronics

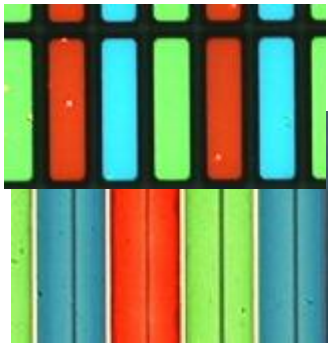
- Lowest possible manufacturing costs
- Scalable to largest size
- ‘Native’ format for flexible displays

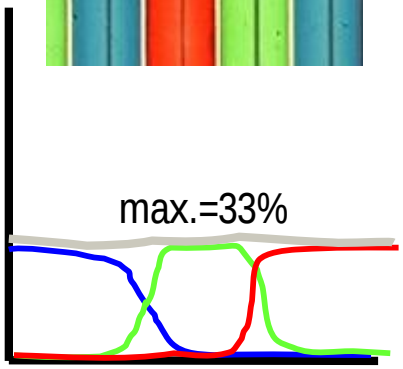
But…..

- Can alignment challenge be solved?
- Can a high performance display like OLED be made?

Architectures to address full color gamut

additive
side-by-side
subpixels

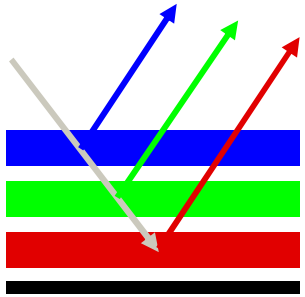


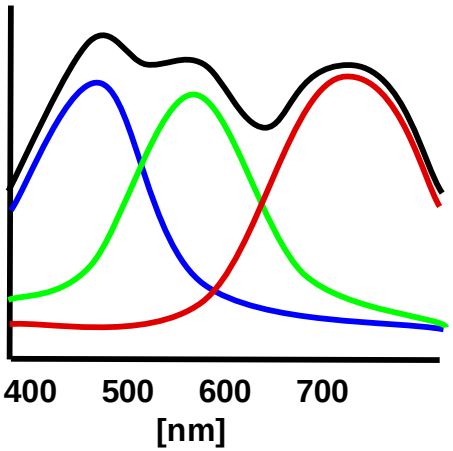


R+G+B = grey (dim)

stacked layers

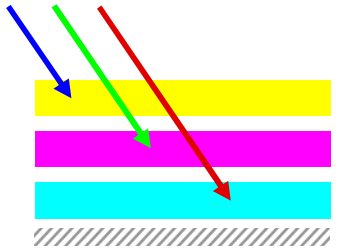
additive

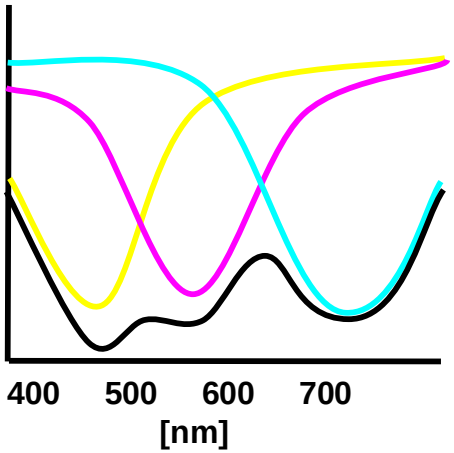




R+G+B = murky white

subtractive

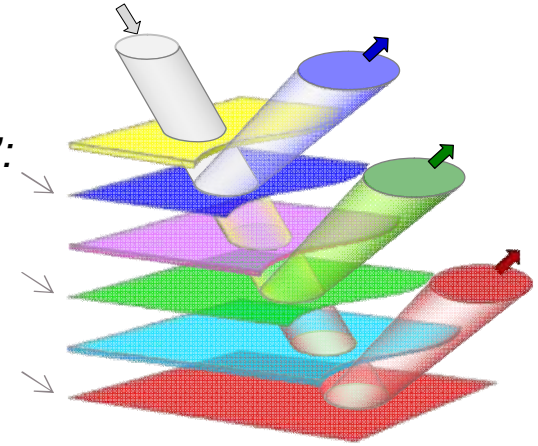




-R -G -B = brown
(so add black)

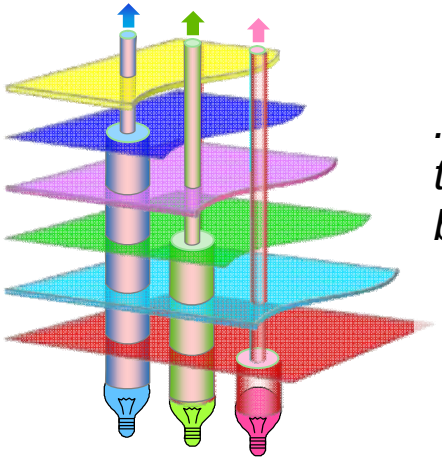
Transflective Demonstrator

'Magic mirrors': reflect 90% RGB as soon as possible…



Reflection mode

Backlight off, bright ambient

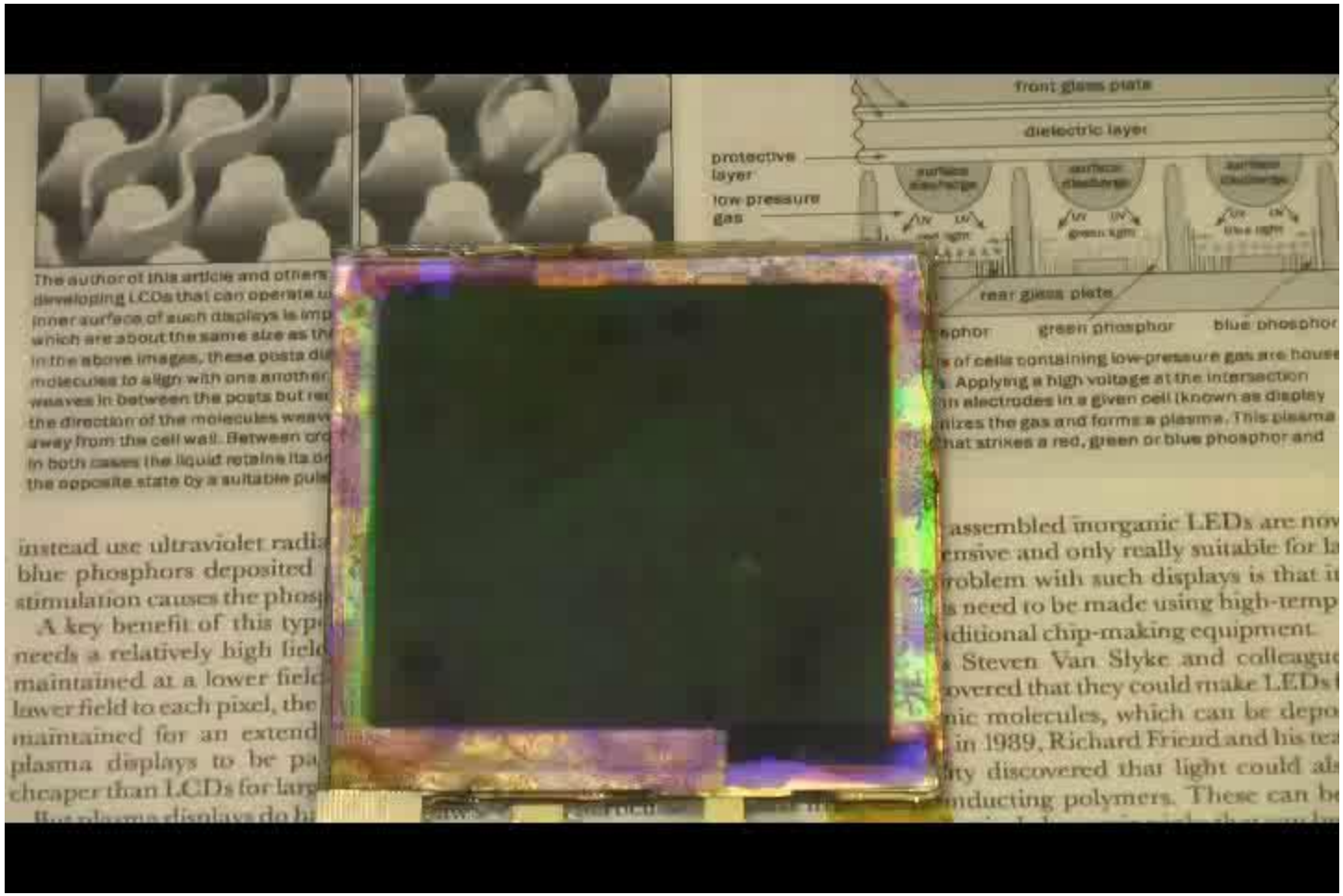


..mirrors <u>also</u> transmit 10% of backlight –

<u>more</u> than transmission of conventional LCD!

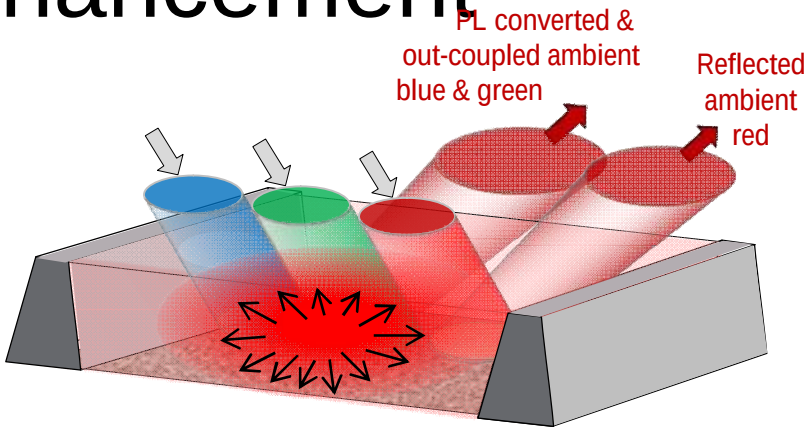
Transmission mode

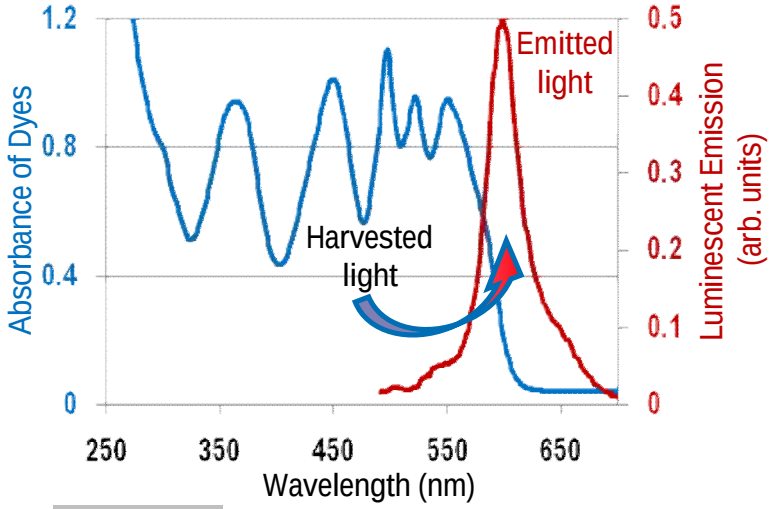
Backlight on, dark ambient

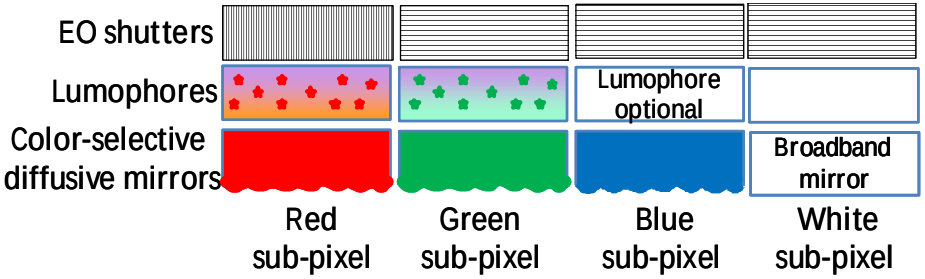

front glass plate
dielectric layer
protective layer
low-pressure gas
rear glass plate
green phosphor
blue phosphor

Photoluminescent enhancement

- Single layer design is simpler to fabricate
- Luminescent materials capture light from shorter wavelengths and down-convert it
- Focus on materials development

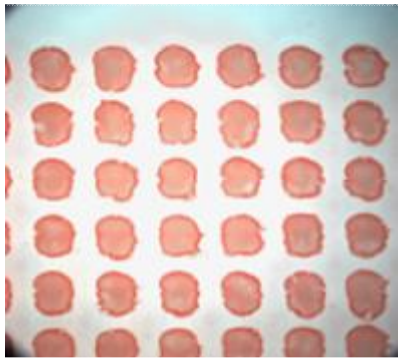




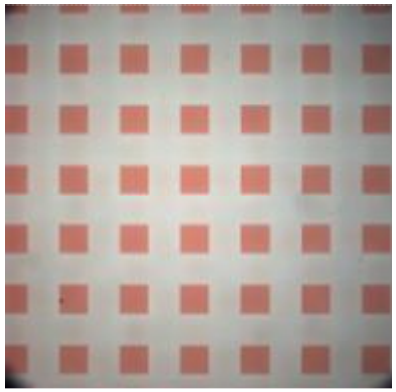


PL swatches exceed SNAP standard – also brighter than perfect reflectors

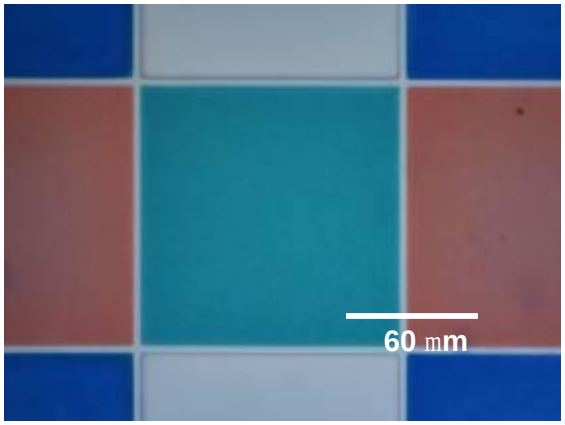
Templated Color Filters



Red filter resin deposited by inkjet



Red filter resin deposited into patterned wells

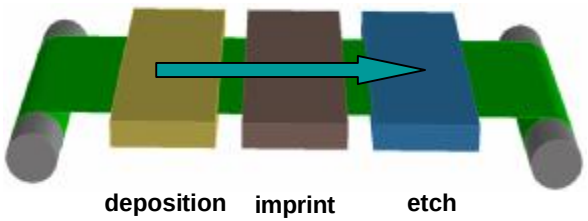


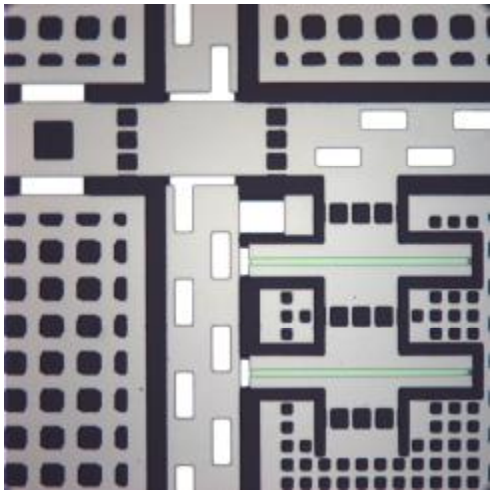
RGB+ White filter pattern

Templated color filter array laminated to FCD E-Ink display

Project with eInk and Flexible display center funded by FlexTechAlliance

SAIL technology: World's first roll-to-roll fabricated display





- SAIL (self-aligned imprint lithography) roll-to-roll manufacturing of displays on flexible substrates
- Initial non-exclusive license to PowerFilm Solar for fabrication of self-powered wrist-worn military displays
- Wired magazines top 10 technologies, recipient of Merck award for outstanding display technology, printed electronics award for manufacturing technology,FlexTech Alliance 'Flexi' Award recipient of government support from USDC, FlexTech Alliance and Army Research Labs

R2R Tool Development

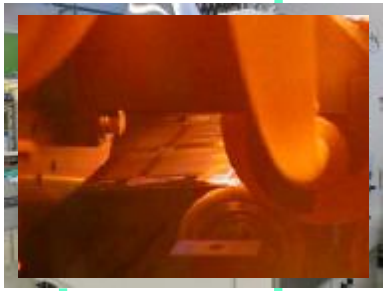
13” production solar cell deposition

13” drum PECVD

13” drum RIE

13” wet etcher

4” imprinter



10” drum PECVD

13” drum sputter

13” RIE

13” imprinter

2005 | 2006 | 2007 | 2008 | 2009 | 2010

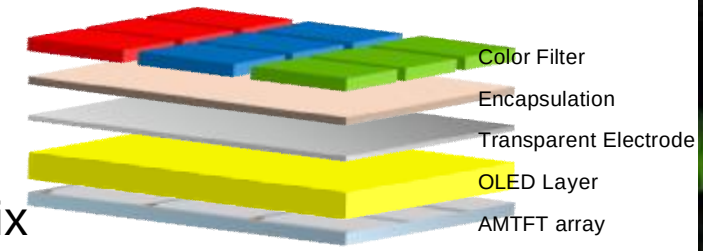
Next steps towards commercialization

- September 22, 2008 PowerFilm announced that it has taken a license to the SAIL technology
- October 6th, 2008 PowerFilm announced it has won a $1.4M / year cooperative agreement from the U.S. Army for development of a 'self powered flexible display' . HP Labs and PowerFilm will collaborate on the contract.
- PowerFilm Solar has created Phicot as a subsidiary to commercialize the technology

phicot

HEWLETT PACKARD

Flexible OLED Display Approach

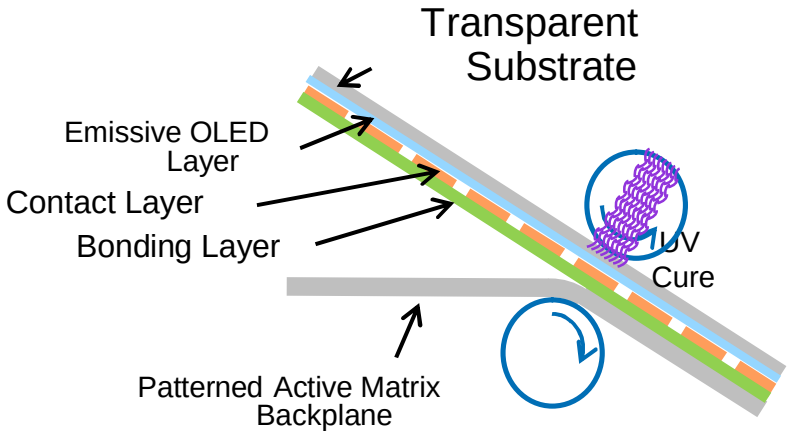


OLED Display Stack

GE R2R OLED

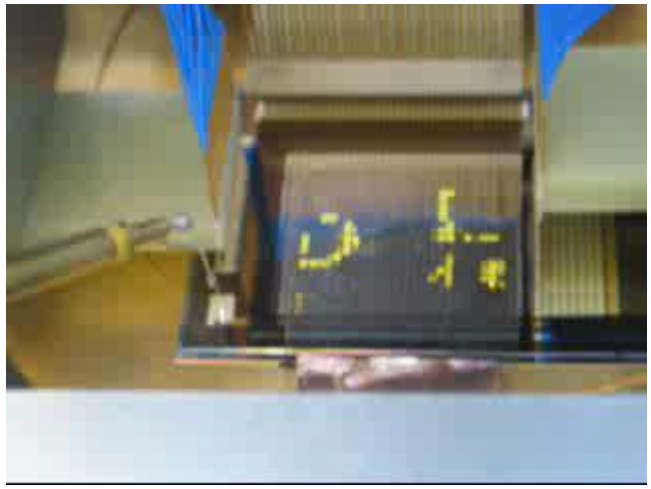
Goal: R2R fabricated Active Matrix OLED Displays

- Utilize R2R white OLEDs being developed for lighting
- Alignment free integration of frontplane and backplane
  - Micro-pixelation
  - Anisotropic conductive adhesive
- Enhance the capabilities of SAIL backplanes
  - More complex pixel circuits for driving currents
  - Higher performance semiconductors

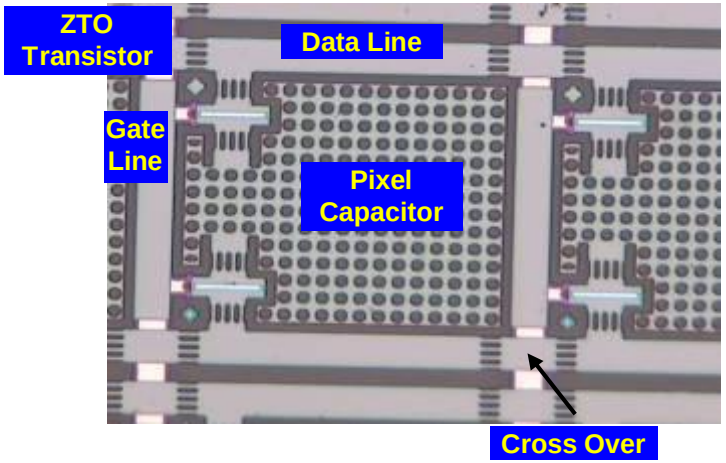


Lamination of OLED to Backplane

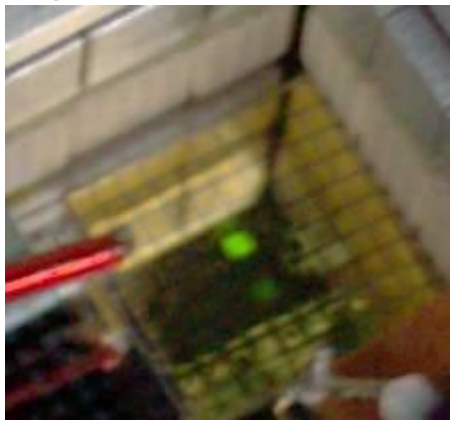
OLED Backplane Development



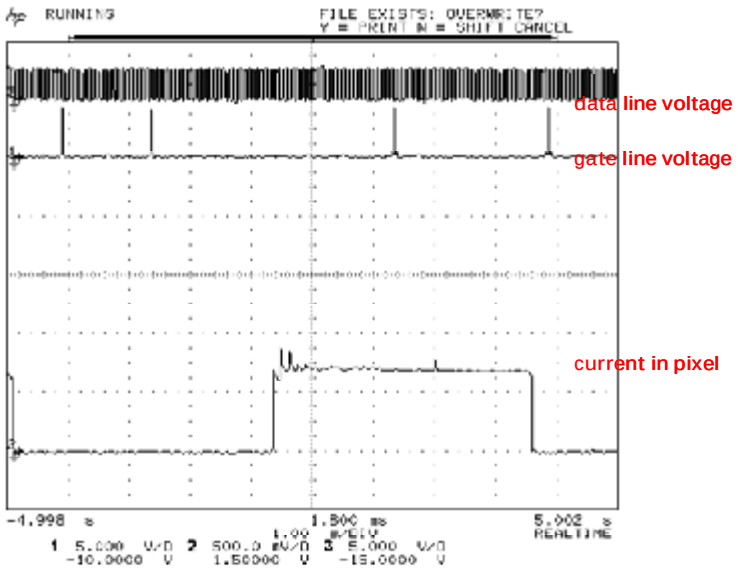
Micro-OLED display driven by traditionally processed backplane using SAIL TFT stack



SAIL processed Zinc Oxide pixel transistors



OLED driven by R2R SAIL processed aSi active matrix pixel circuit



Output of SAIL aSi pixel circuit