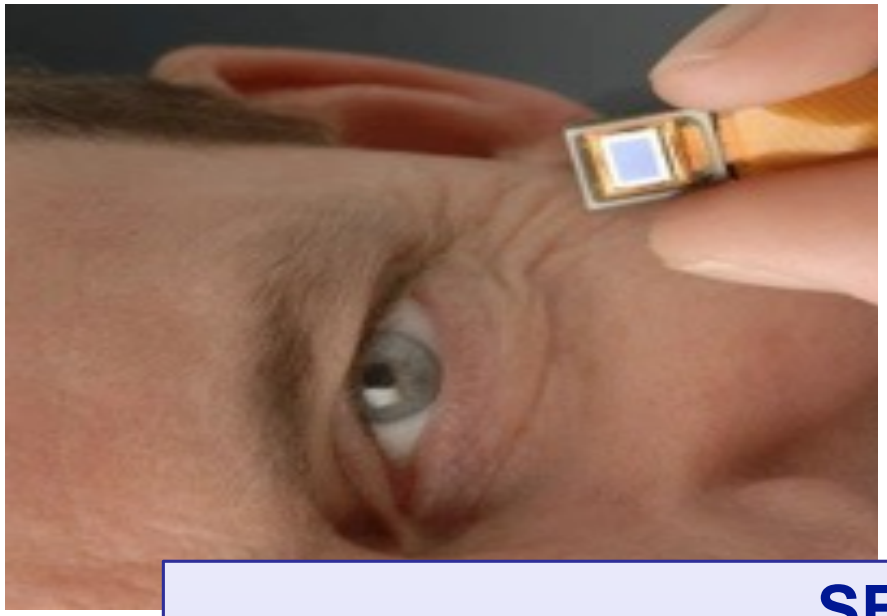


SECTION 10

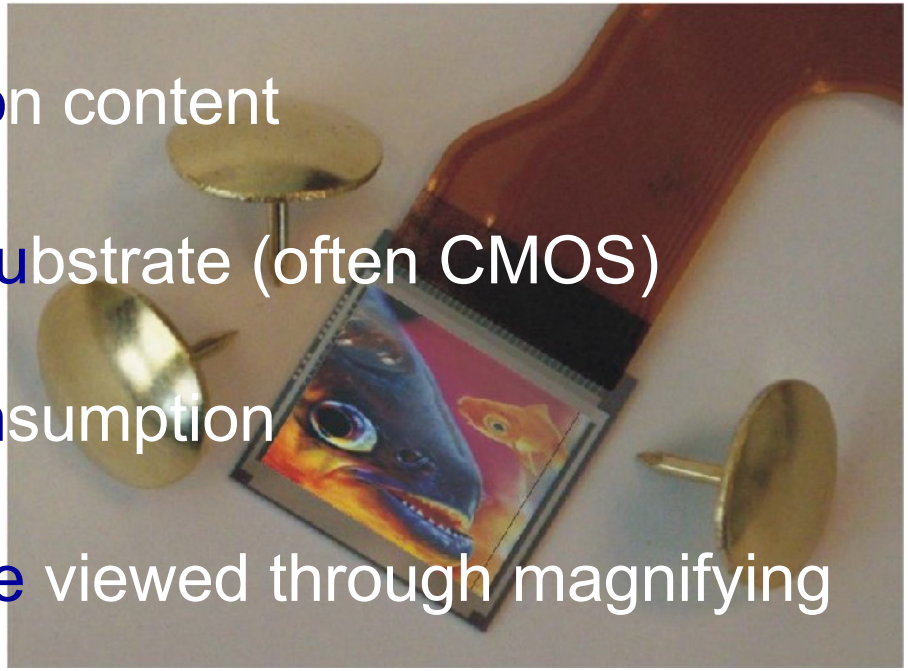
MICRODISPLAYS FOR PROJECTION AND NEAR-TO-EYE SYSTEMS

Ref: Handbook of Visual Display Technologies
Part LXIV Microdisplay Technologies

Microdisplay Definition

Physically small, but

- High information content
- Active matrix substrate (often CMOS)
- Low power consumption
- Enlarged image viewed through magnifying optics



Microdisplay Classification

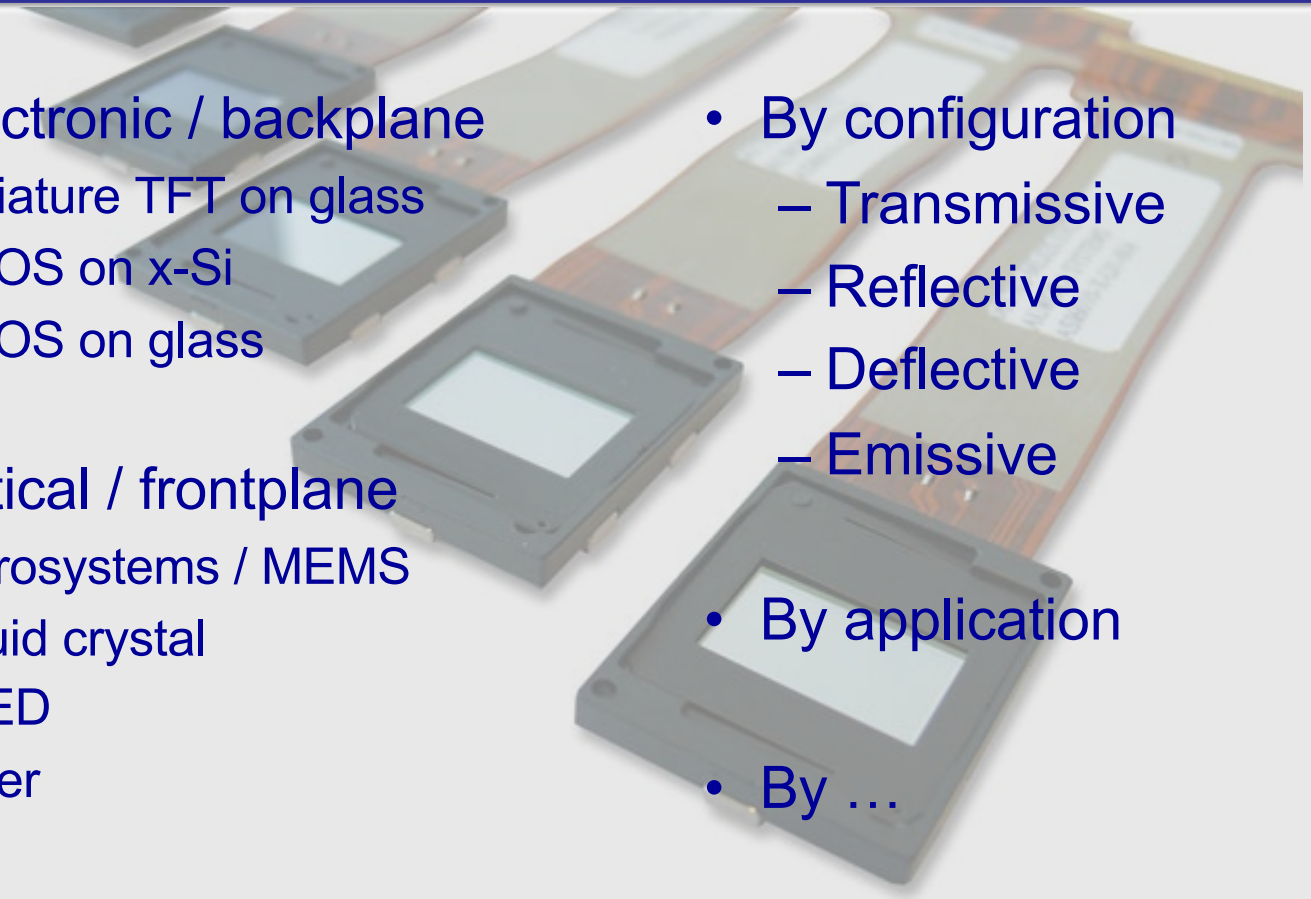
By electronic / backplane

- Miniature TFT on glass
- CMOS on x-Si
- CMOS on glass

By optical / frontplane

- Microsystems / MEMS
- Liquid crystal
- OLED
- Other

- By configuration
  - Transmissive
  - Reflective
  - Deflective
  - Emissive
- By application
- By …



How are Microdisplays different

Smaller lateral dimensions
- Cross talk
- Edge effects
- Aperture ratio
- Visibility of defects

Manufacture
- CMOS wafer based

- CMOS / TFT substrate
  - Available voltage
  - Integrated drivers
  - Reflective substrate

- Methods of colour
  - Three panel
  - Field sequential

Advantages of Microdisplay Systems

Like for like (definition, color depth,frame rate etc)

A microdisplay-based system is probably

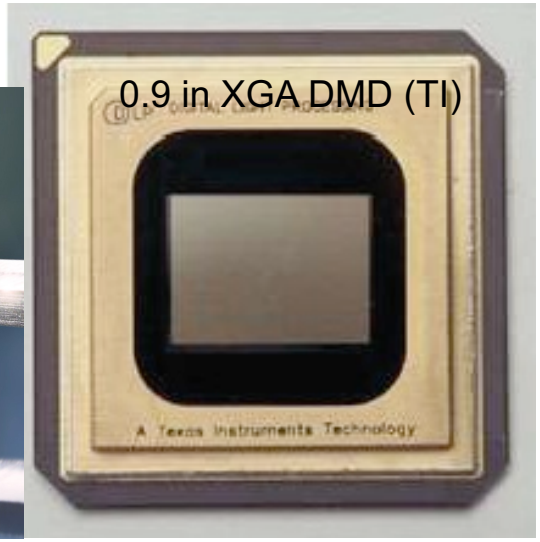
Smaller, lighter portability
Larger image
Lower cost of manufacture
Lower power & battery life

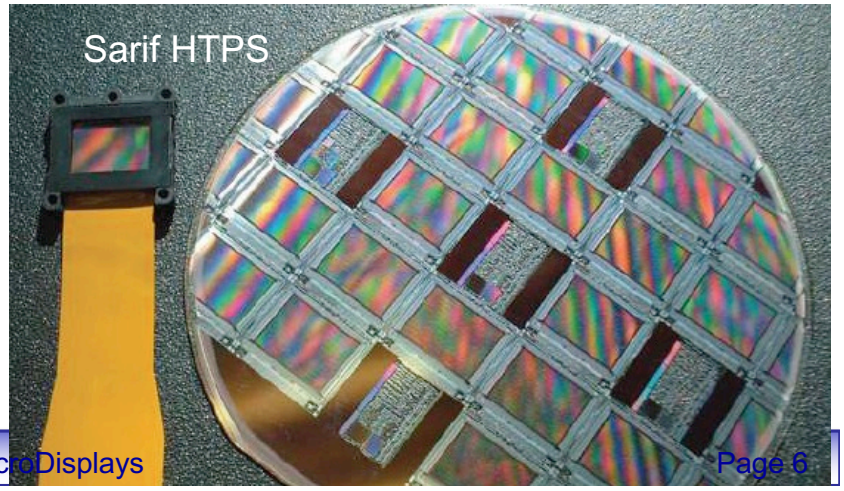
than the equivalent flat panel

But smallness has disadvantages -

Various Microdisplays

NOT TO SCALE





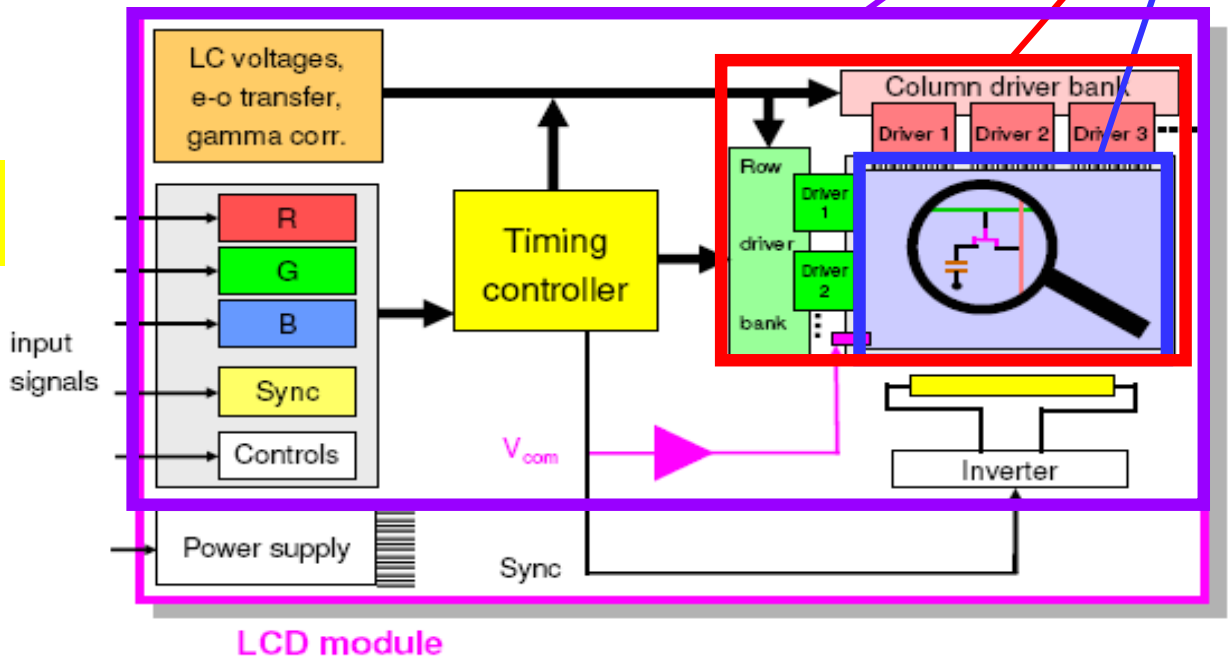
AM LCD Module (including backlight)

Integration on chip capability of CMOS for microdisplay

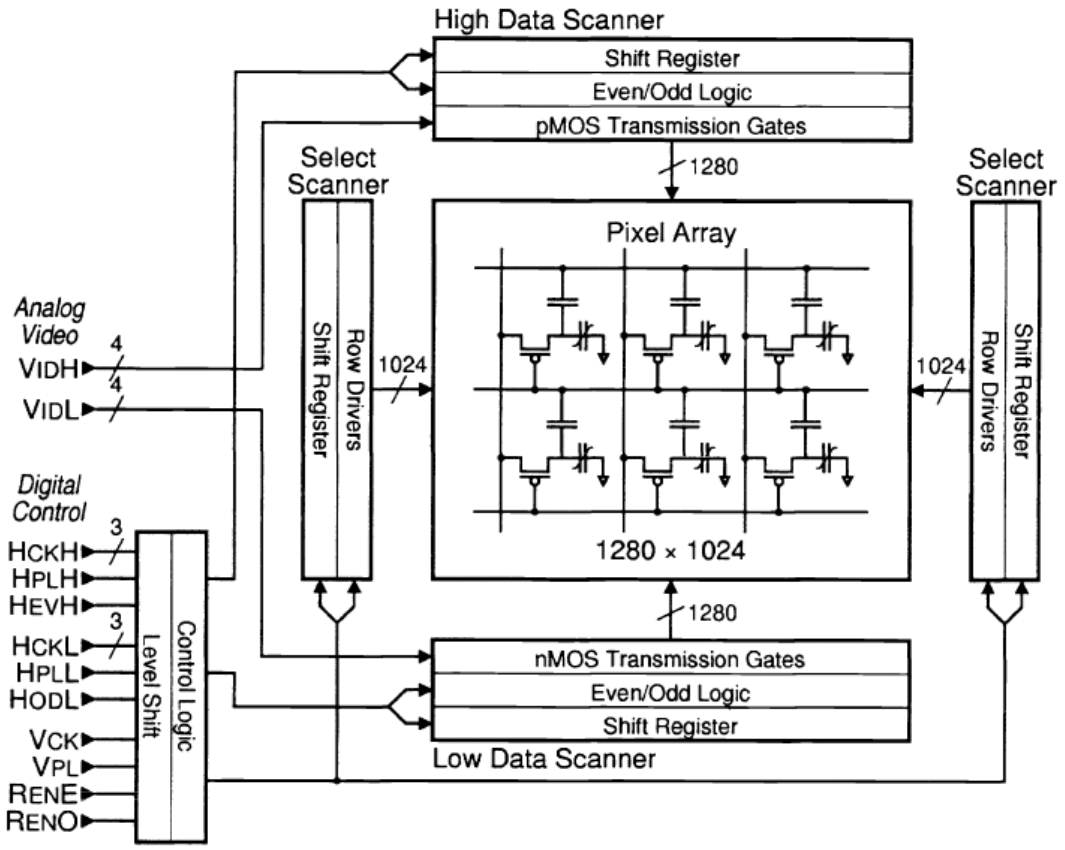
Integration on glass capability of LTPS

Integration on glass capability of amorphous silicon

Repeated From § 5

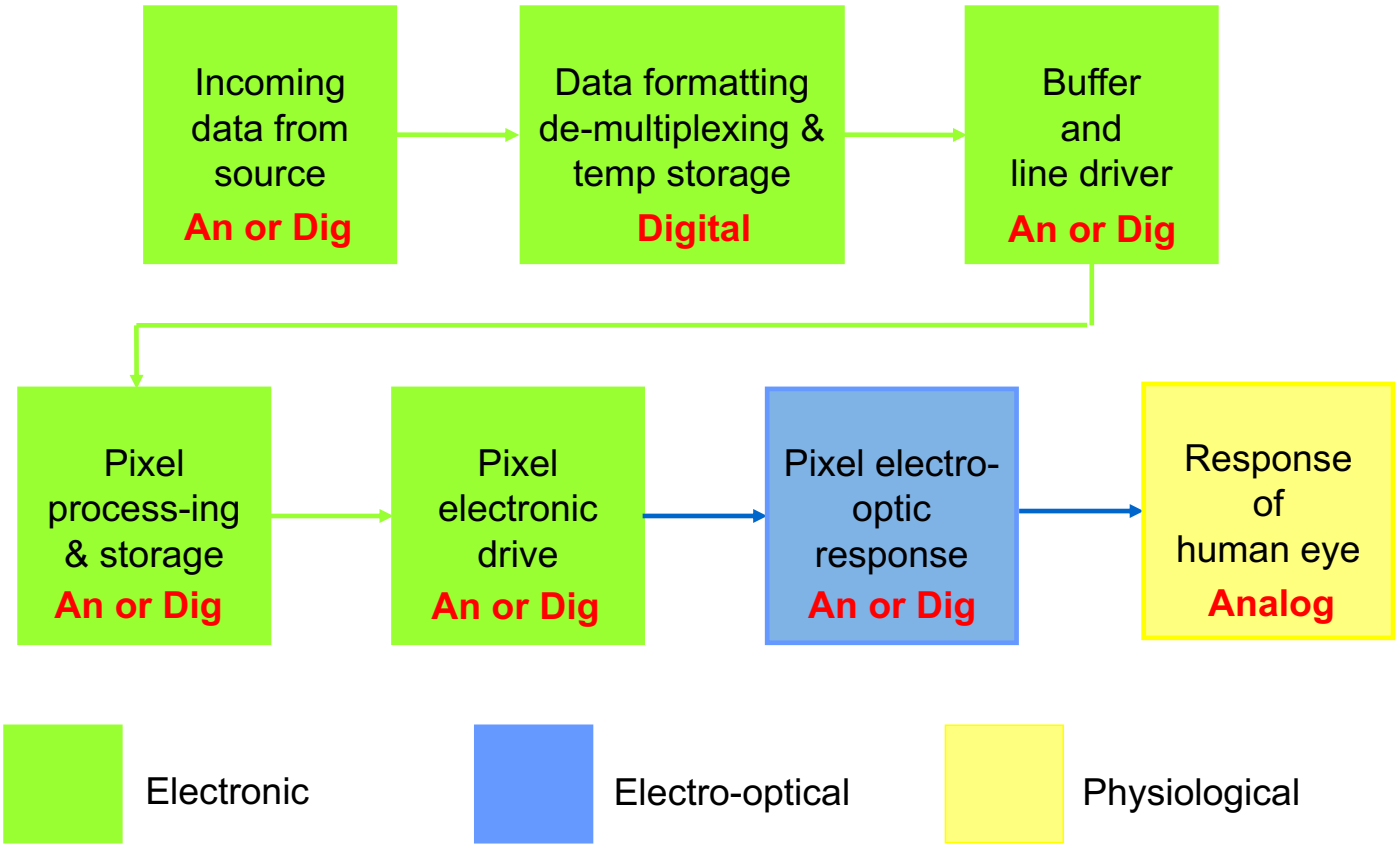


LCOS Backplane Architecture- example

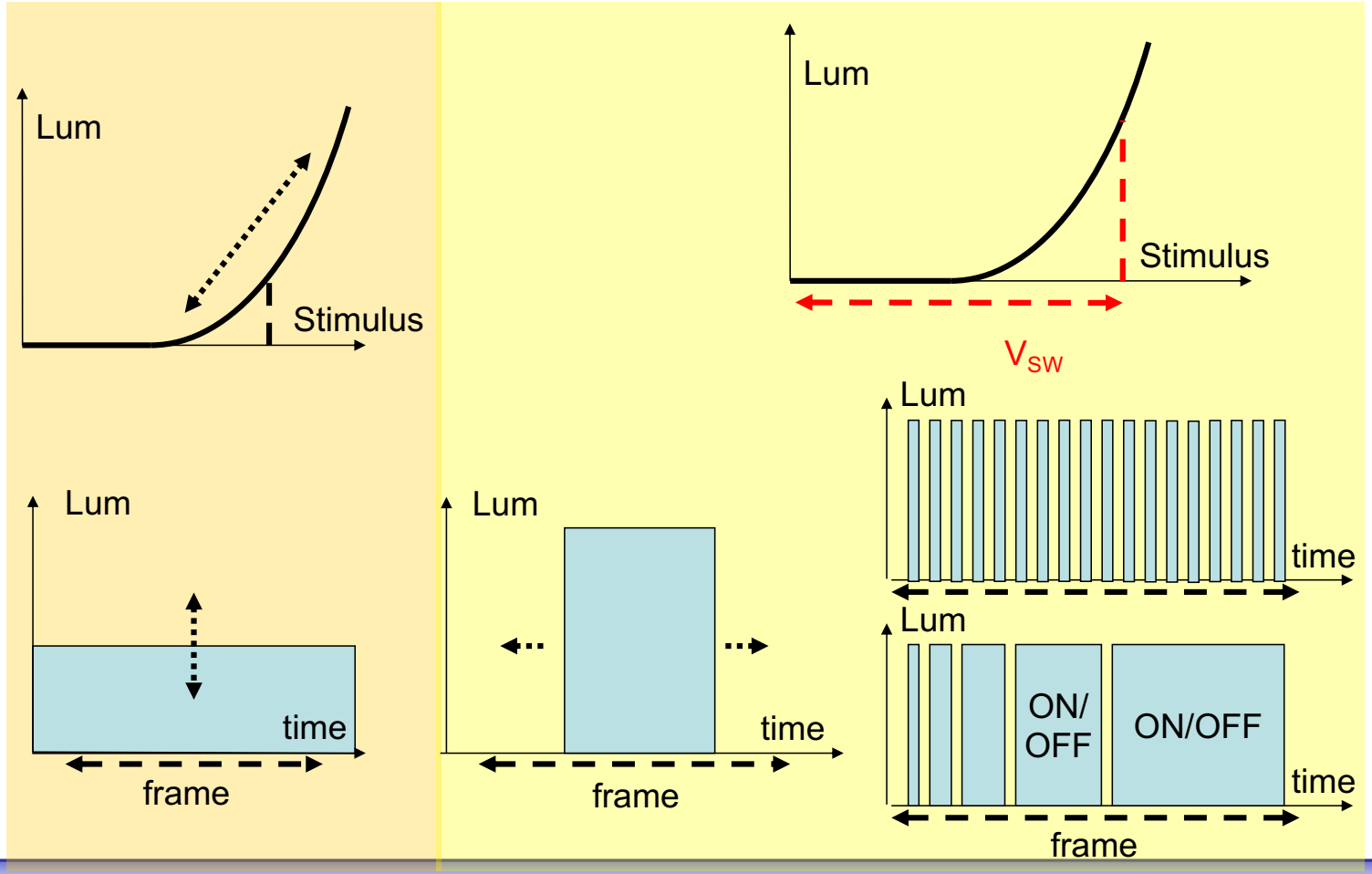


Permission for Reprint, Courtesy Society for Photographic Instrument Engineers

Datapath

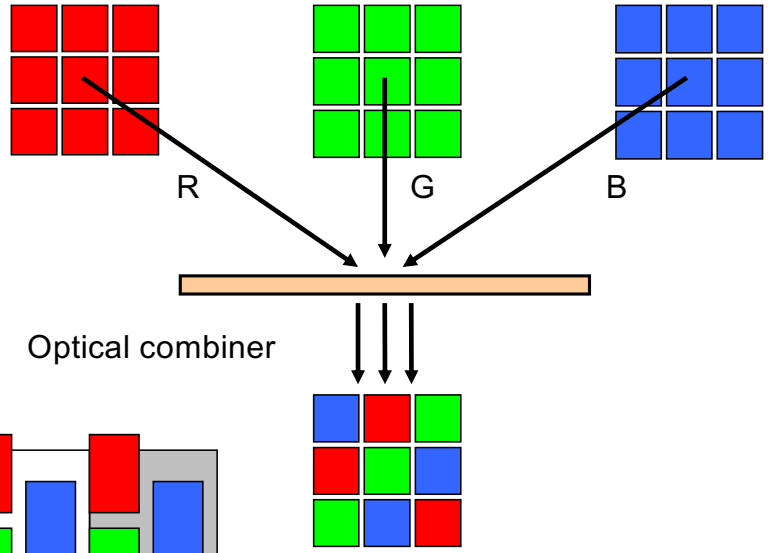

Incoming data from source
An or Dig
Data formatting de-multiplexing & temp storage
Digital
Buffer and line driver
An or Dig
Pixel process-ing & storage
An or Dig
Pixel electronic drive
An or Dig
Pixel electro-optic response
An or Dig
Response of human eye
Analog
Electronic
Electro-optical
Physiological

Methods of Gray Scale Drive



Methods of color - 1

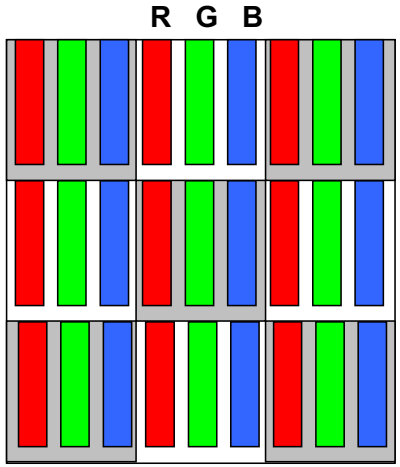
Three chip

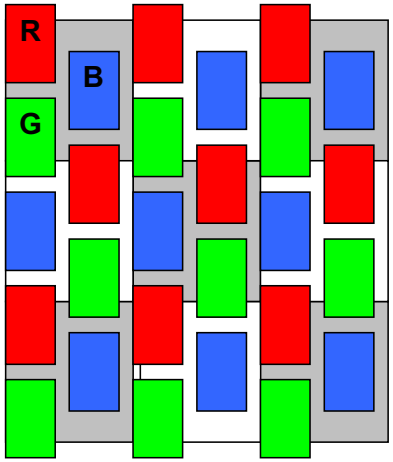


Spatial sub-pixels

RGB stripe

RGB delta

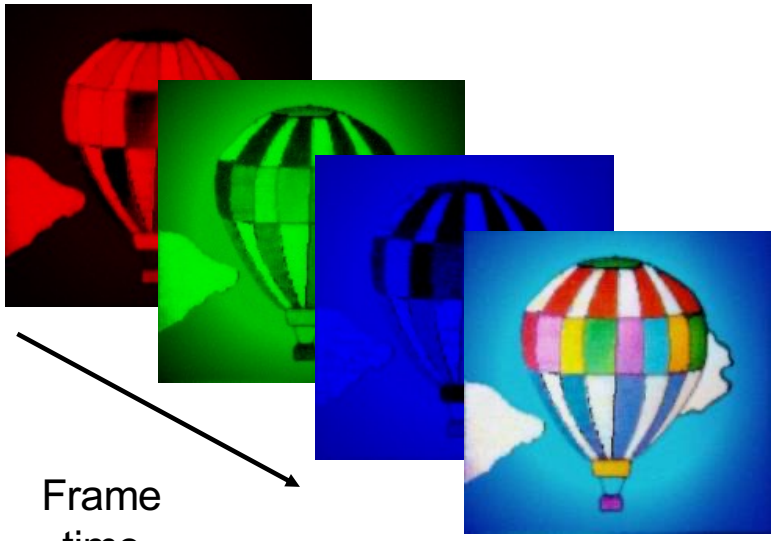




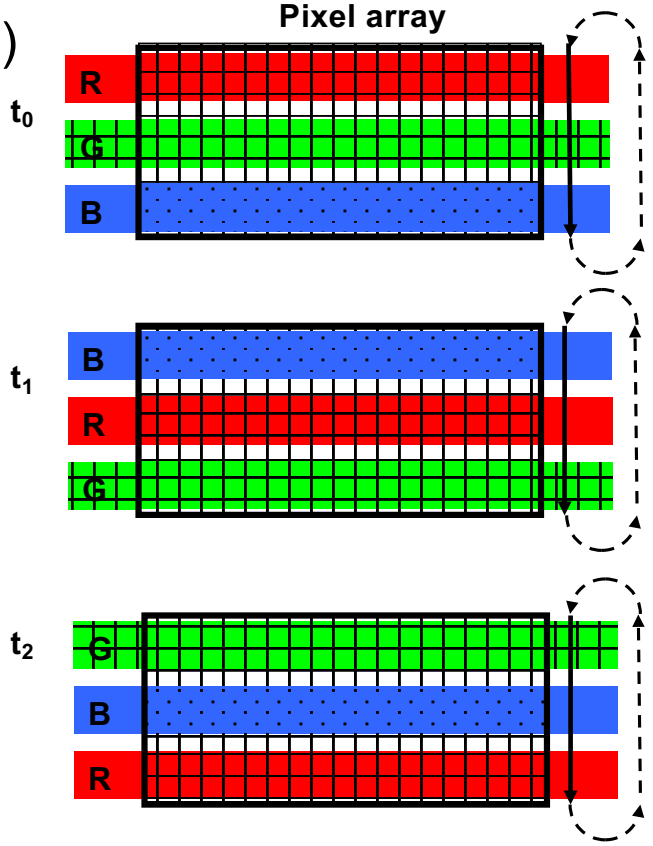
Methods of color - 2

Scrolling color
(single chip)

Field sequential color
(single chip)

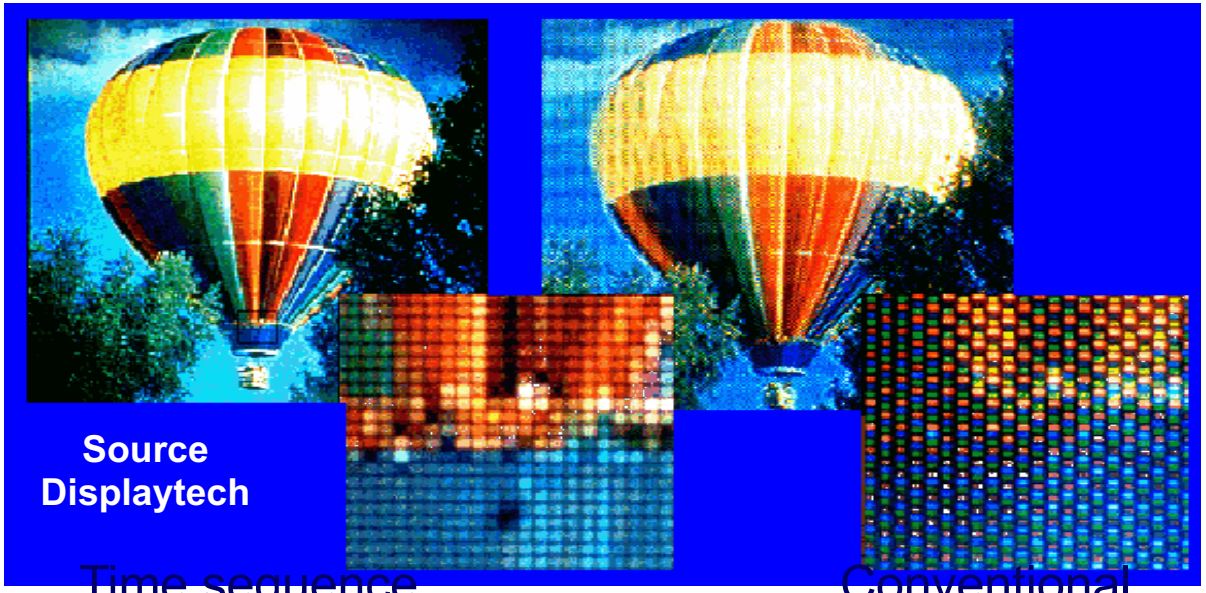


Frame
time

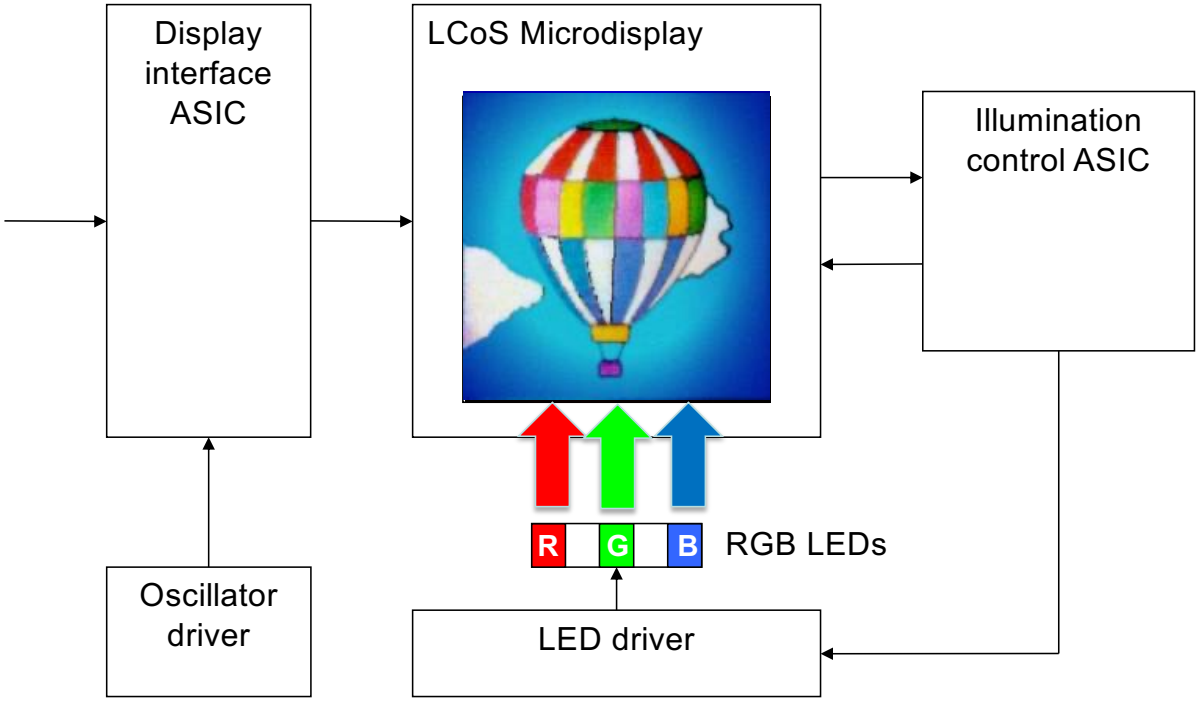


Consequences of field sequential color

- Reduced spatial artifacts
  - No RGB triads
- Increased temporal artifacts
  - Possible color break-up of fast moving scenes



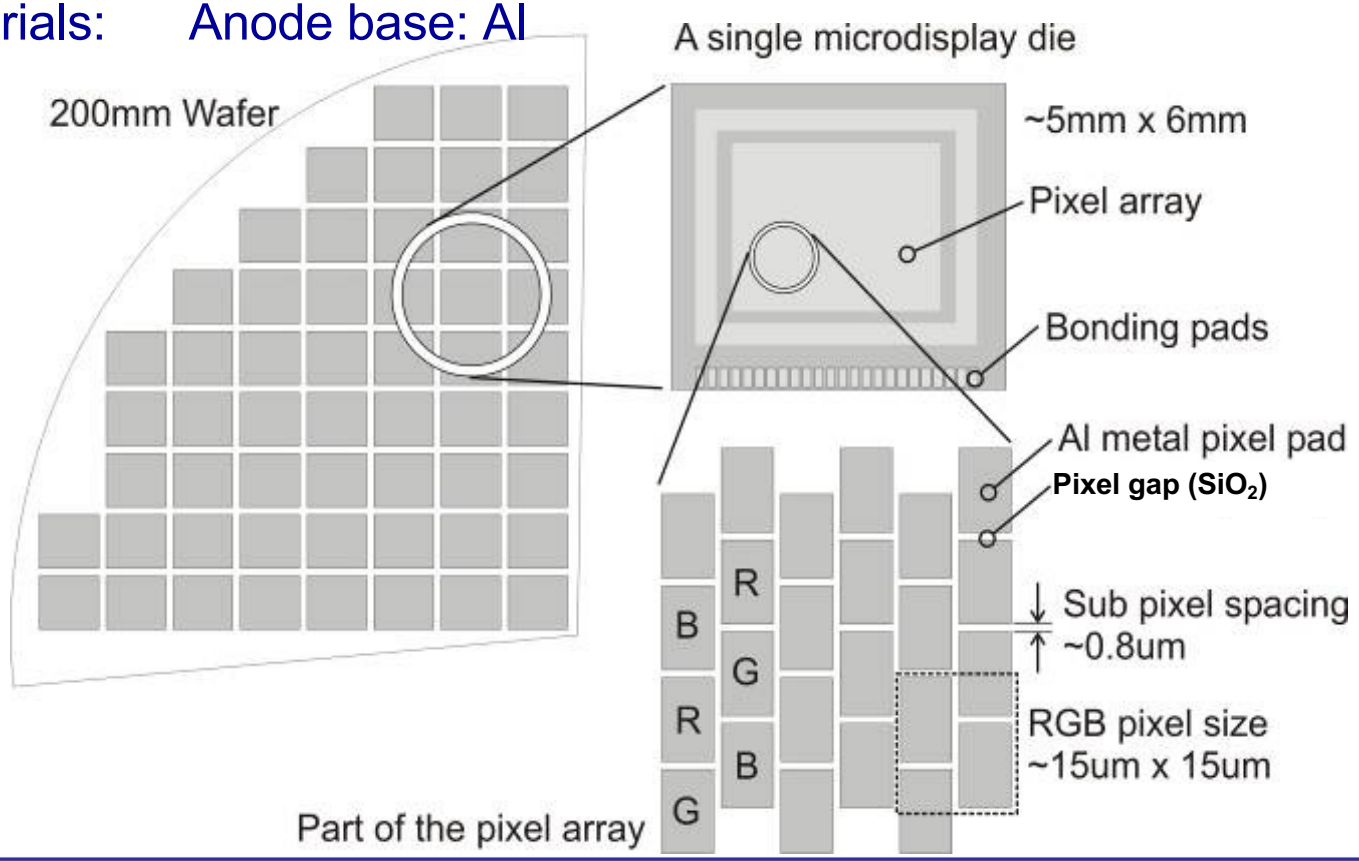
System Architecture – 1-chip example

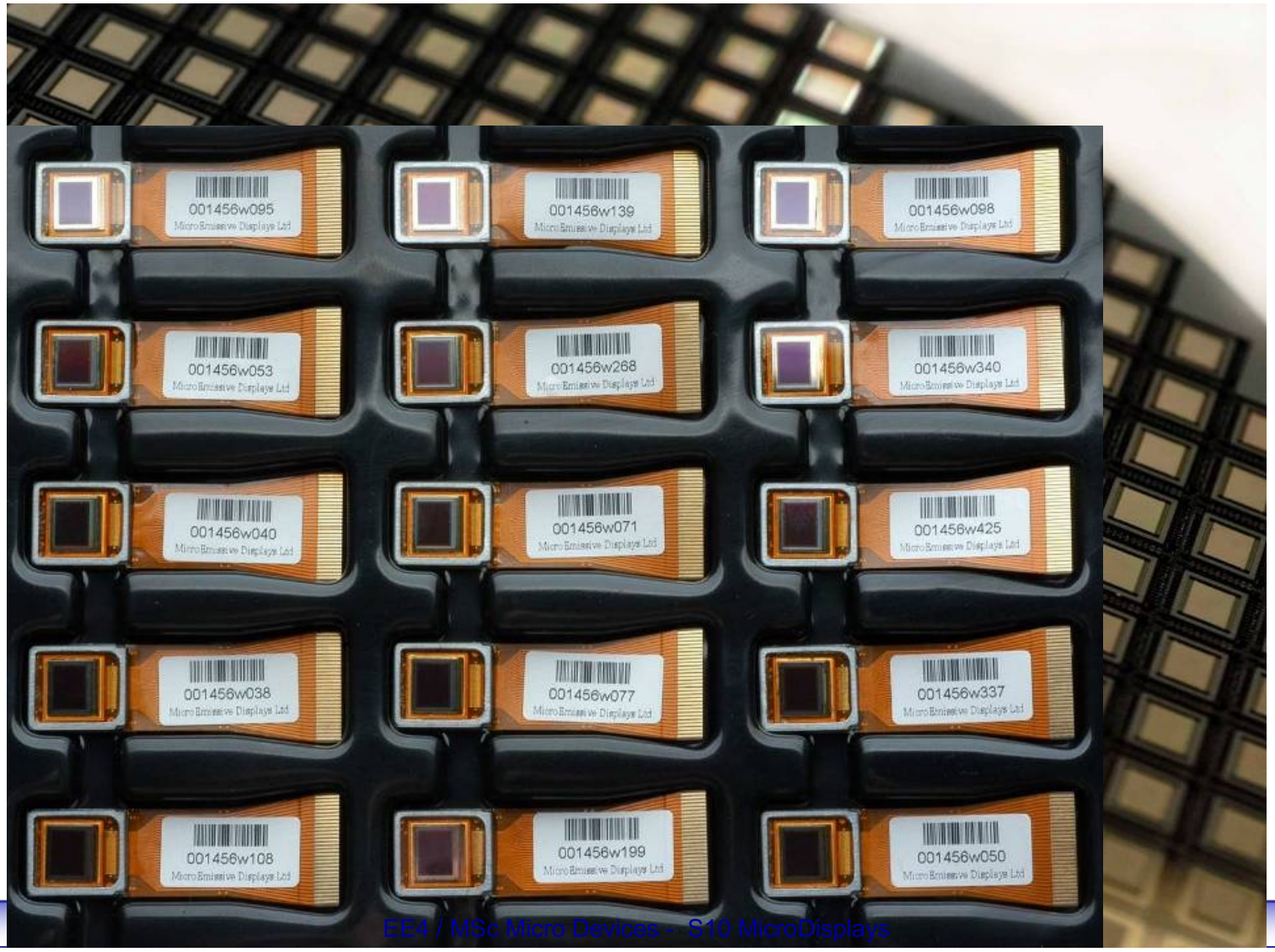


CMOS display backplane

Dimensions: Pixel spacing <1um

Materials: Anode base: Al




001456w095
001456w139
001456w098
001456w053
001456w268
001456w340
001456w040
001456w071
001456w425
001456w038
001456w077
001456w337
001456w108
001456w199
001456w050

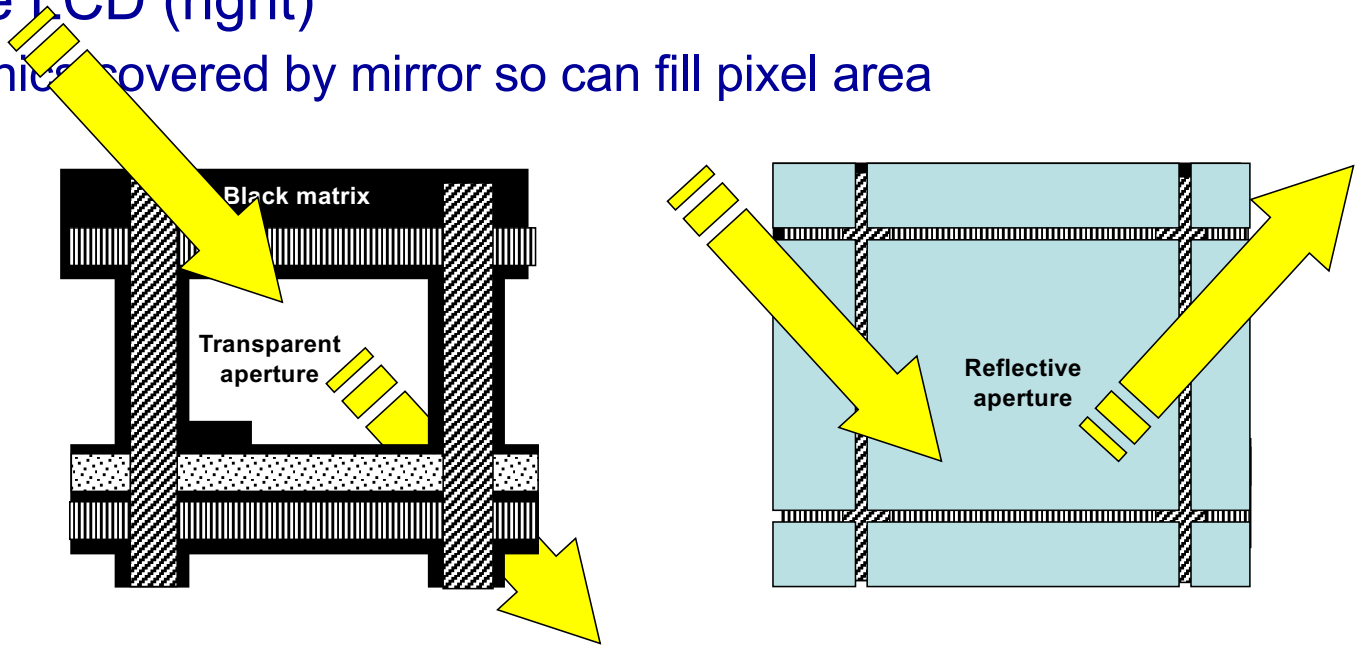
Aperture Ratio and Active Matrix - LCD

Transmissive LCD (left)

– Share area between opaque electronics and transparent aperture so minimise area of electronics

Reflective LCD (right)

– Electronics covered by mirror so can fill pixel area



Aperture Ratio and Active Matrix - Emissive

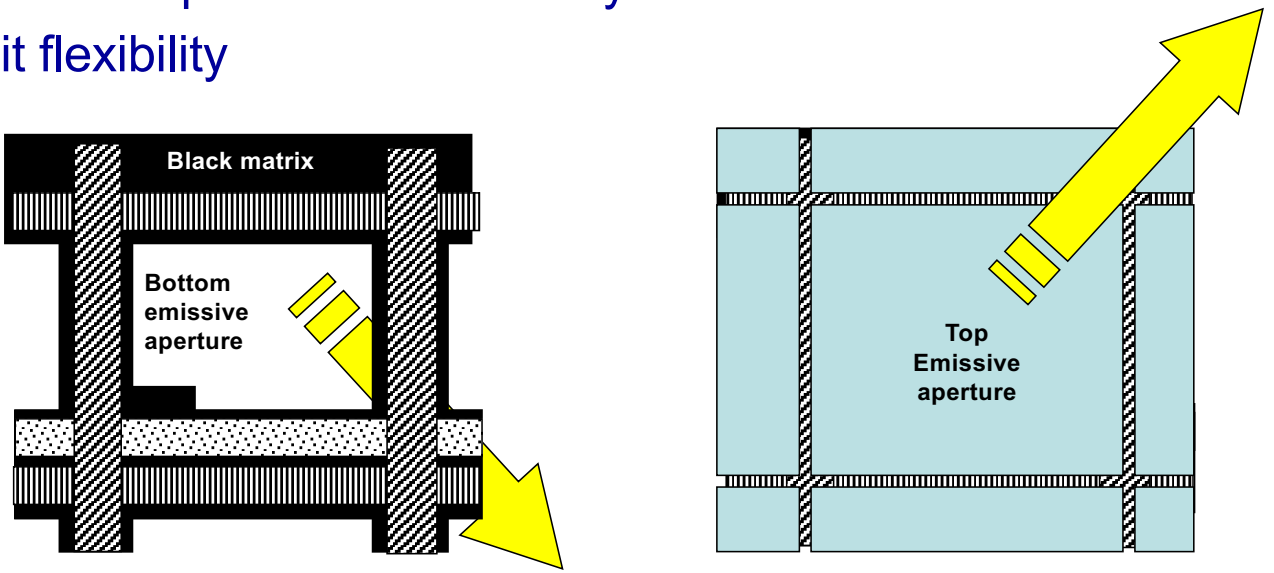
Bottom emitting OLED

– Share area between opaque electronics and transparent aperture so minimise area of electronics

Top emitting OLED (right)

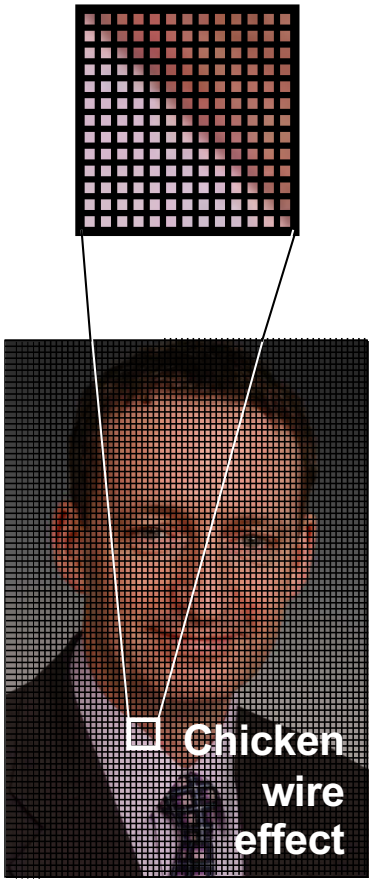
– Electronics can fill pixel area hidden by electrode

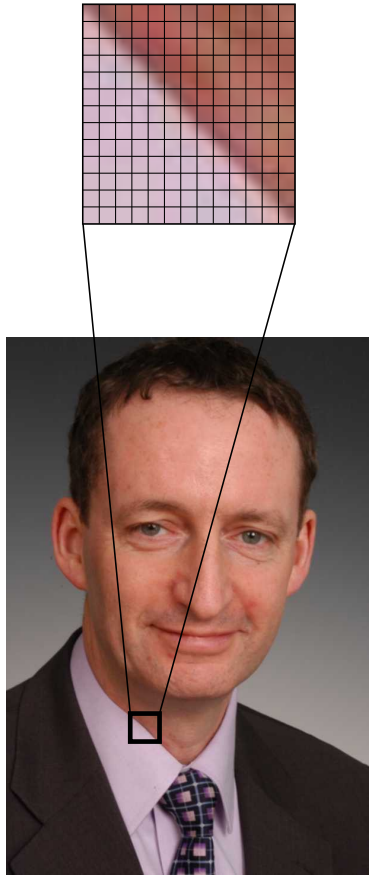
– More circuit flexibility



The effect of aperture ratio

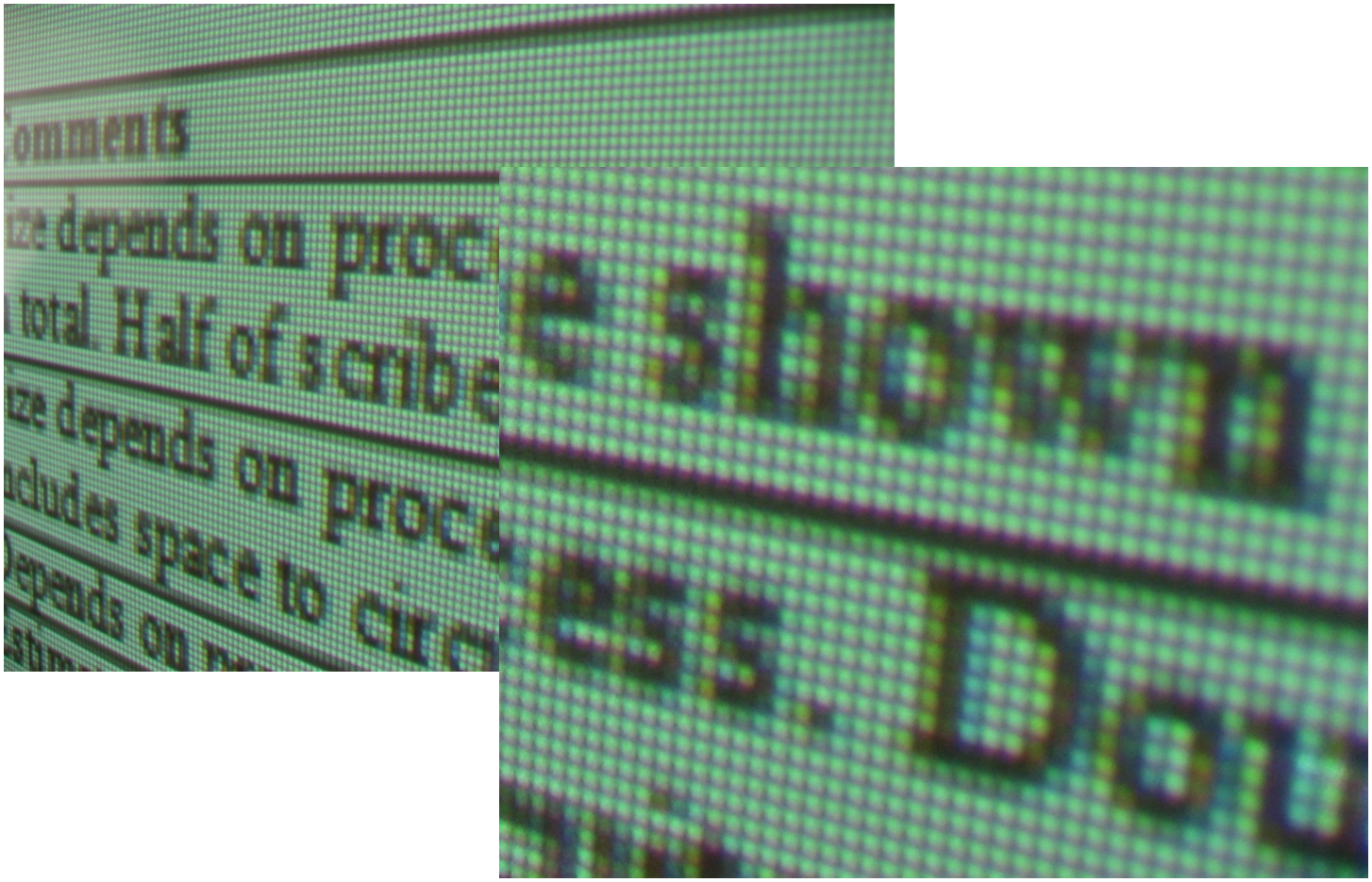
Transmissive / bottom emissive
Low aperture ratio



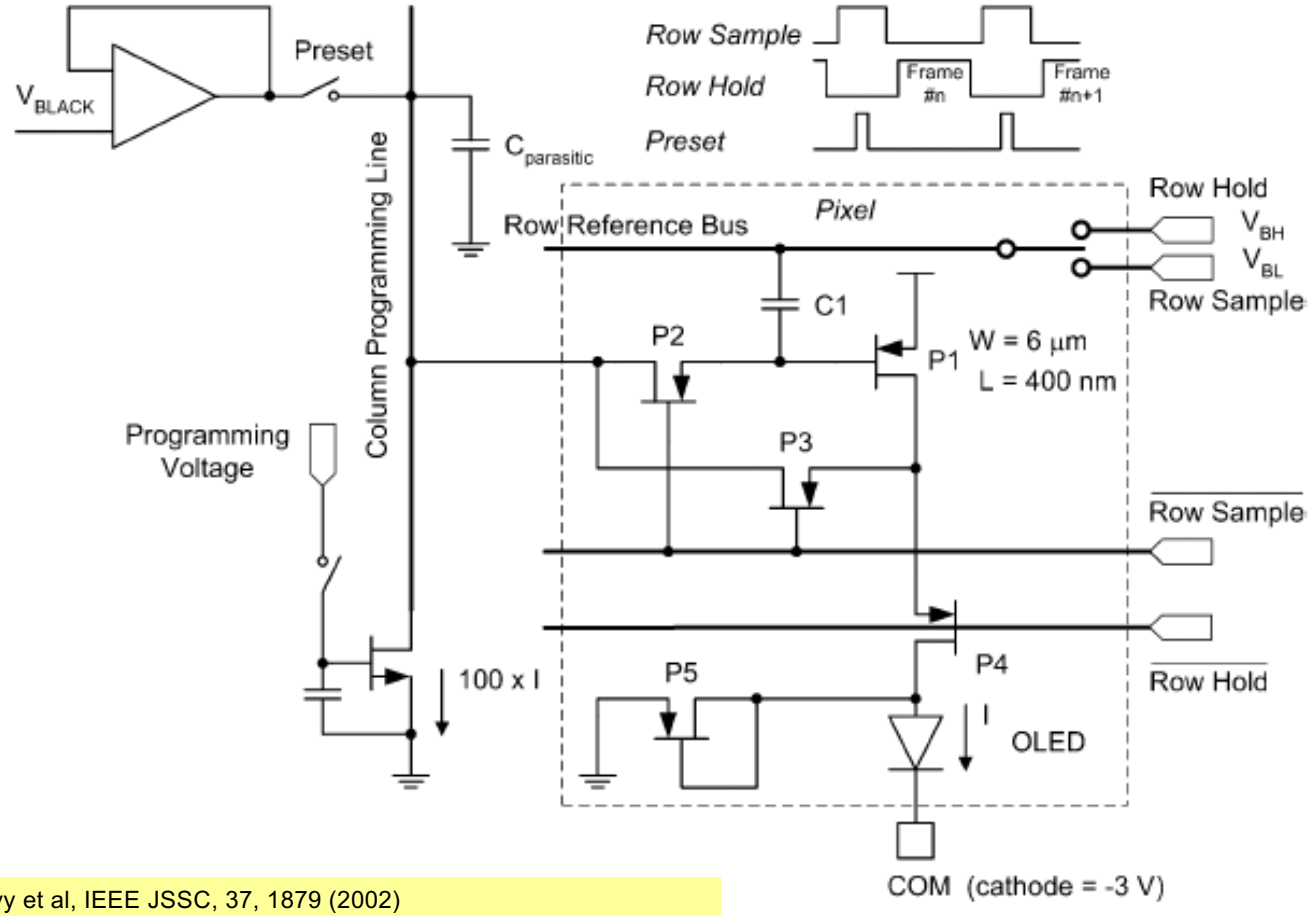


Reflective / top emissive
High aperture ratio

The effect of aperture ratio



OLED µdisplay pixel circuit – analog example



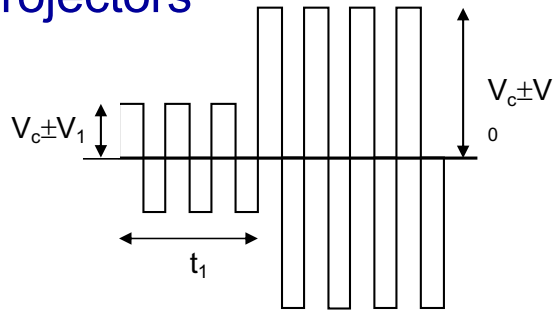
Ref Levy et al, IEEE JSSC, 37, 1879 (2002)

Digital drive / analog response

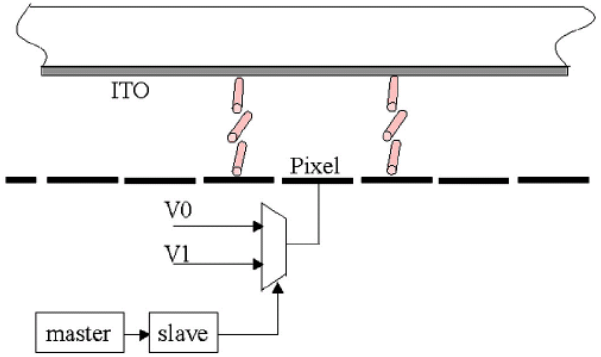
JVC D-ILA

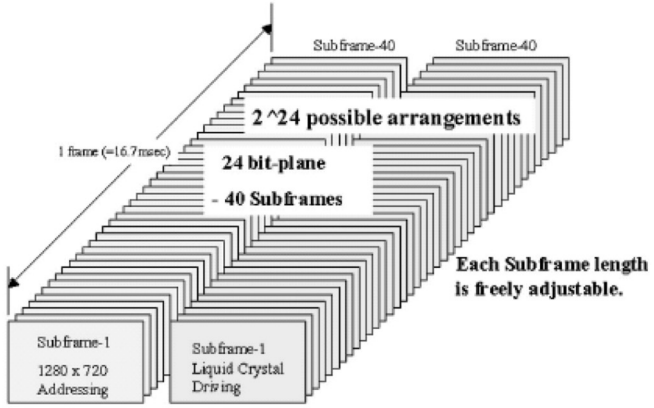
http://dila.jvc.com

Used in JVC high-end projectors



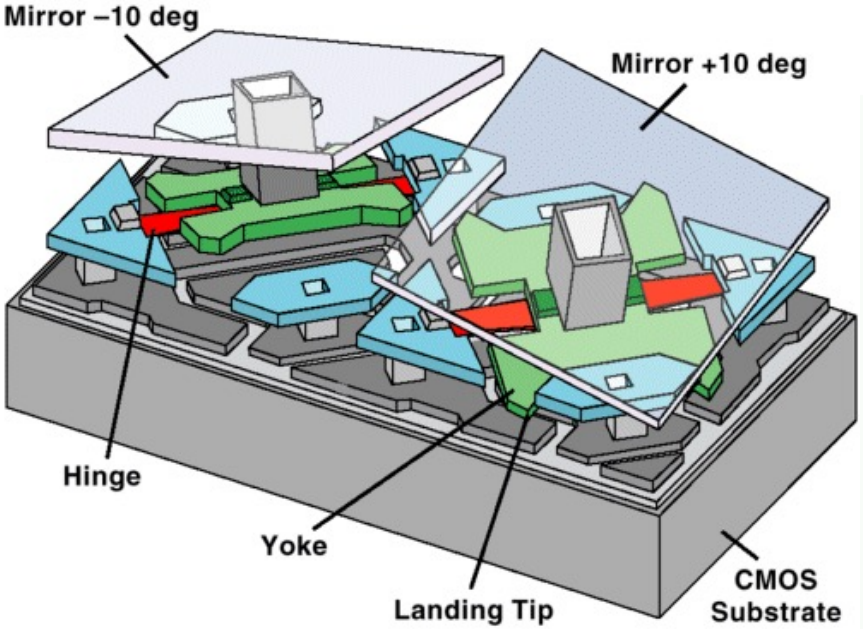
DLA-RS3000, 8k projector

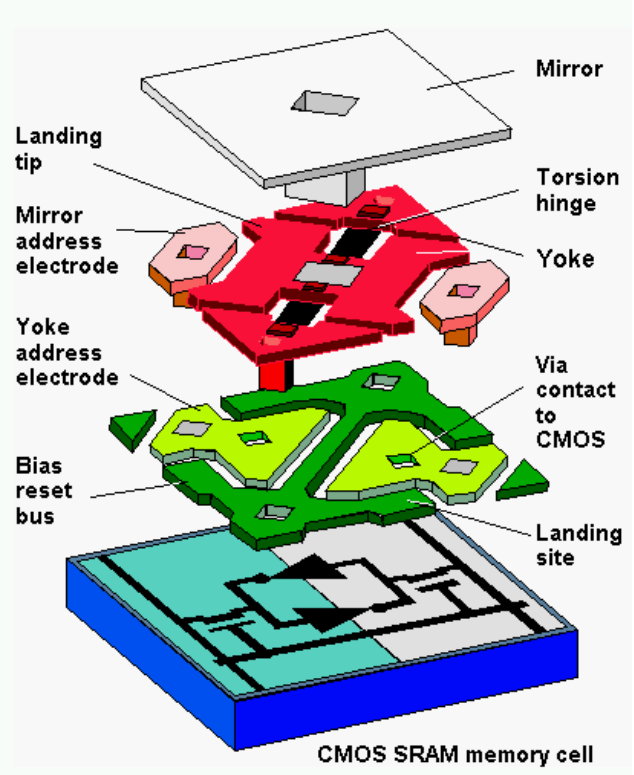




Permission for Reprint, courtesy of the Society for Information Display

TI DMD / DLP



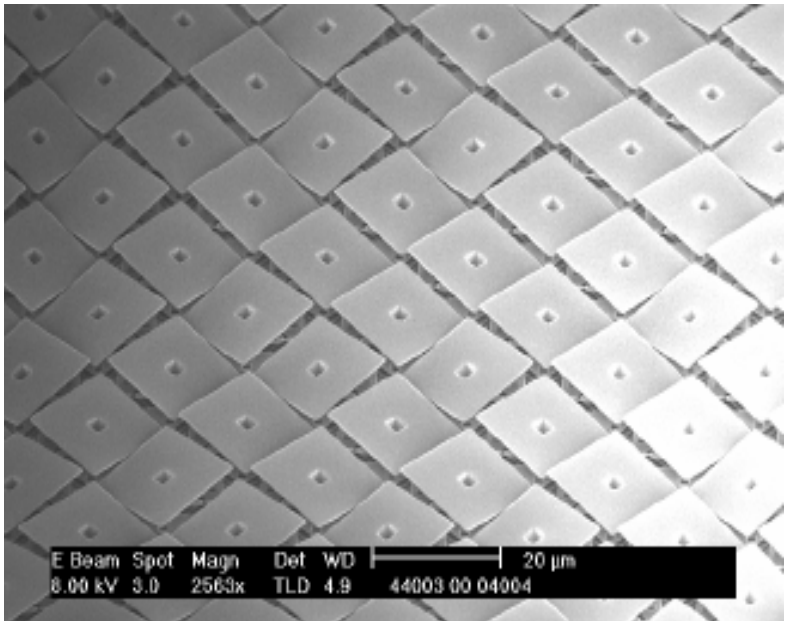


CMOS SRAM is used in DMD / DLP for pixel drive

Figure courtesy of Texas Instruments

TI DMD Array

SEM of DMD array showing left/right on/off diagonal tilt of mirrors
Significant light-loss at central support “via”
Pixel pitch 13.8 µm

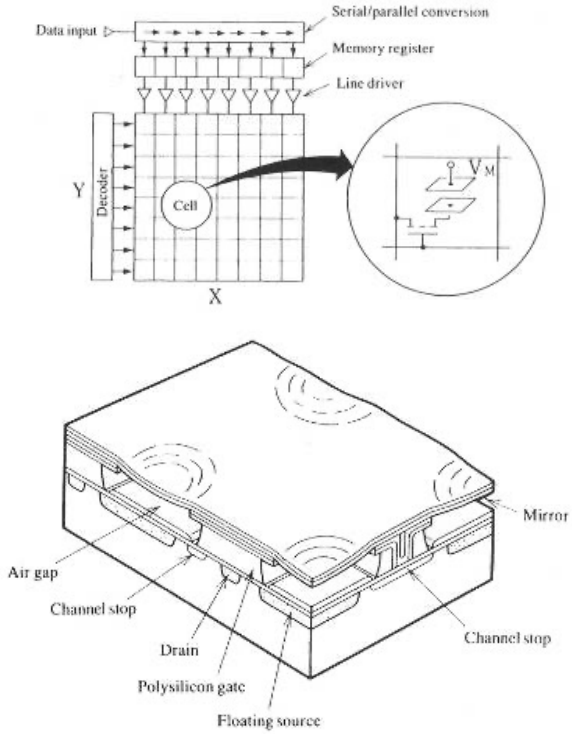


Douglass, 2nd Mechatronics and Microsystems Symposium, 2005

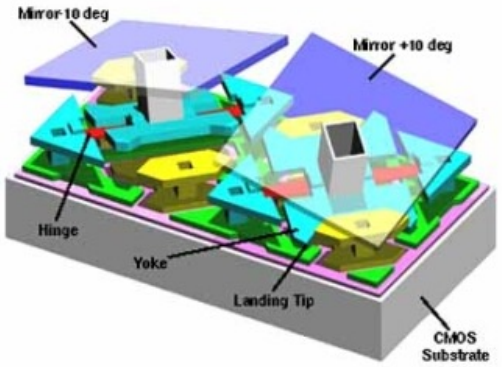
Basis of DLP branded products by Texas Instruments

Origins of DMD / DLP

1977 Analog Deformable Mirror Device (DMD)



1987 Digital Micro-mirror Device (DMD)



1997 Introduced to the market

2007 A market leader

MicroLED Microdisplays

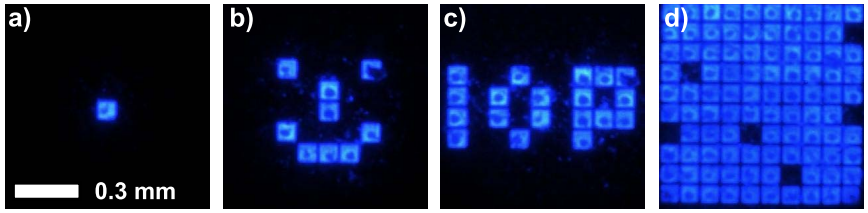
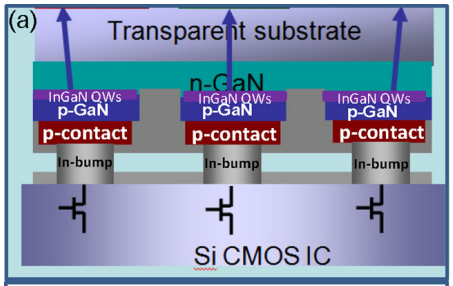
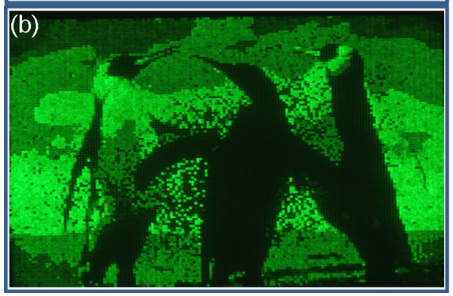
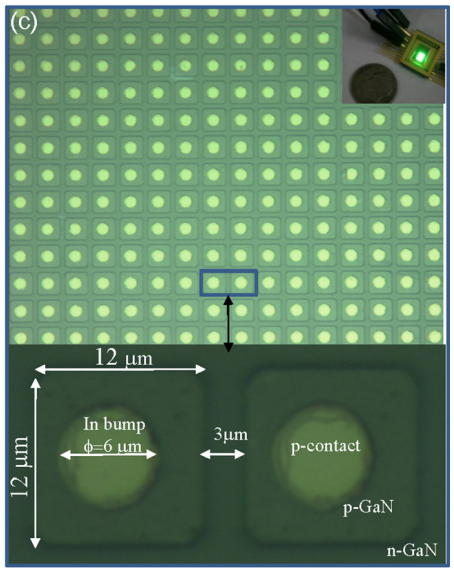
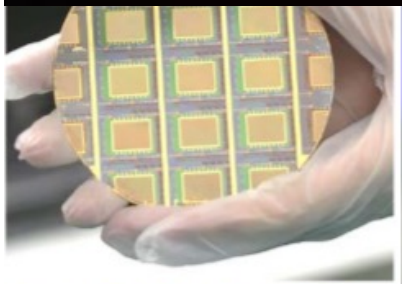


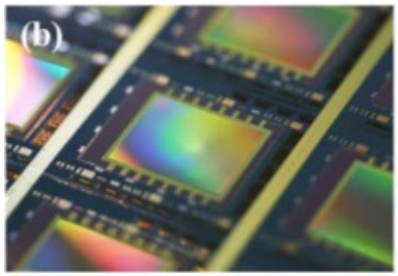
Fig. 3. Patterns displayed on device B at 10^6 cd/m^2 (~7.7 mA/pixel). (a) Single pixel. (b) Smiley. (c) Letters IOP. (d) Full array with a few defects. The voltage was 3.6 V and the camera settings were kept identical for all micrographs.

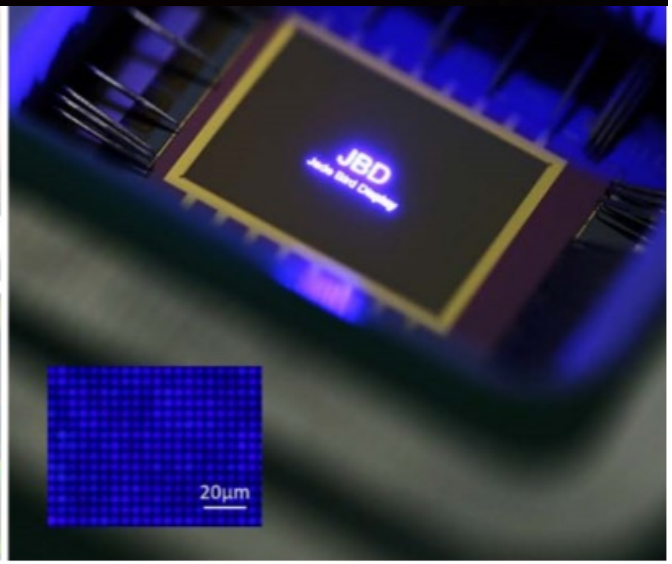




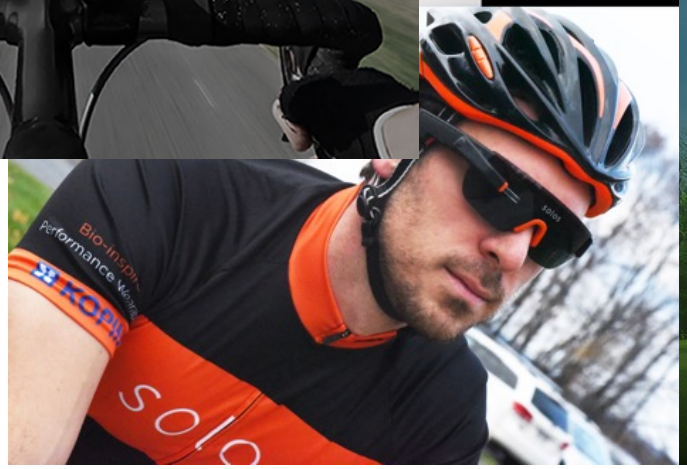


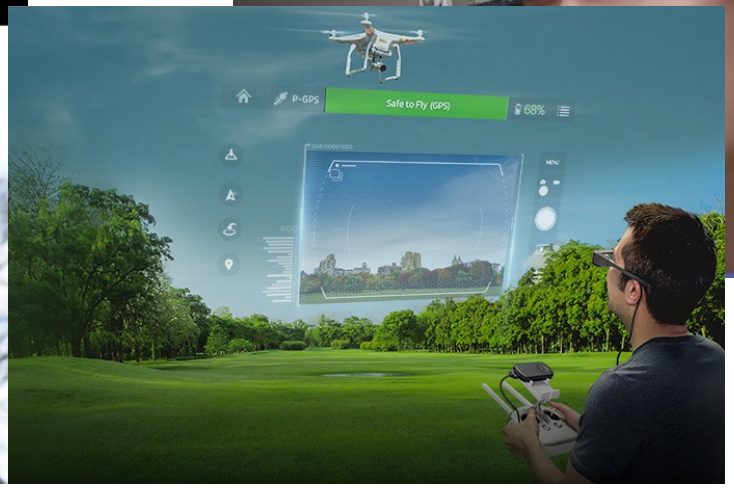






Augmented Reality





Applications - Projection

- Projection
  - Luminance
  - Colour
  - Contrast
  - Image quality
- Rear projection
  - Thin-ness
- Front projection
  - Size
  - weight

Applications - Near-to-Eye

- Near-to-Eye
  - **Small, light-weight**
  - **Low power**
  - **Highly integrated**
- Electronic Viewfinder (EVF)
  - Hand-held
  - Often secondary display
- Head Mounted
  - Hands-free
  - Professional
  - Consumer

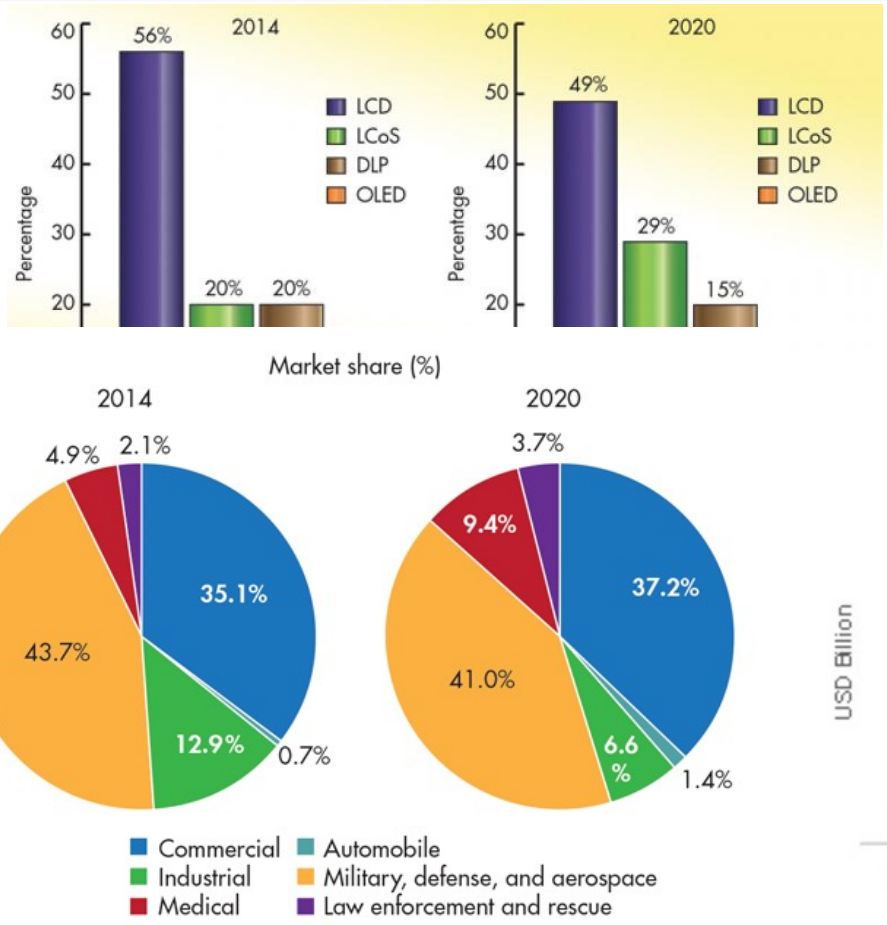
Applications - Pocket Projection

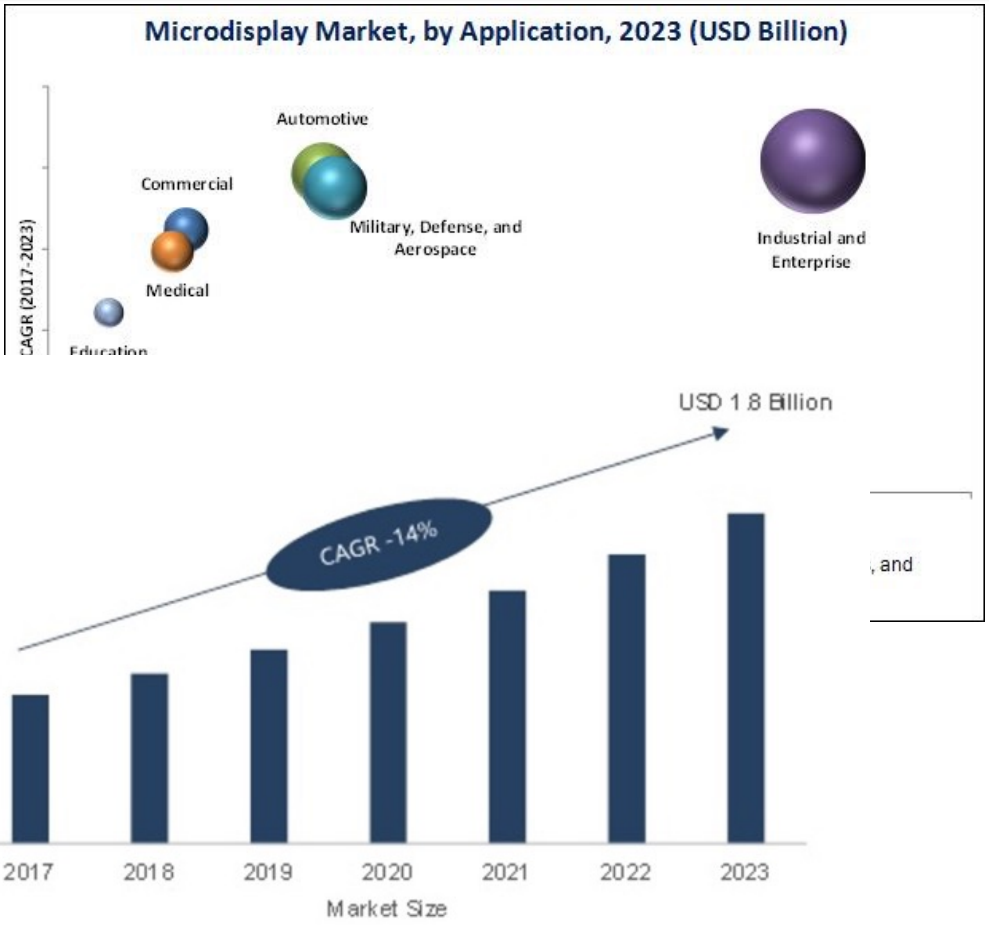
Recent application and new / emerging market

Combines some requirements of conventional projection with NTE

- Medium to high brightness
- Low power
- Small size
- Light weight

Microdisplay Market Forecast

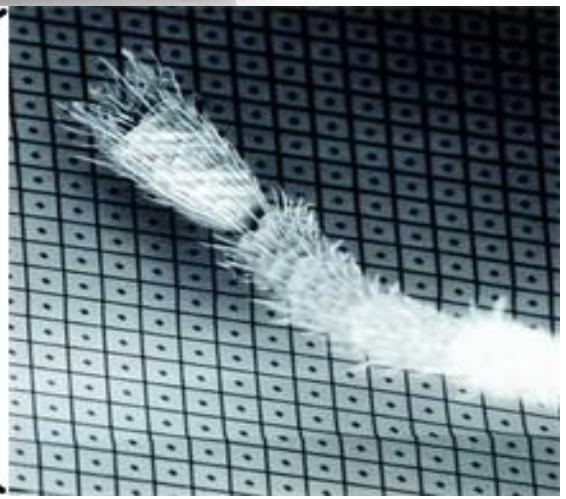




Texas Instruments

DLP = Digital Light Processor

DMD = Digital Micromirror Device



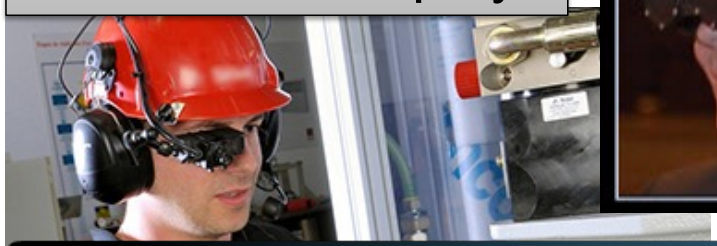
R&D $1.72B

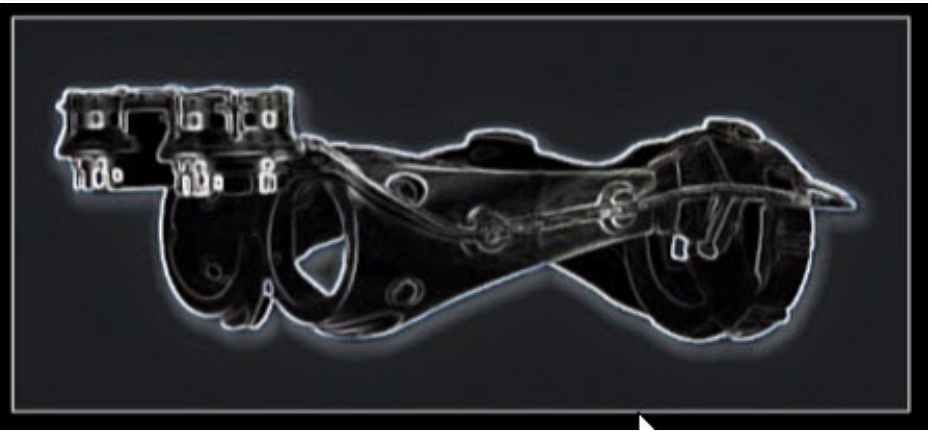
35k employees

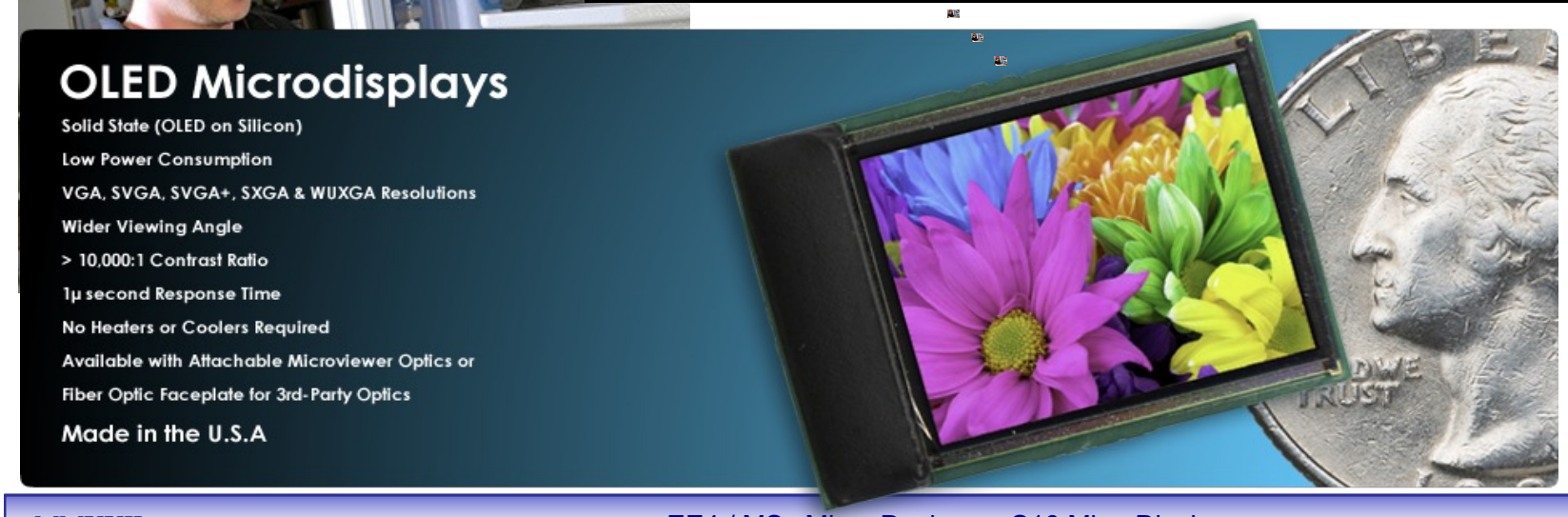
2011 revenue $13.7B

eMagin (USA)

High-resolution
High definition
OLED microdisplays

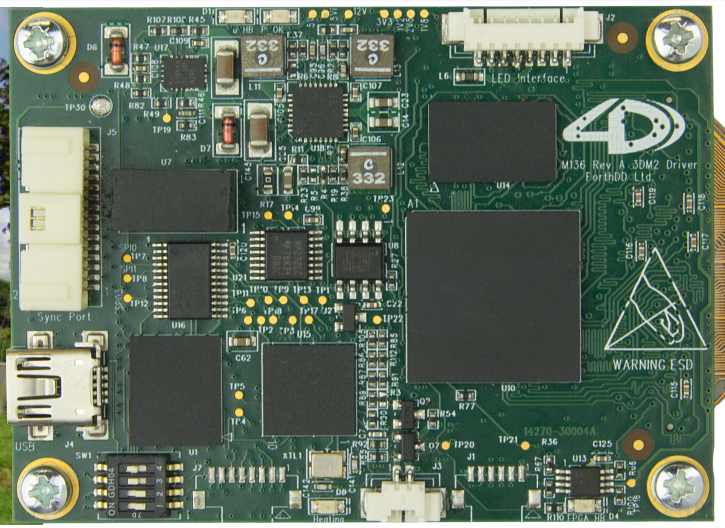




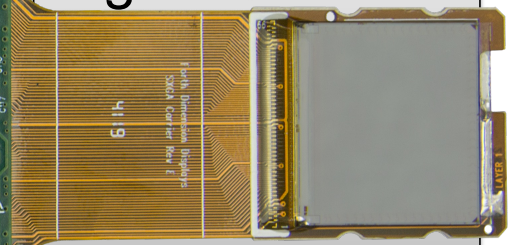


Forth Dimension Displays (UK)

About Forth Dimension



High-resolution
High definition

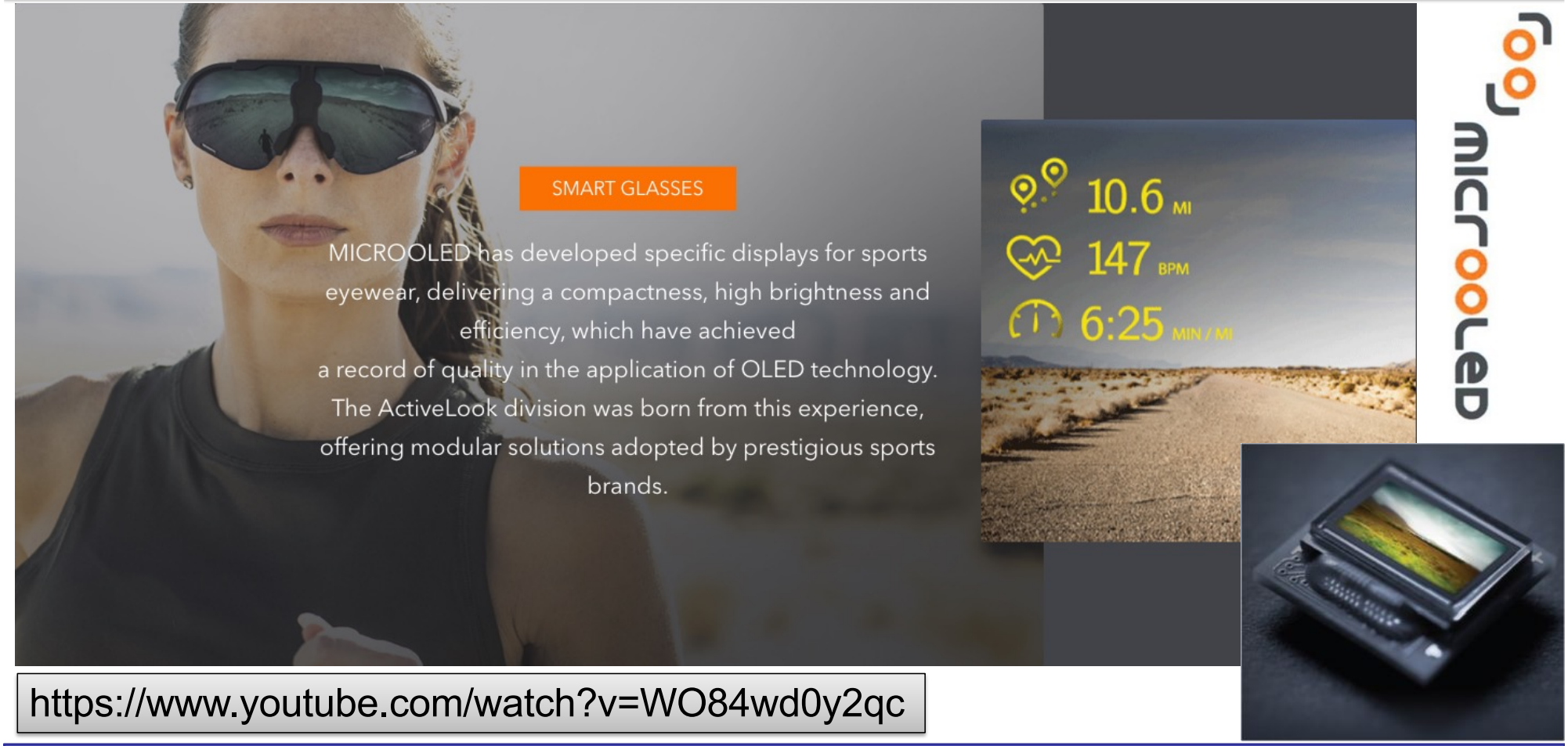


FLCoS μdisplay

Technology

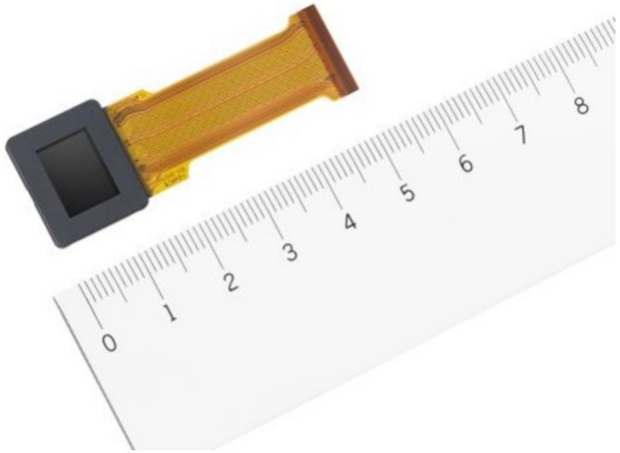
All Digital, Time Domain Imaging

MicroOLED http://www.microoled.net

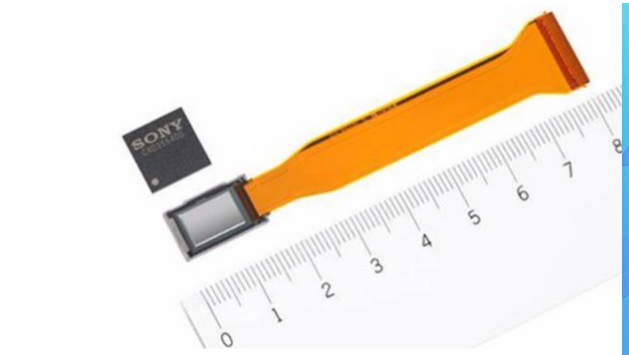


https://www.youtube.com/watch?v=WO84wd0y2qc

Sony (Asia)



0.5-type OLED Microdisplay ECX339A



The SXRD241A full HD reflective LCD device (bottom) and
the CXD3554GG high-definition signal processing drive LSI (top) 『CXD3