NBAY 6120: Disruptive Technologies

Display Technology and Human-Computer Interfaces

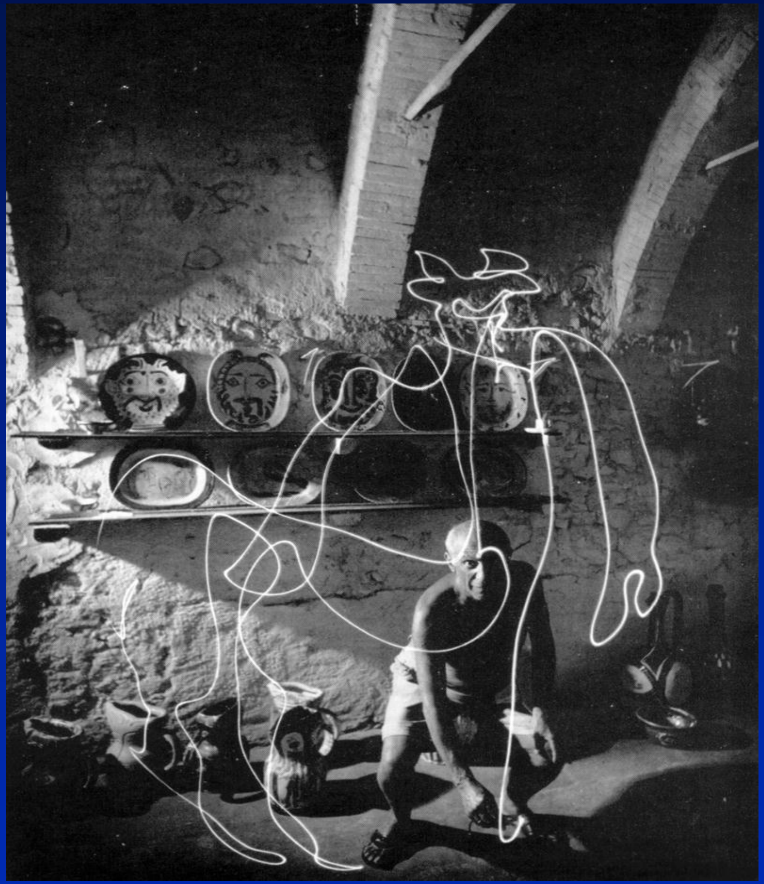
Lecture #5
March 15, 2017
Donald P. Greenberg

Required Reading

- J.C.R. Licklider, “Man-Computer Symbiosis.” IRE Transactions on Human Factors in Electronics. March 1960. IRE Transactions.

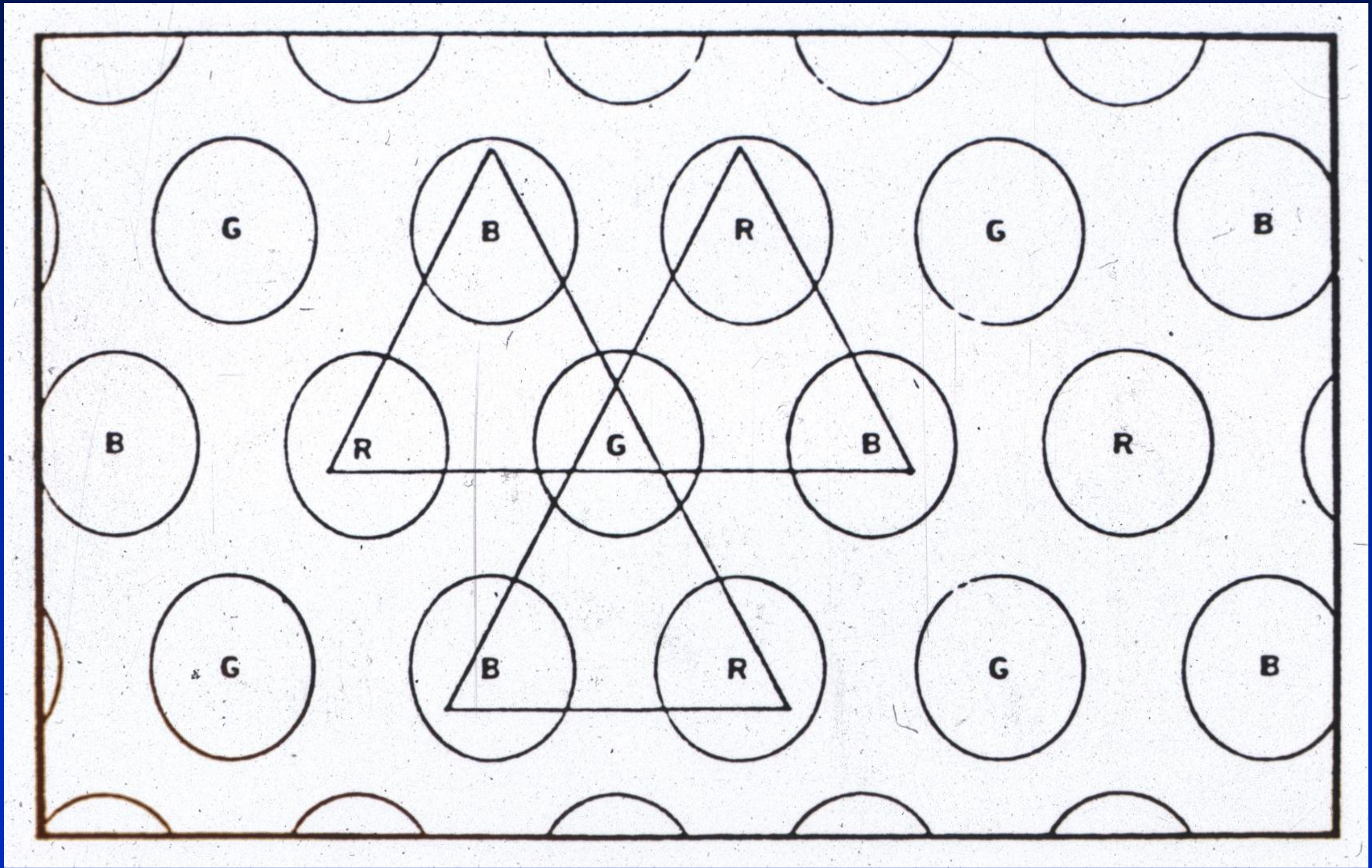
The persistence of vision

"And when a coal of fire is moved nimbly in the circumference of a circle makes the whole circumference appear like a circle of fire; is it not because the Motions excited in the bottom of the Eye by the Rays of Light are of a lasting nature..." (Newton, 1730)

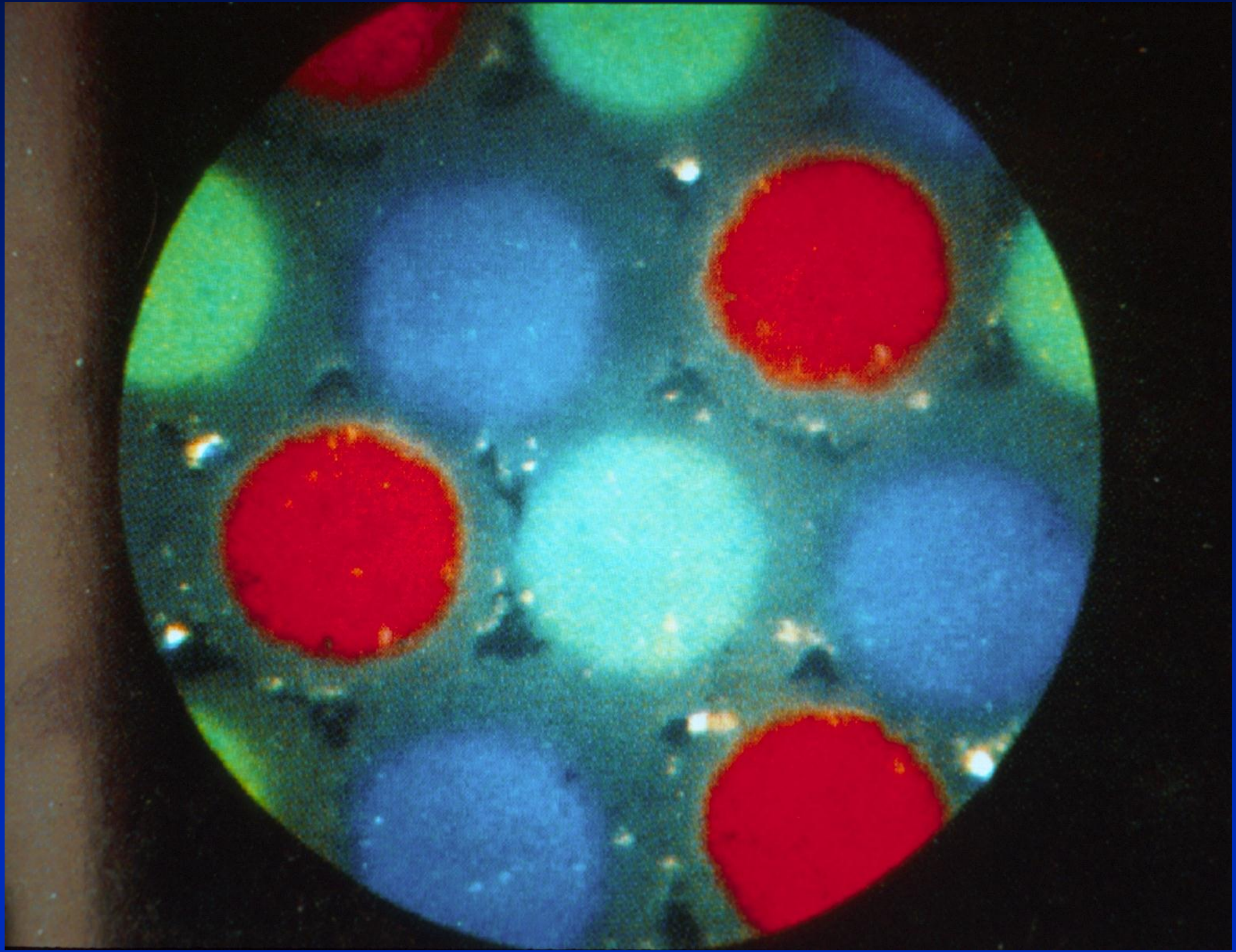


Georges Seurat, A Sunday on La Grande Jatte. 1884-1886

A Pixel Consists of Approximately 2 2/3 Triads



A Pixel Consists of Approximately 2 2/3 Triads



Update Rate

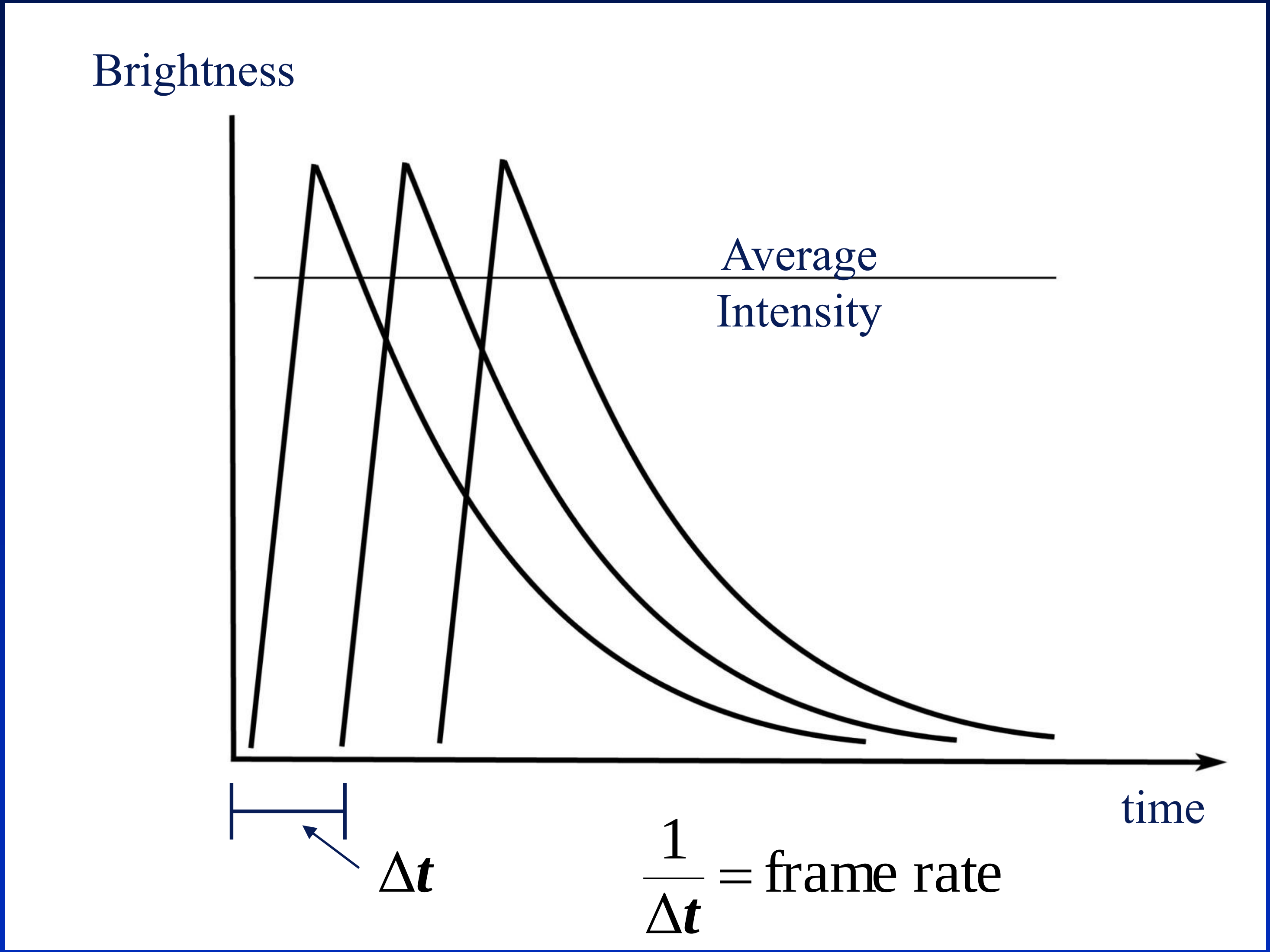
- The update rate is the number of changed images which are displayed per second.
- For the average human observer if changed images are shown at greater than 12 frames per second one can perceive motion .

Zoetrope

Flicker Fusion Frequency

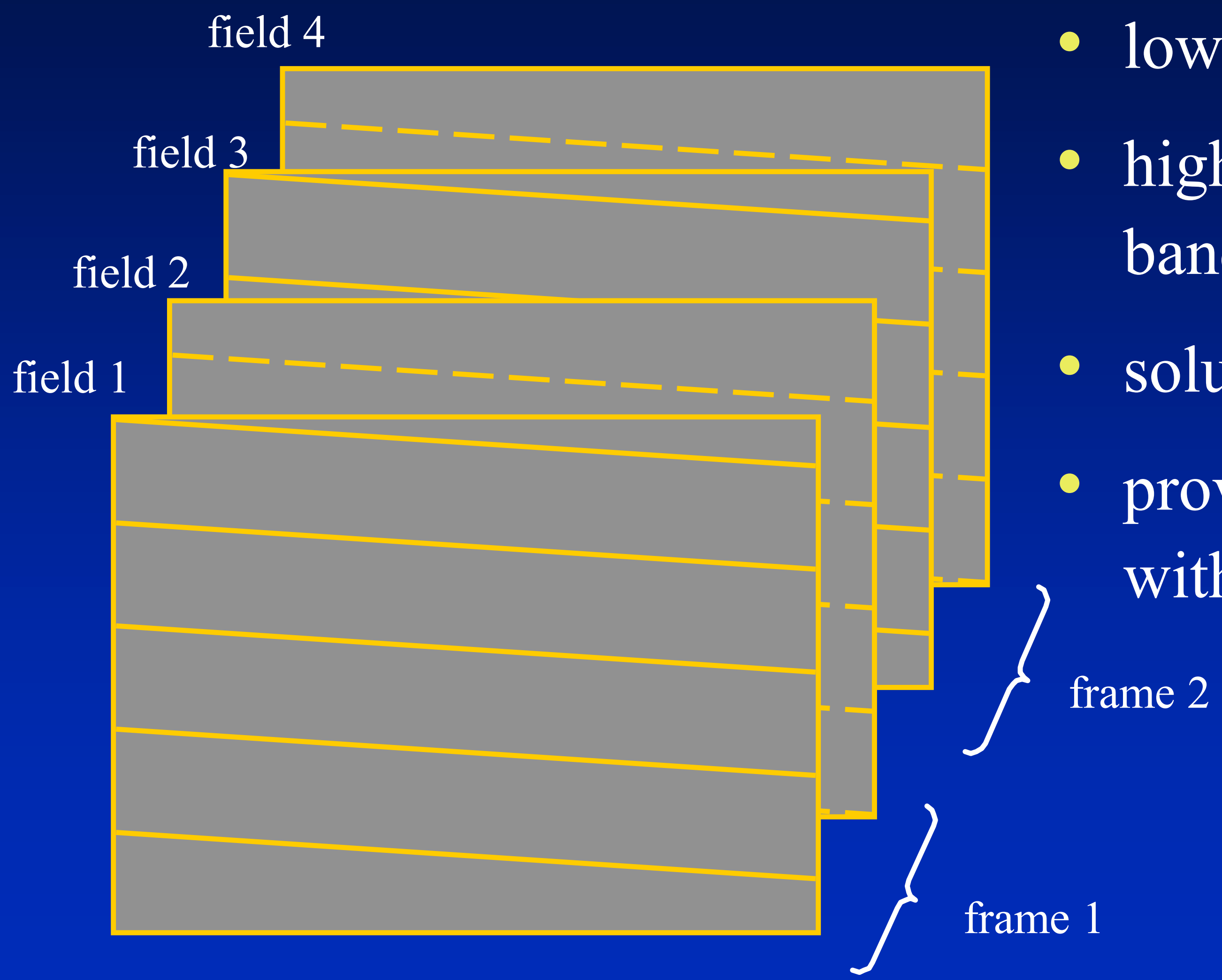
- The flicker fusion frequency of the average human observer is approximately 60 cycles per second.
- If the refresh rate is greater than this threshold, the observer sees a constant intensity.

Phosphor Decay Behavior



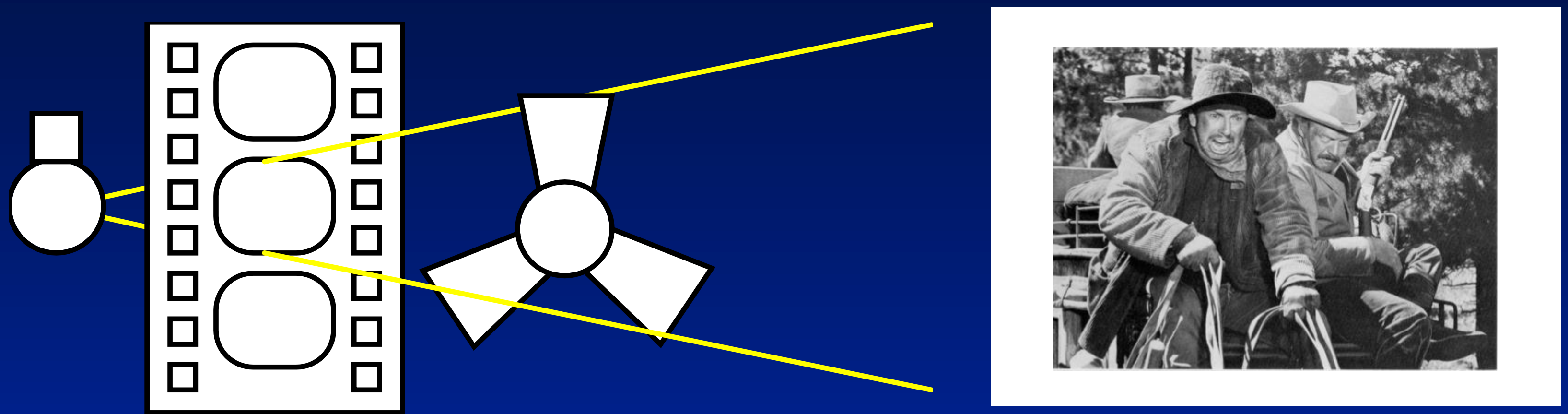
Temporal Properties of NTSC

REFRESH

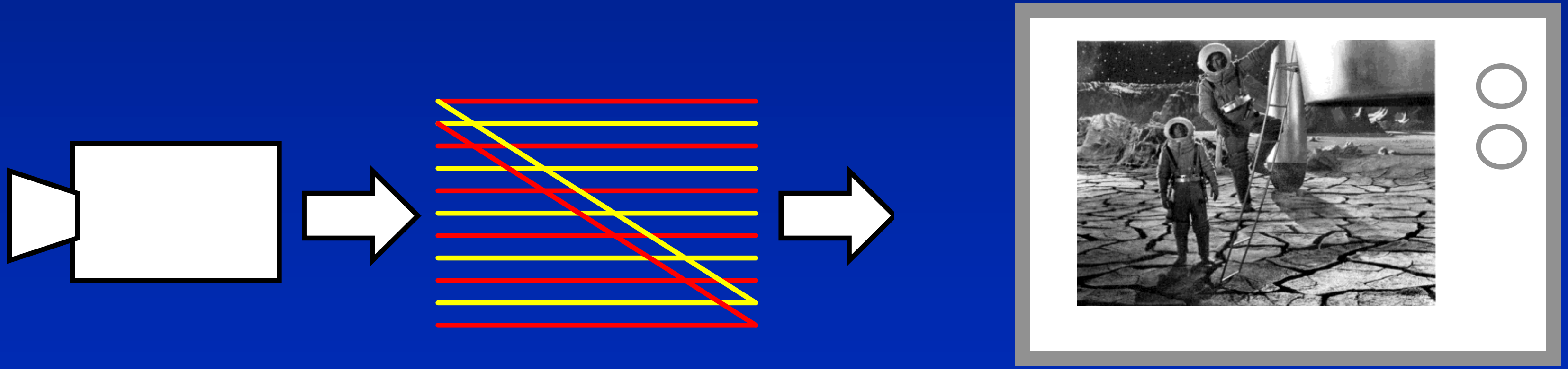


- low refresh rate -> flicker
- high refresh rate -> too much bandwidth
- solution: interlacing
- provides 60 Hz refresh rate with only 30 Hz update rate

Update Rate vs. Refresh Rate



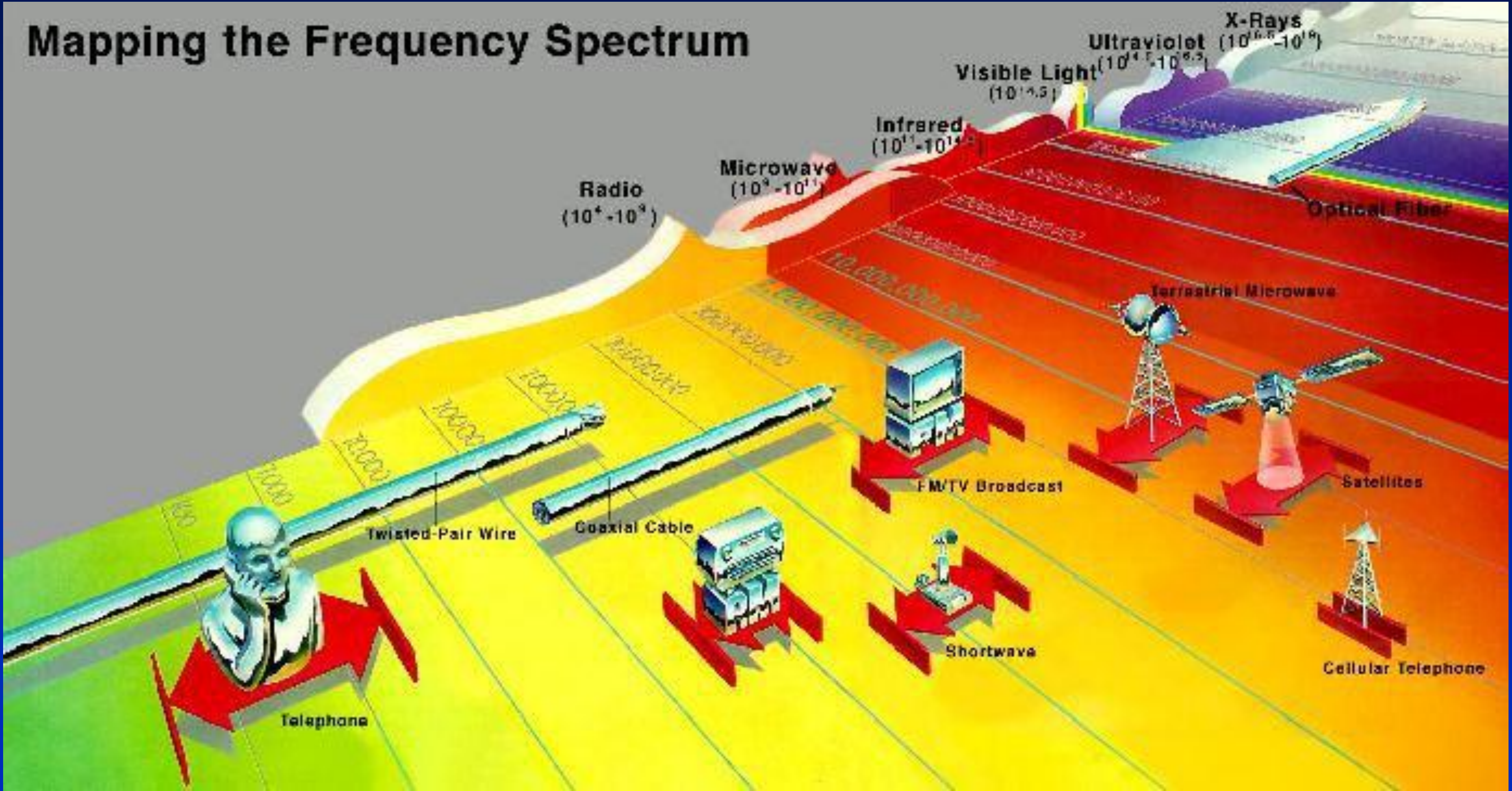
Film: 24fps update rate, 3 blade shutter, 72Hz refresh rate



Video: 30fps update rate, 2:1 interlacing, 60 Hz refresh rate

- interlacing: matches flicker limits of vision, minimizes bandwidth

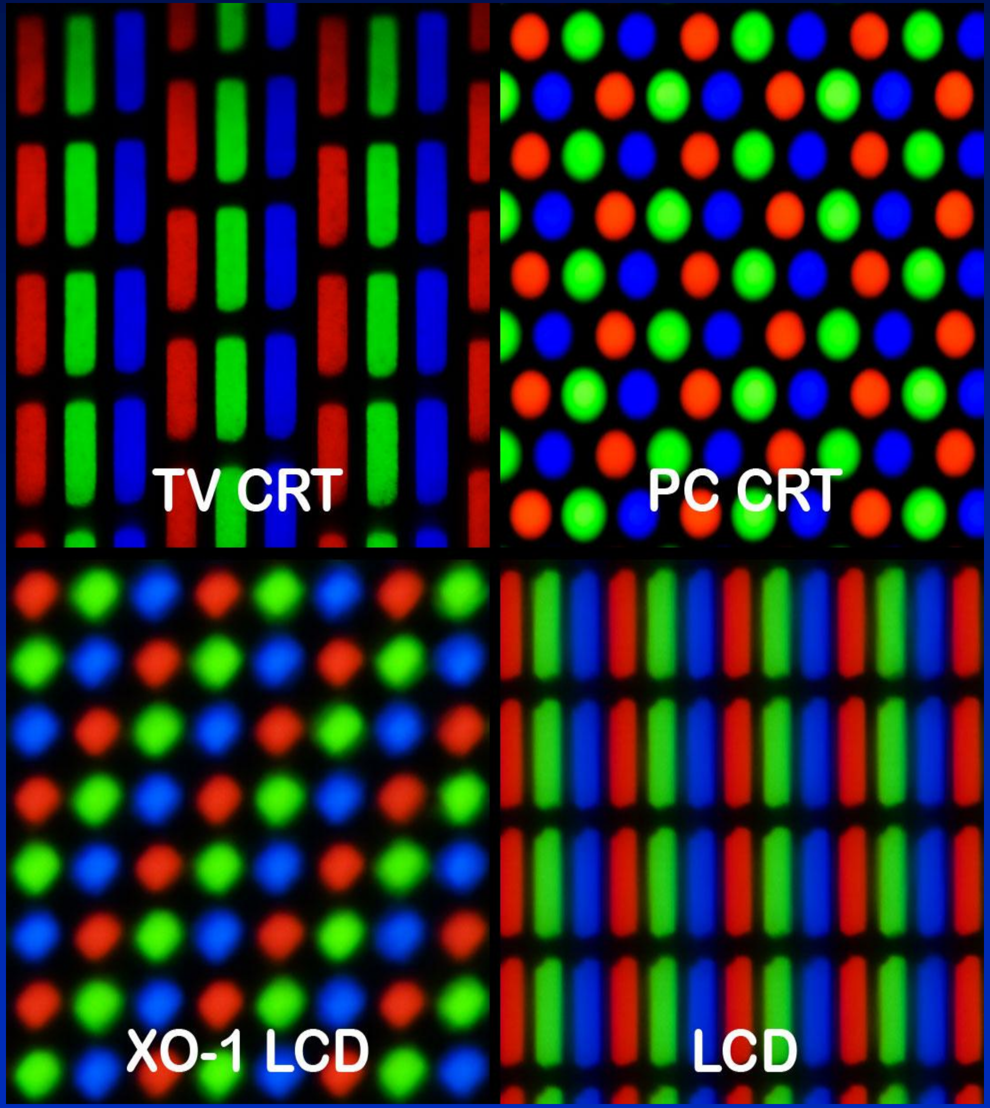
Mapping the Frequency Spectrum



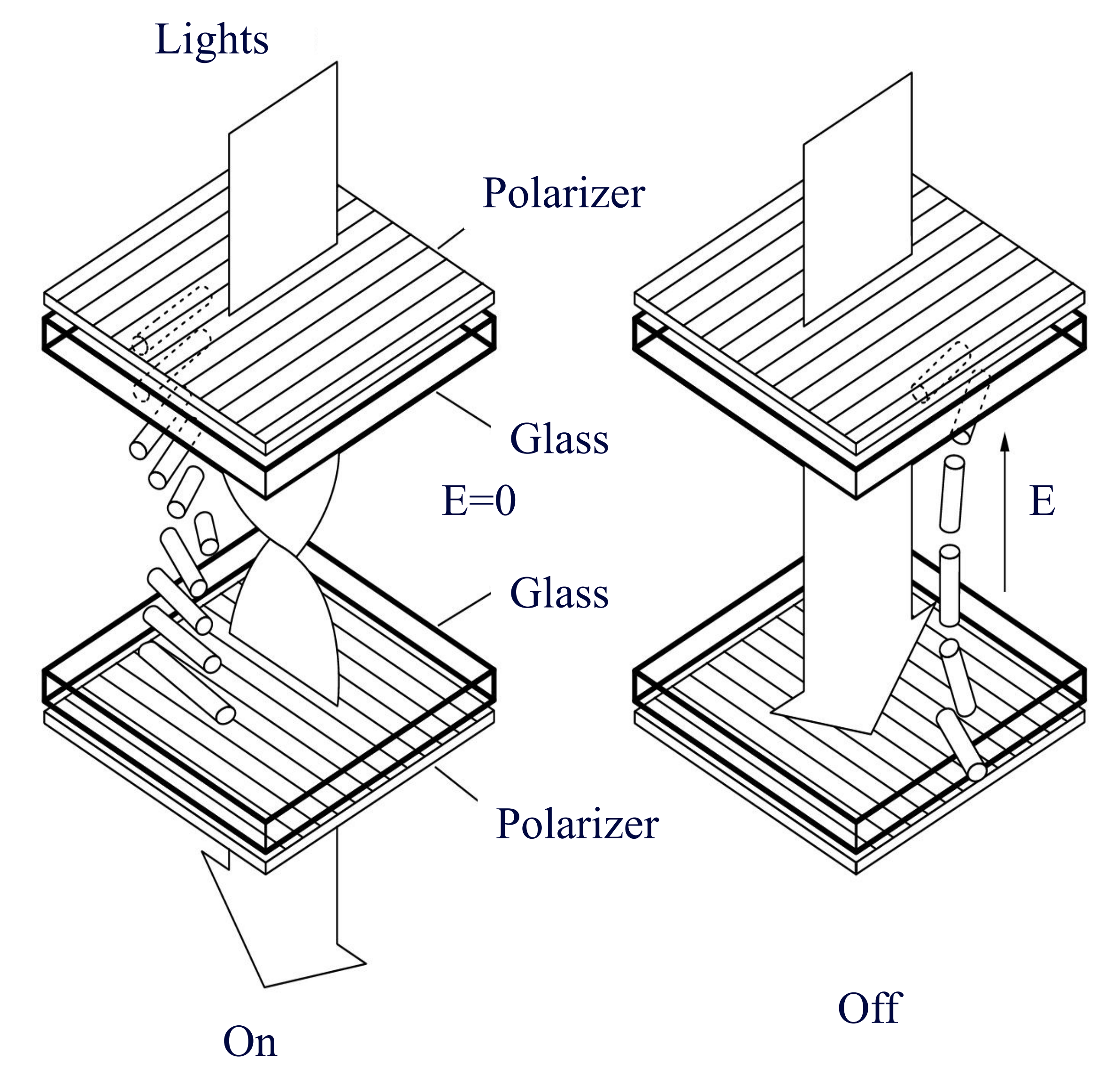
Important Properties of Liquid Crystals

- Crystals are transparent
- Can alter the orientation of polarized light passing through them
- Polarization properties can be changed by applying electrical field
- Switching can be done fast

Different Pixel Configurations

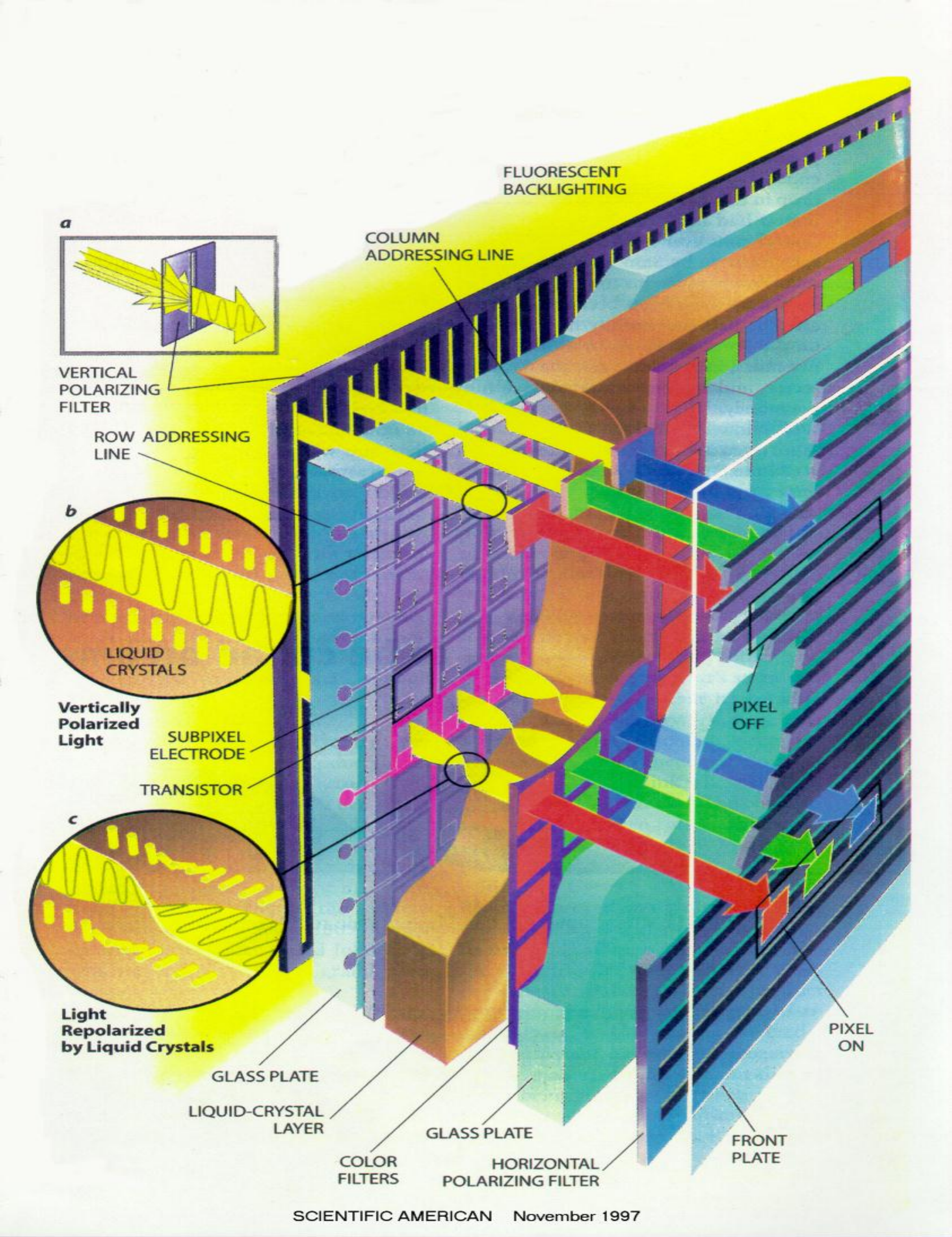


Polarization of Liquid Crystal



Scientific American, November 1997

Liquid Crystal Color Display

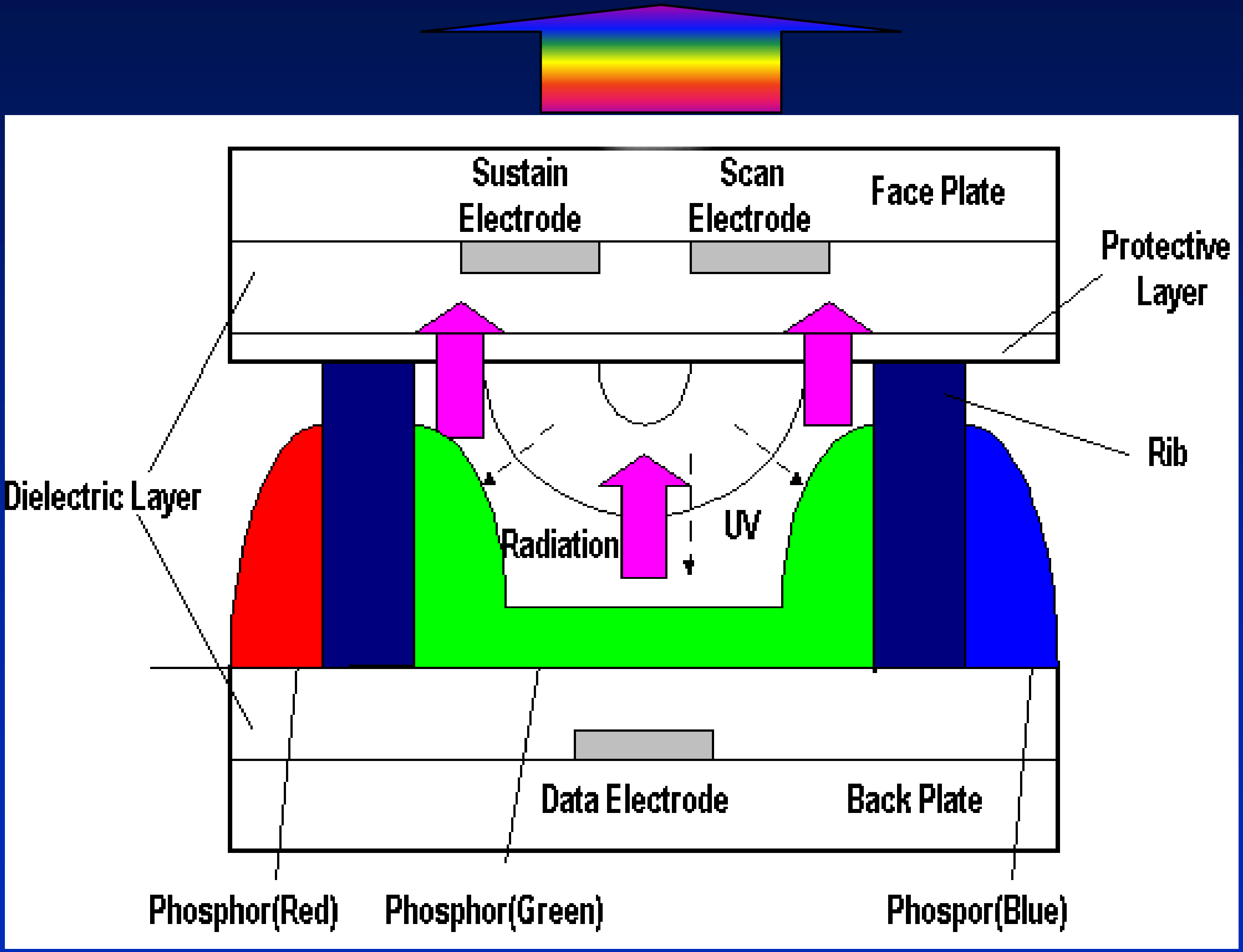


Scientific American, November 1997

LCD Advantages & Disadvantages

- Can have high resolution. (Corning & Samsung)
- Requires very flat glass panels which are now being produced relatively cheaply.

Plasma Display Technology



Plasma Display: Advantages & Disadvantages

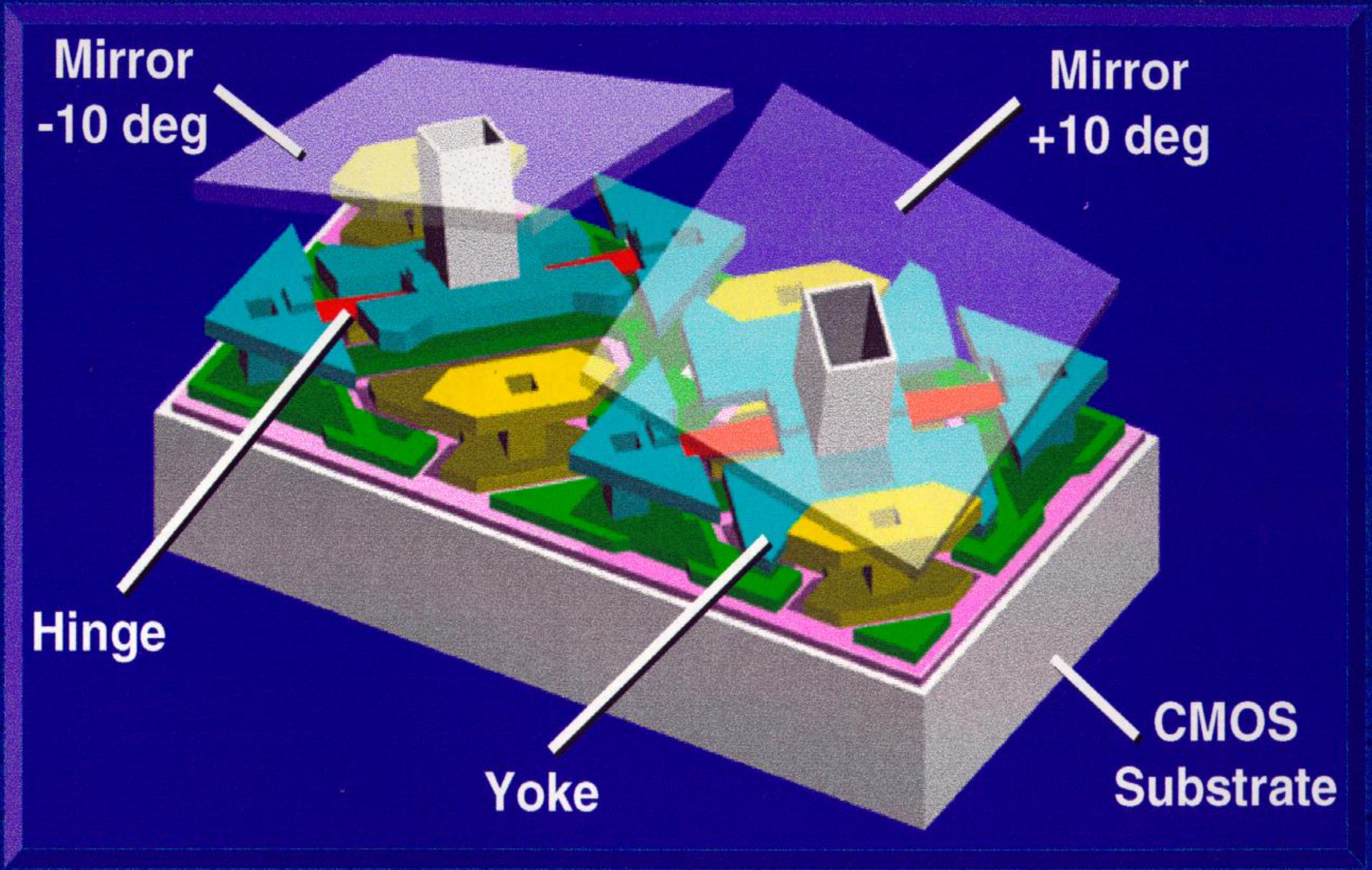
- The advantage is that they can have high brightness (at the expense of watts). Thus can be used in brightly lit areas.

- The difficulty with plasma displays is that the cell size (pixel) is large relative to a liquid crystal. Thus for a given resolution, the screens must be large.

Digital Micromirror Devices (DMD)

- Pioneered by Texas Instruments. The research on these micromechanical (MEMs) devices started in 1977.
- The first digital light valve projection systems (DLPs) had mirrors measuring 17 microns per side. At 1280 x 1028 resolution (HDTV) this resulted in a rather large chip in 1996.

DMD Structure

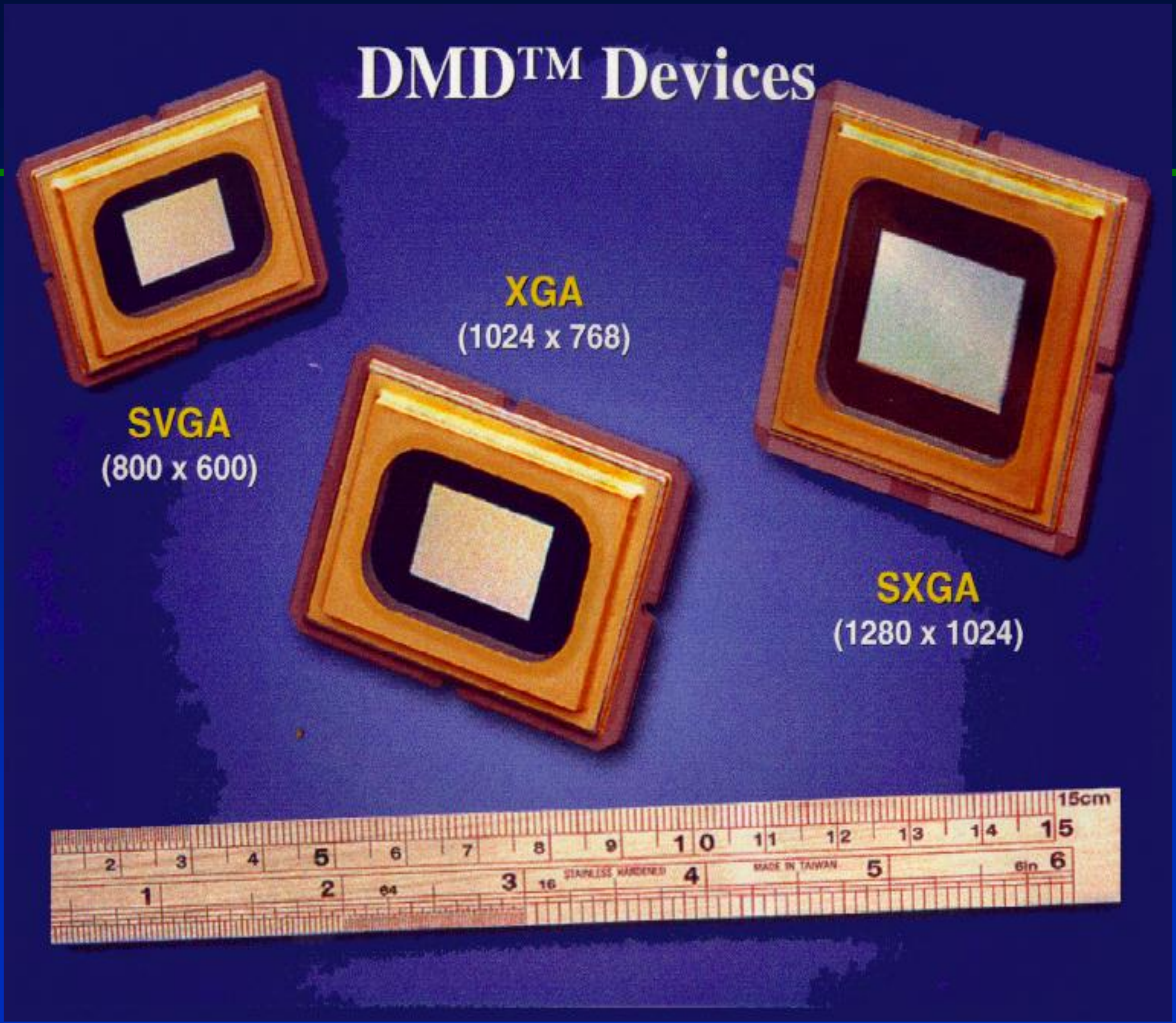


Digital Micromirror Device (DMD™)

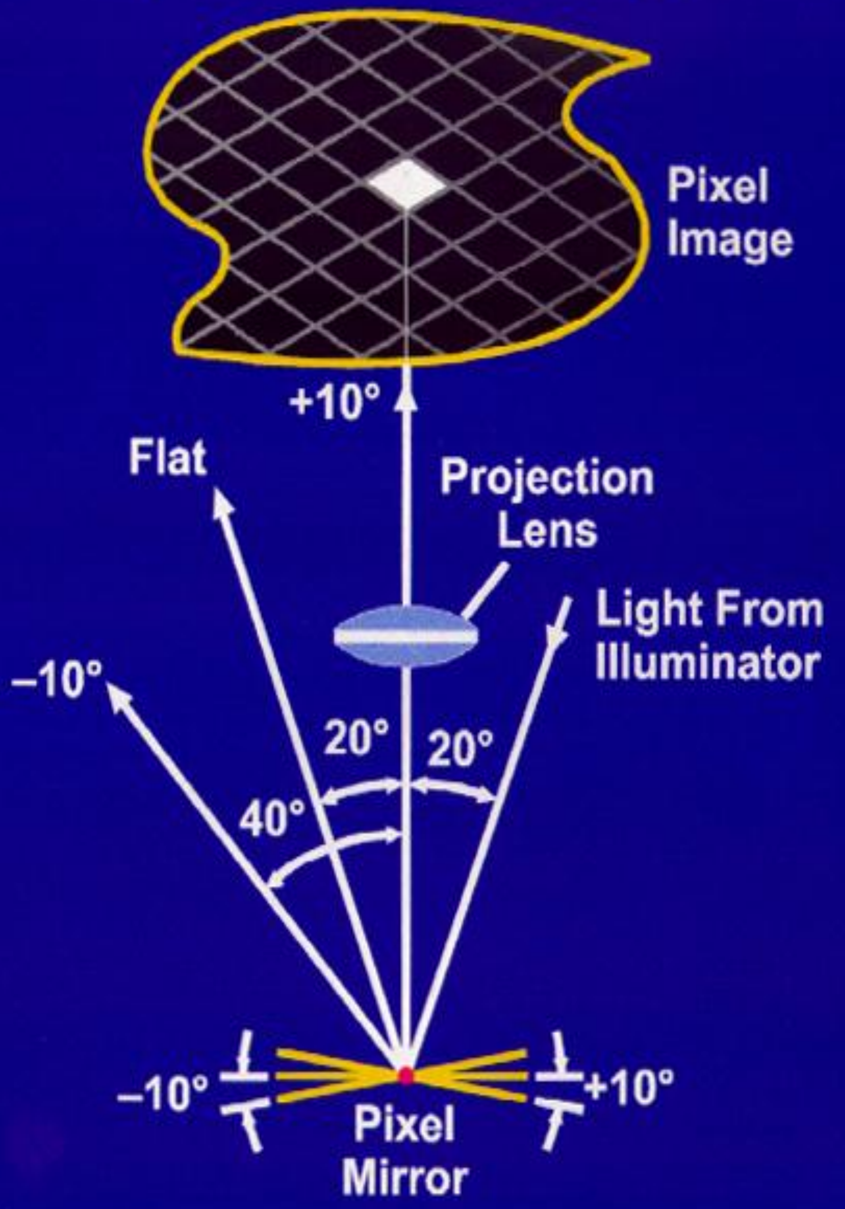
A True Microelectromechanical System

DLP™

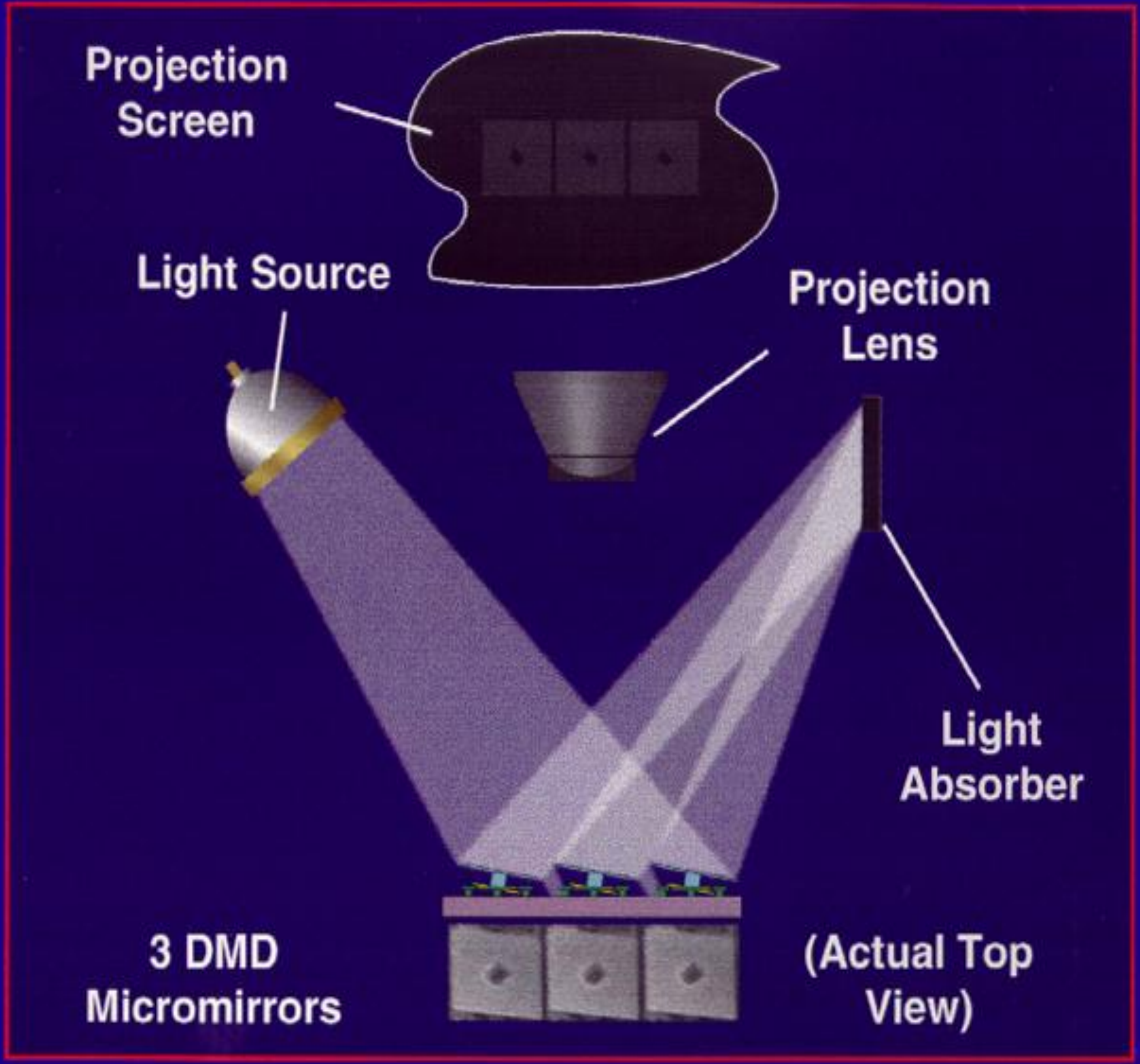
A TEXAS INSTRUMENTS TECHNO


DMD™ Devices
SVGA
(800 x 600)
XGA
(1024 x 768)
SXGA
(1280 x 1024)
15cm

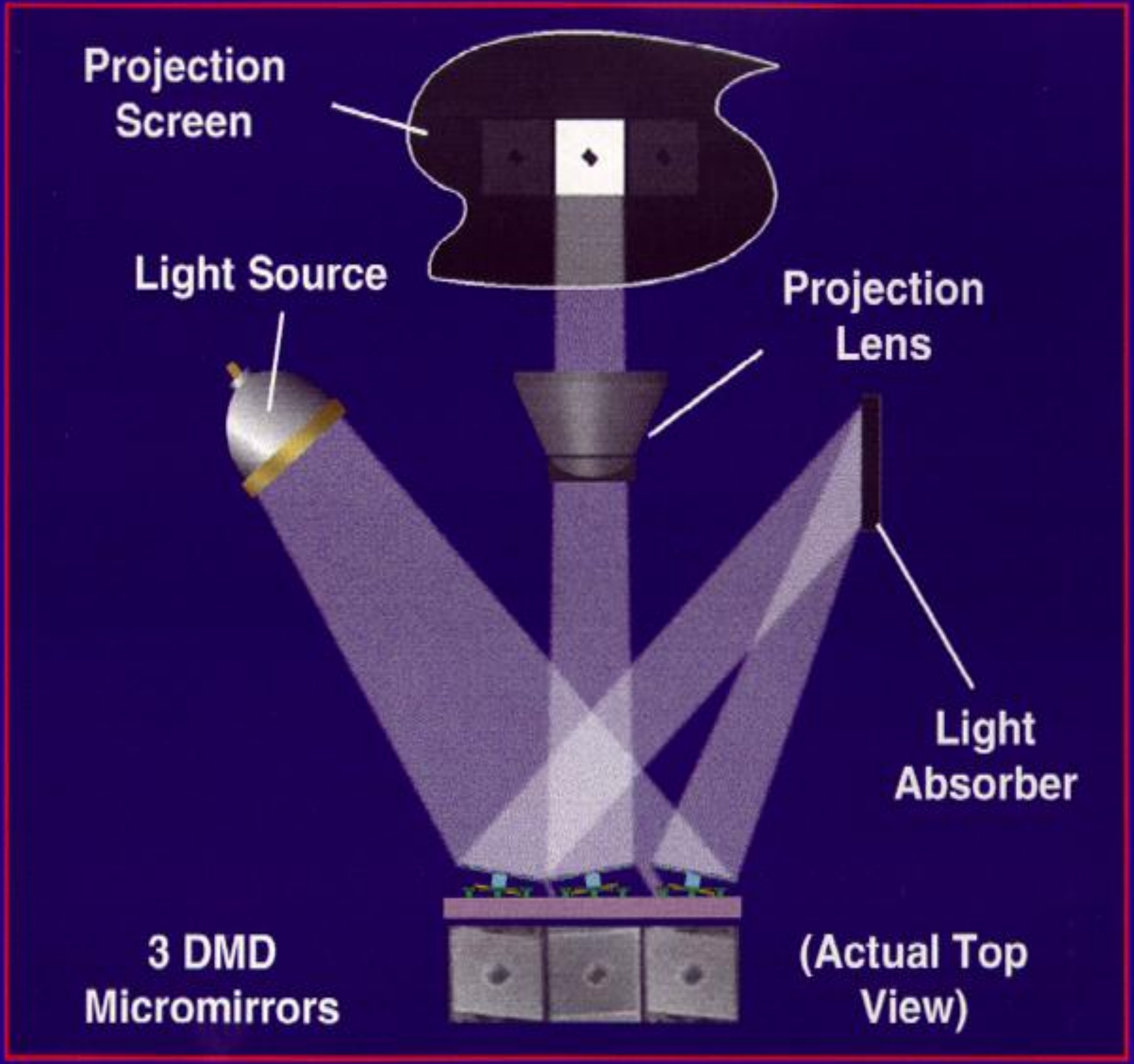
DMD™ Optical Switching Principle

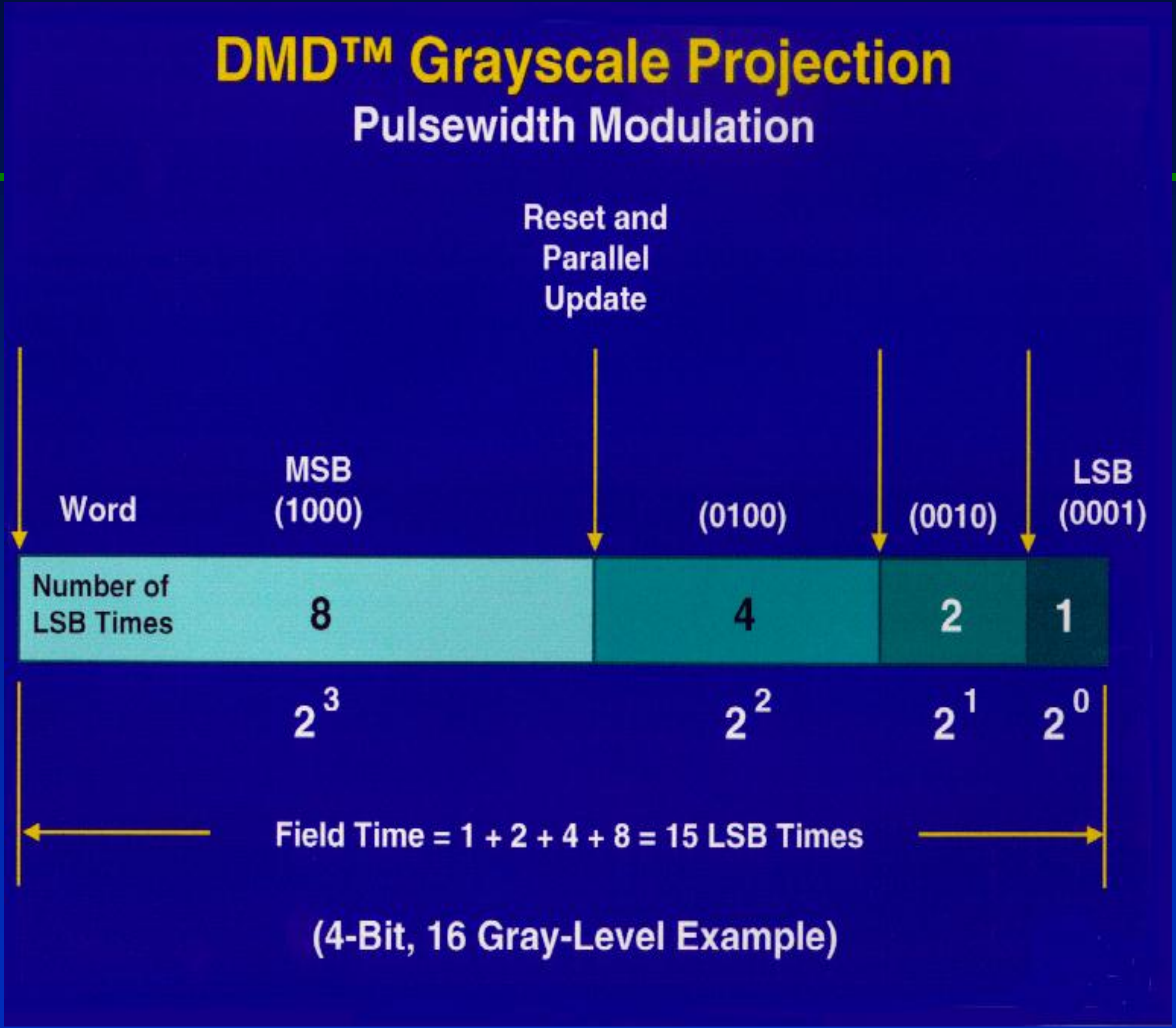


DMD™ Switching Example (All Off)



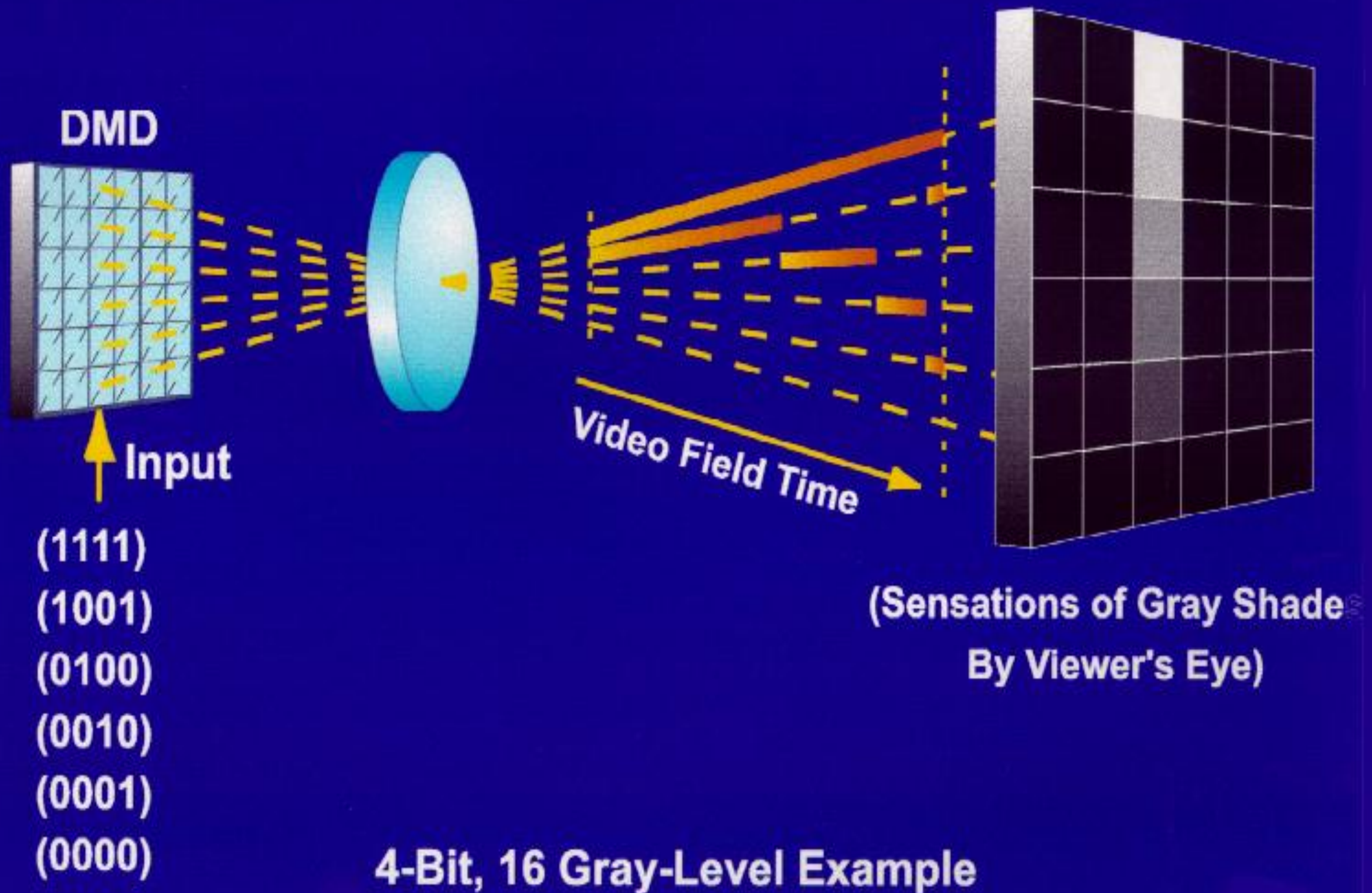
DMD™ Switching Example (1 On)




DMD™ Grayscale Projection
Pulsewidth Modulation
Reset and Parallel Update
Word
MSB (1000)
(0100)
(0010)
LSB (0001)
Number of LSB Times
8
4
2
1
2 3
2 2
2 1
2 0
Field Time = 1 + 2 + 4 + 8 = 15 LSB Times
(4-Bit, 16 Gray-Level Example)

How Grayscale is Created

DMD™ Binary Pulsewidth Modulation



Example: Lenna Original

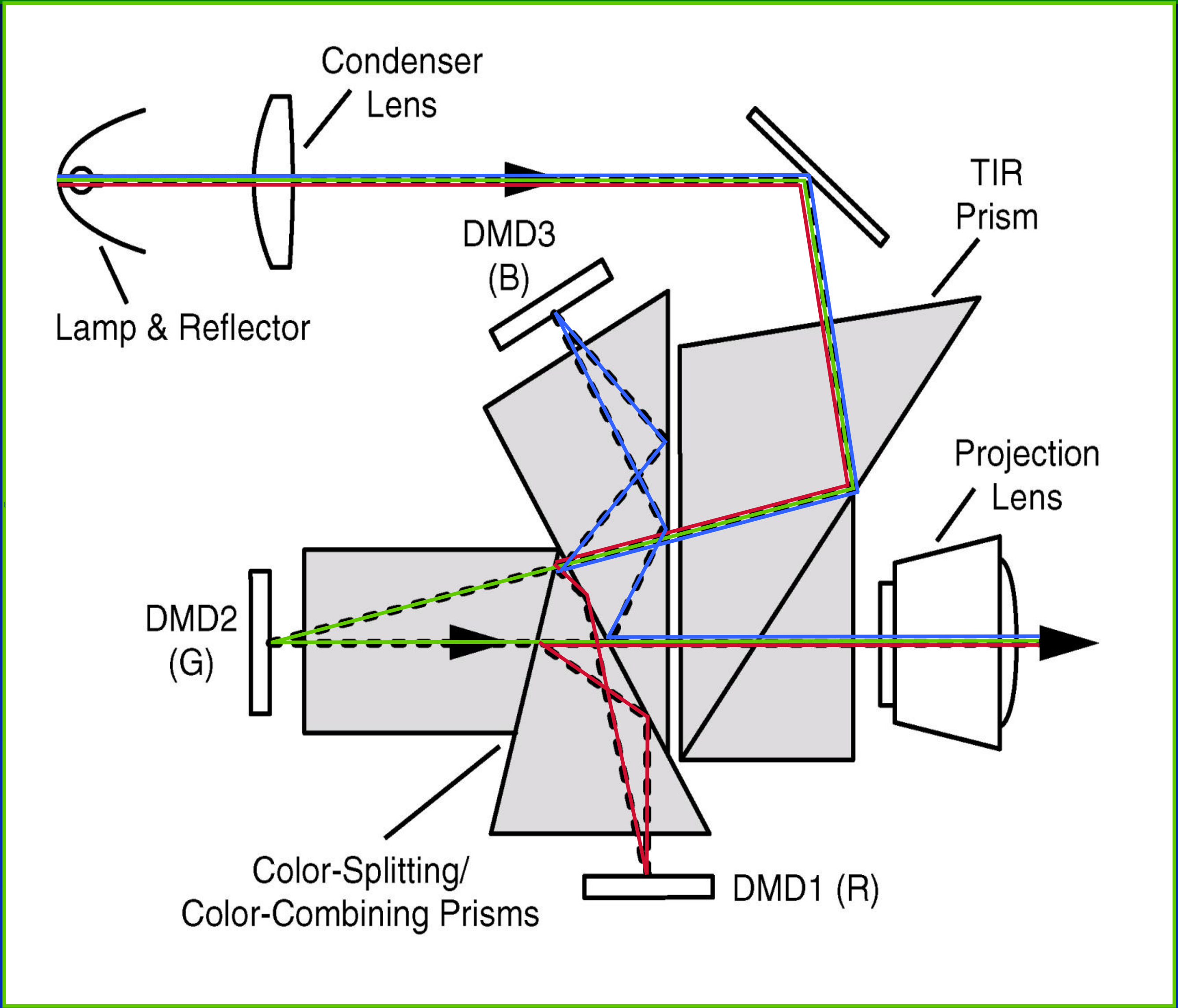
1000

1100

1110

11111111

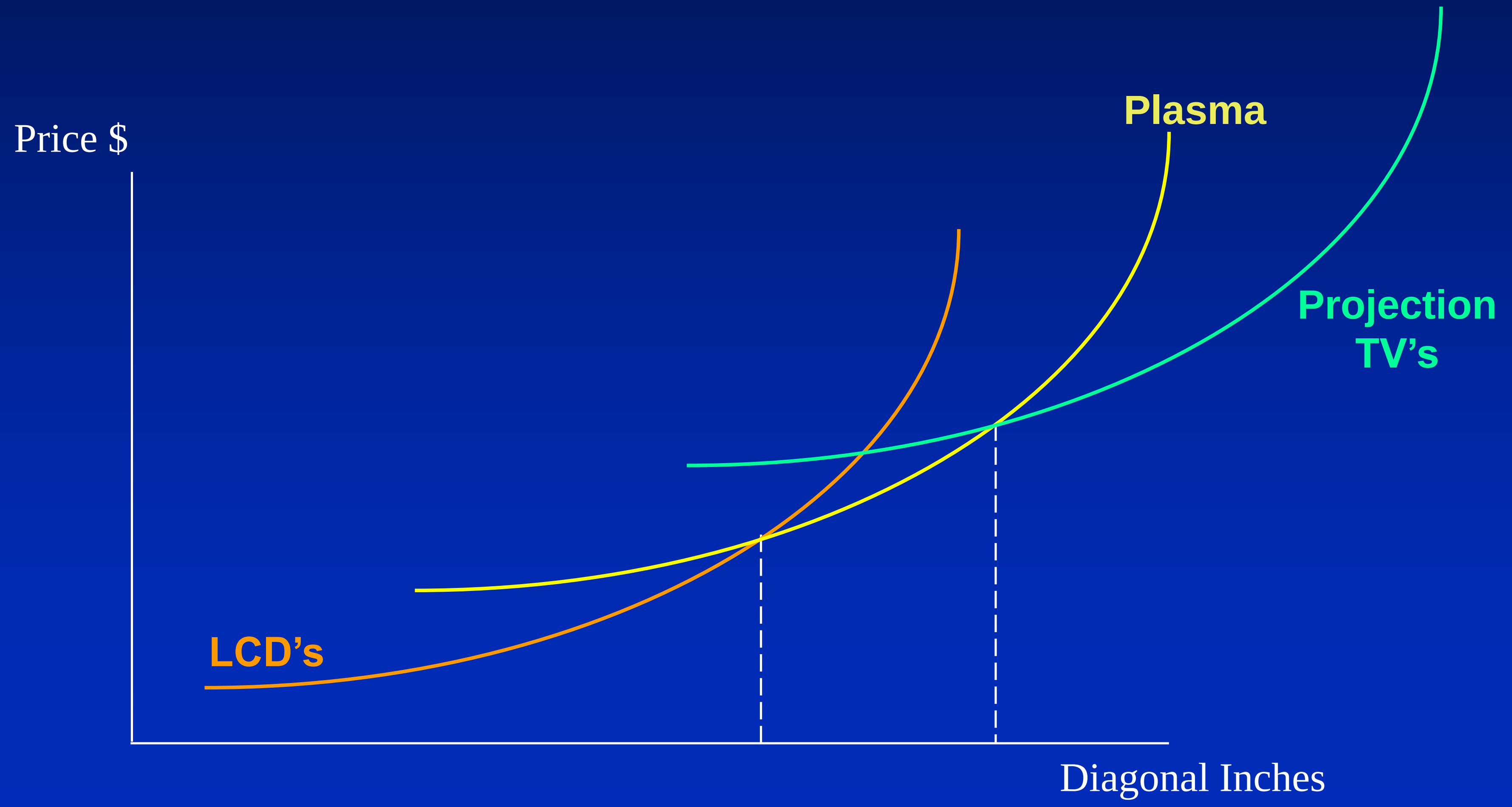
3-Chip DLP Optical System



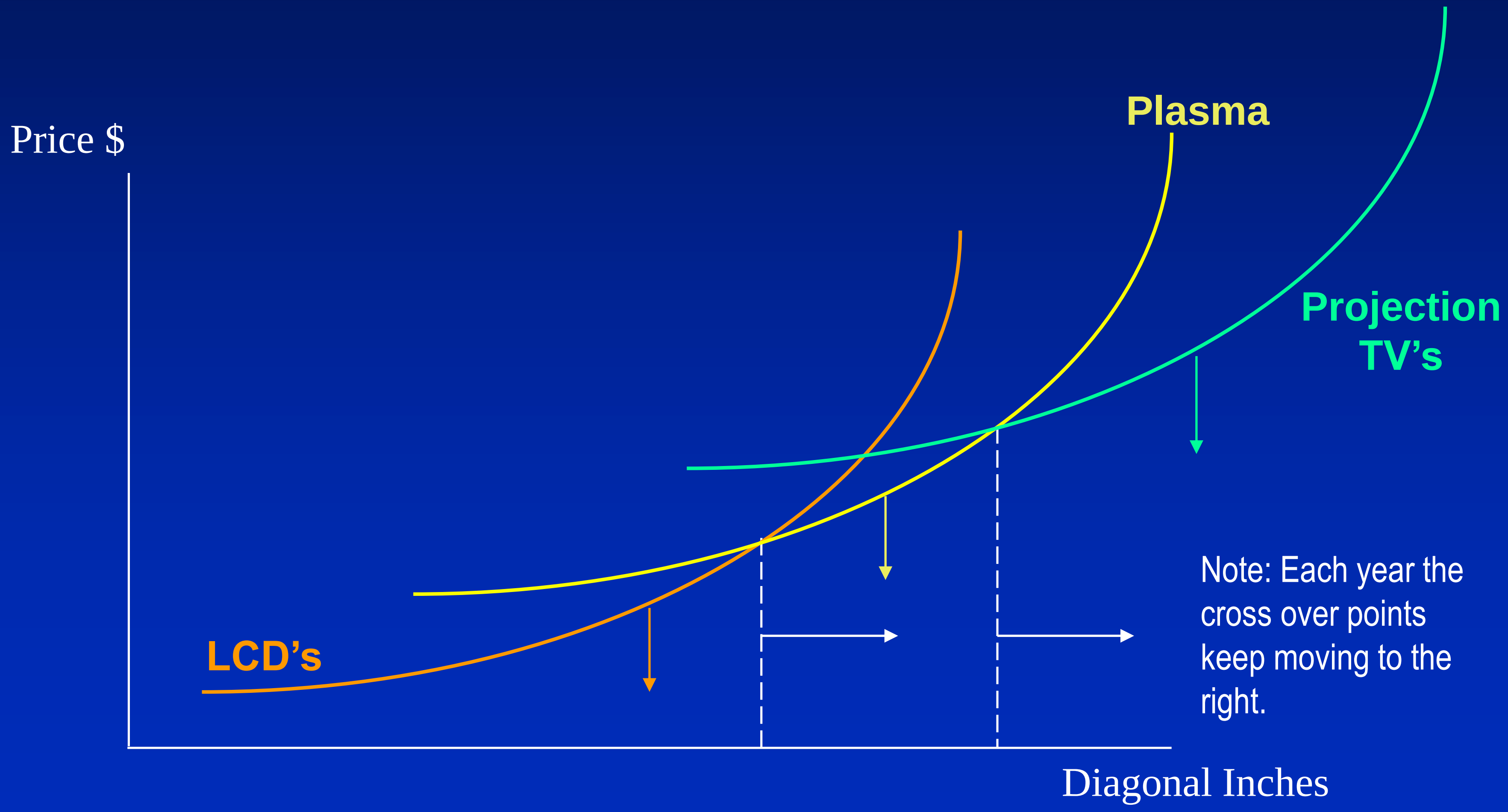
Digital Micromirror Devices (DMD)

- Pioneered by Texas Instruments. The research on these micromechanical (MEMs) devices started in 1977.
- The first digital light valve projection systems (DLPs) had mirrors measuring 17 microns per side. At 1280 x 1028 resolution (HDTV) this resulted in a rather large chip in 1996.
- Today this technology is used in almost all digital theaters and some home televisions.
- Most theaters now use DLP with 4K resolution (4096 x 2160)

Cost of HDTV Displays



Cost of HDTV Displays



Note: Each year the cross over points keep moving to the right.

Modifications to Existing Technology

- The quest for size
- The quest for brightness

Cornell Panoramic Projection System

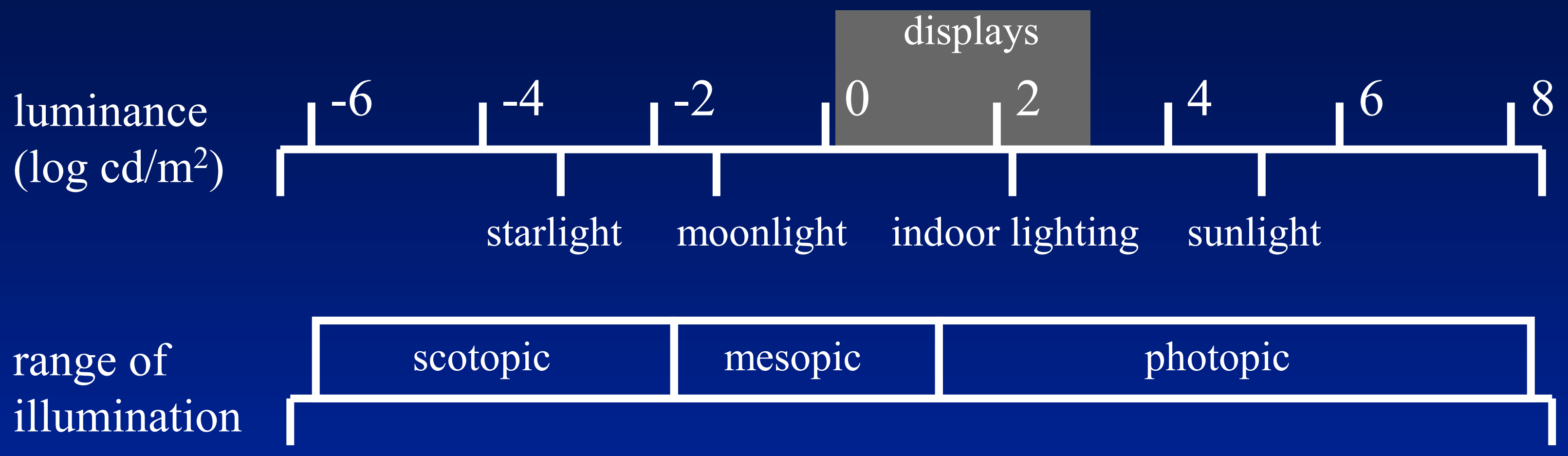
NASA Ames Control Room

FutureFlight Center at NASA-Ames

Stonybrook’s Reality Deck

Samsung 110-inch 4K UHD TV 2014

Visual Adaptation



- poor contrast
- no color
- low acuity

- good contrast
- good color
- high acuity

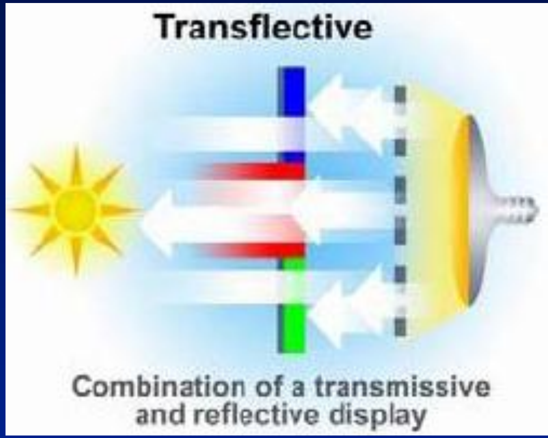
Sunnybrook Display Technology

High resolution
colour LCD

High Dynamic Range
Display

Low resolution
Individually Modulated
LED array

The XO and One Laptop Per Child



The custom XO display contains a reflective layer between it's backlight and the specially formatted LCD layer, allowing it to turn high ambient lighting conditions to it's advantage.

The display is not only inexpensive ($30/unit), but is also much easier on the eyes.

Images Through Screen Doors

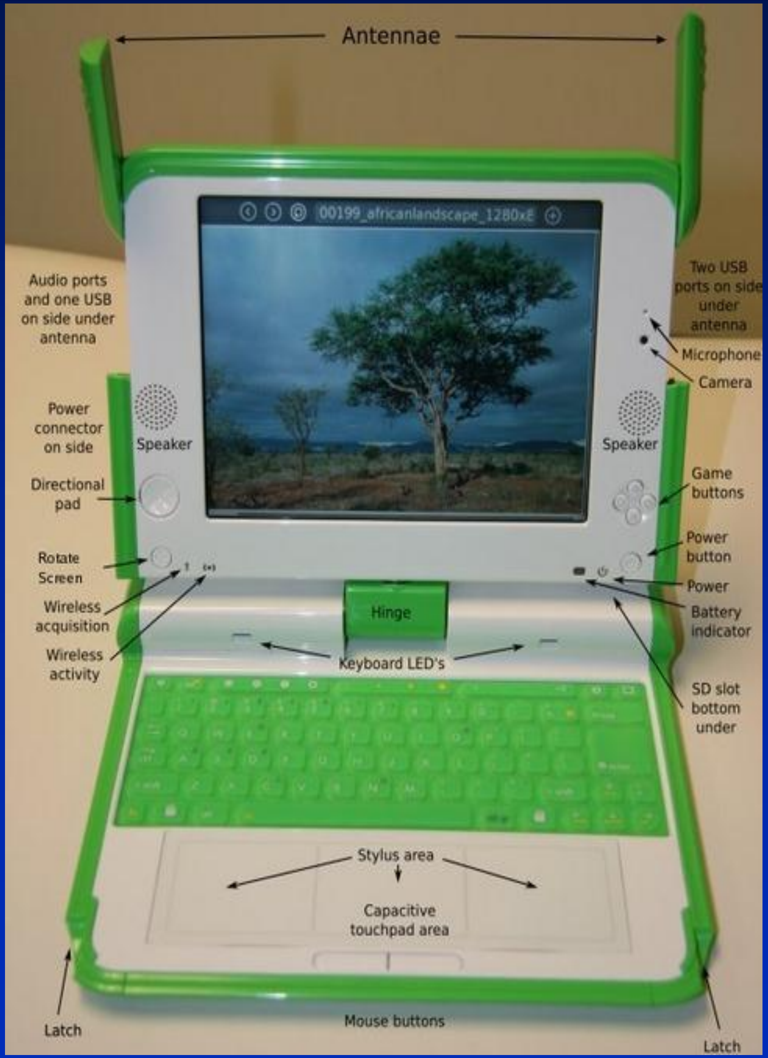
Pixel Qi

A Backlight
E Mirror
B Layer of liquid crystals
C Color filters
D Ambient light

Pixel Qi


pumpkin.jpg - Windows Picture and Fax Viewer
U.S. Knew of Fort Hood S
BY DAVID JOHNSTON AND SCOTT SHANE
WASHINGTON — Intelligence agencies intercepted communications last year and this year between the military psychiatrist accused of shooting to death 13 people at Fort Hood, Tex., and a radical cleric in Yemen known for his incendiary anti-American teachings.
But the federal authorities dropped an inquiry into the matter after deciding that the messages from the psychiatrist, Maj. Nidal Malik Hasan, did not suggest any threat of violence and concluding that no further action was warranted, government officials said Monday.
Major Hasan's 10 to 20 messages to Anwar al-Awlaki, once a spiritual leader at a mosque
Pixel Qi

OLPC XO-4 Touch August 2013



http://wiki.laptop.org/go/XO-4_Touch

Organic LEDs (OLEDs)

SOFT LIGHT: Junji Kido of Yamagata University shows off his bright and smooth prototype OLED system.

John Boyd. "Let There Be (a New Kind of) Light," IEEE Spectrum, July 2007.

Organic LEDs (OLEDs)

- Composed of a thin film of organic compounds and conductive layers sandwiched between two electrodes

- When the charges recombine in the organic layer, energy is released in the form of photons

- Can be made with fluorescent-based or phosphorescent material

John Boyd. “Let There Be (a New Kind of) Light,” IEEE Spectrum, July 2007.

Organic LEDs (OLEDs) Advantages

- In theory, the energy of this conversion could reach 100%
- Thickness can be measured in nanometers (extremely thin and lightweight) excluding the substrate
- Can be manufactured in sheet form
- Can be put on a variety of substrates including flexible plastic
- Material is environmentally friendly (no harmful elements)

John Boyd. "Let There Be (a New Kind of) Light," IEEE Spectrum, July 2007.

Potential Uses

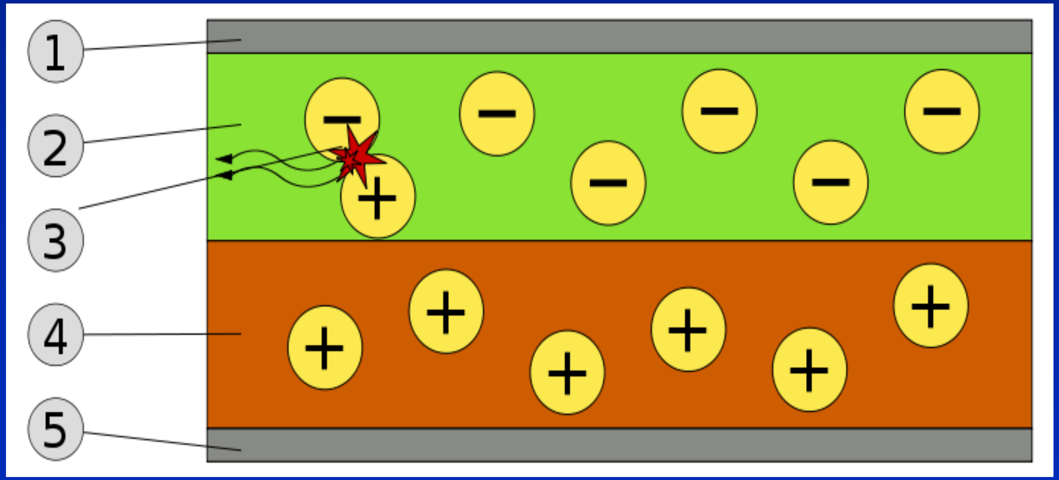
- Could be applied as wallpaper for illumination purposes
- Very bright and can replace light bulbs – already 4x more efficient than light bulbs in terms of lumens/watt
- With ability to produce red, green, and blue (new), can be used for displays

John Boyd. "Let There Be (a New Kind of) Light," IEEE Spectrum, July 2007.

OLED Explanation

A. A voltage is applied across the OLED such that the anode is positive with respect to the cathode. Electrons flow from cathode to anode.

B. Thus the cathode gives electrons to the emissive layer and the anode withdraws electrons from the conductive layer (causing electron holes).

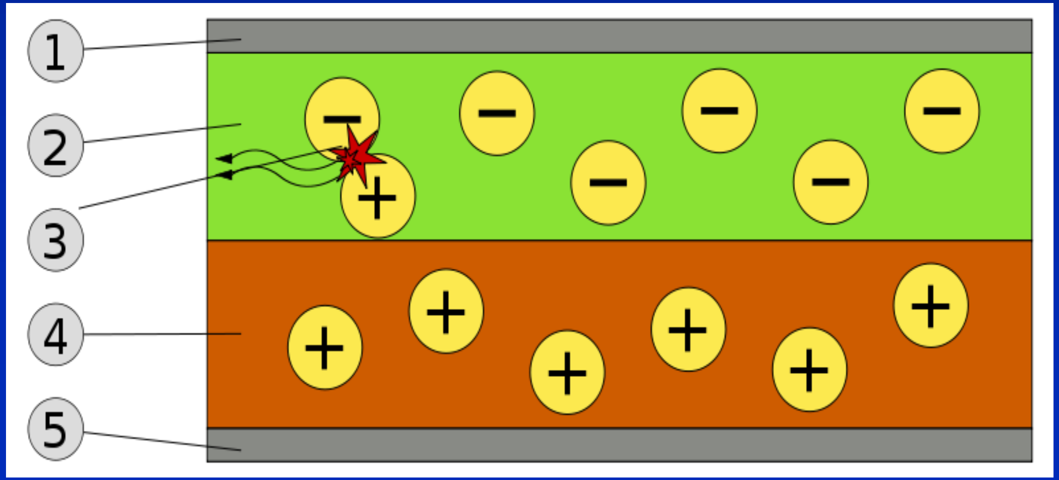


OLED Explanation

C. Electrostatic forces bring the electrons and holes together and they recombine.

D. In organic semiconductors, holes are more mobile than electrons. This happens closer to the emissive layer.

E. The recombination causes an emission of radiation whose frequency is in the visible region.

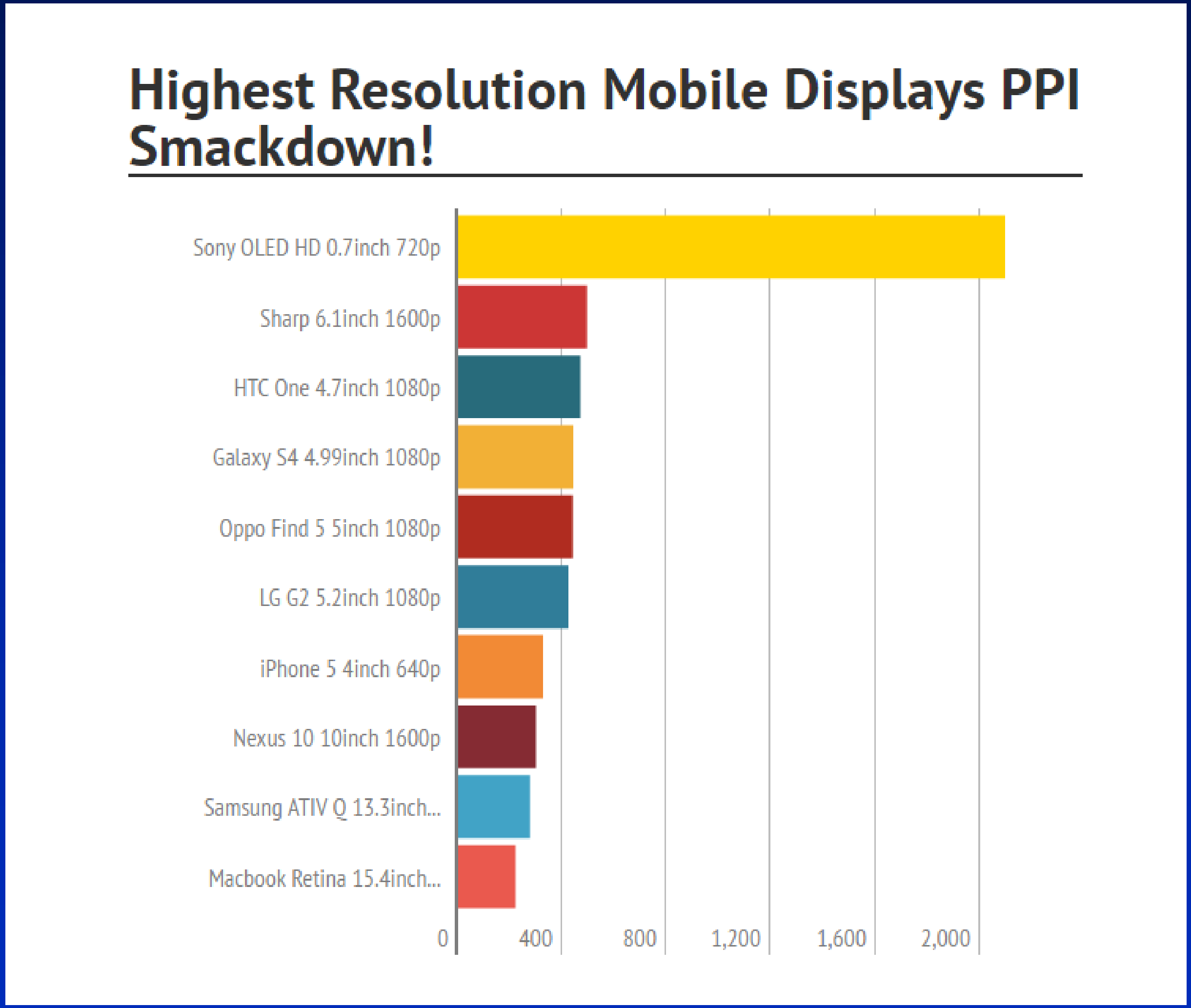


Sony 11-inch OLED Panel 2007

Samsung Curved OLED TV

LG press-on 'wallpaper' TV under 1mm thick

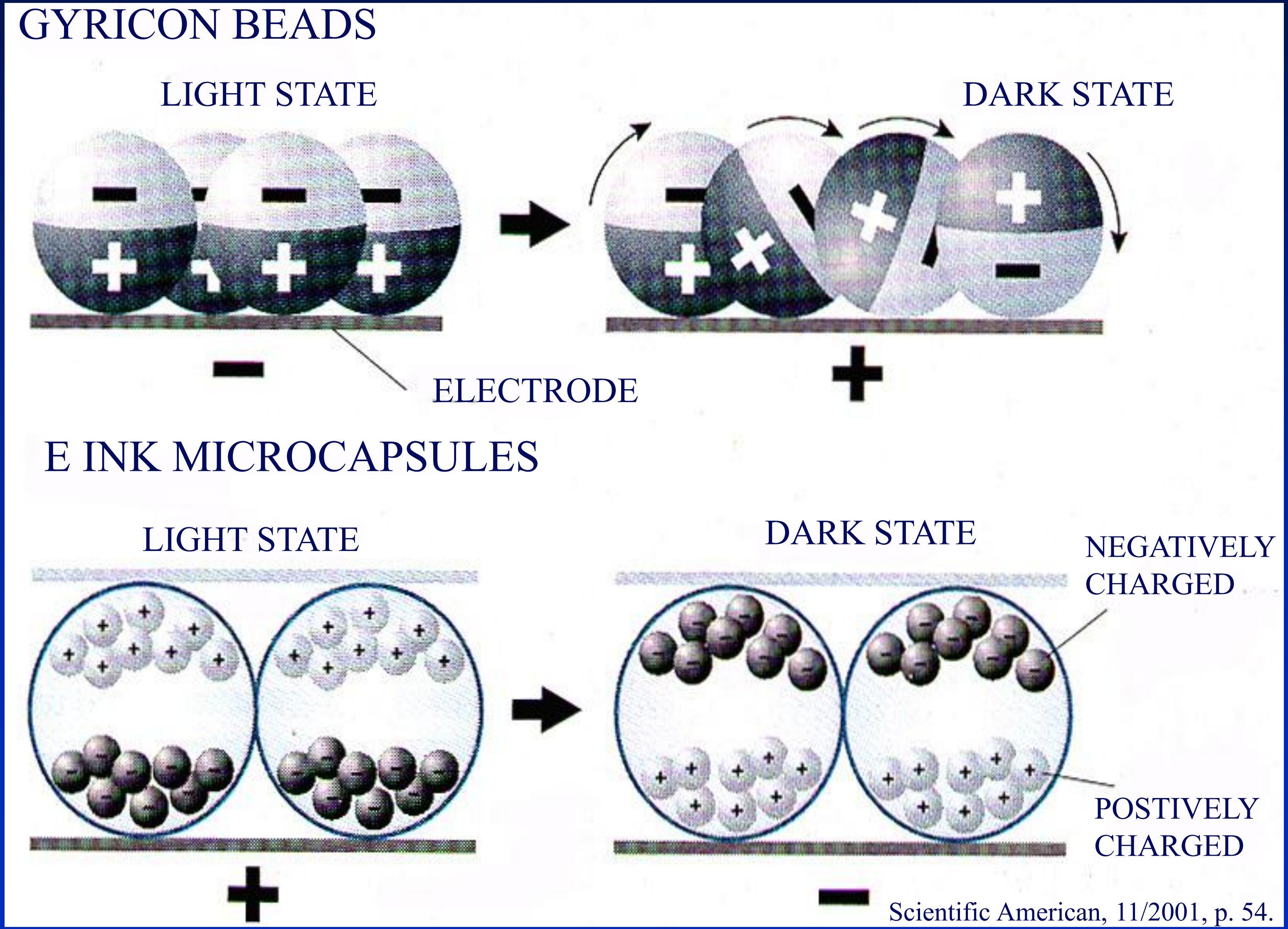
Sony's 2098 ppi 9/29/2016

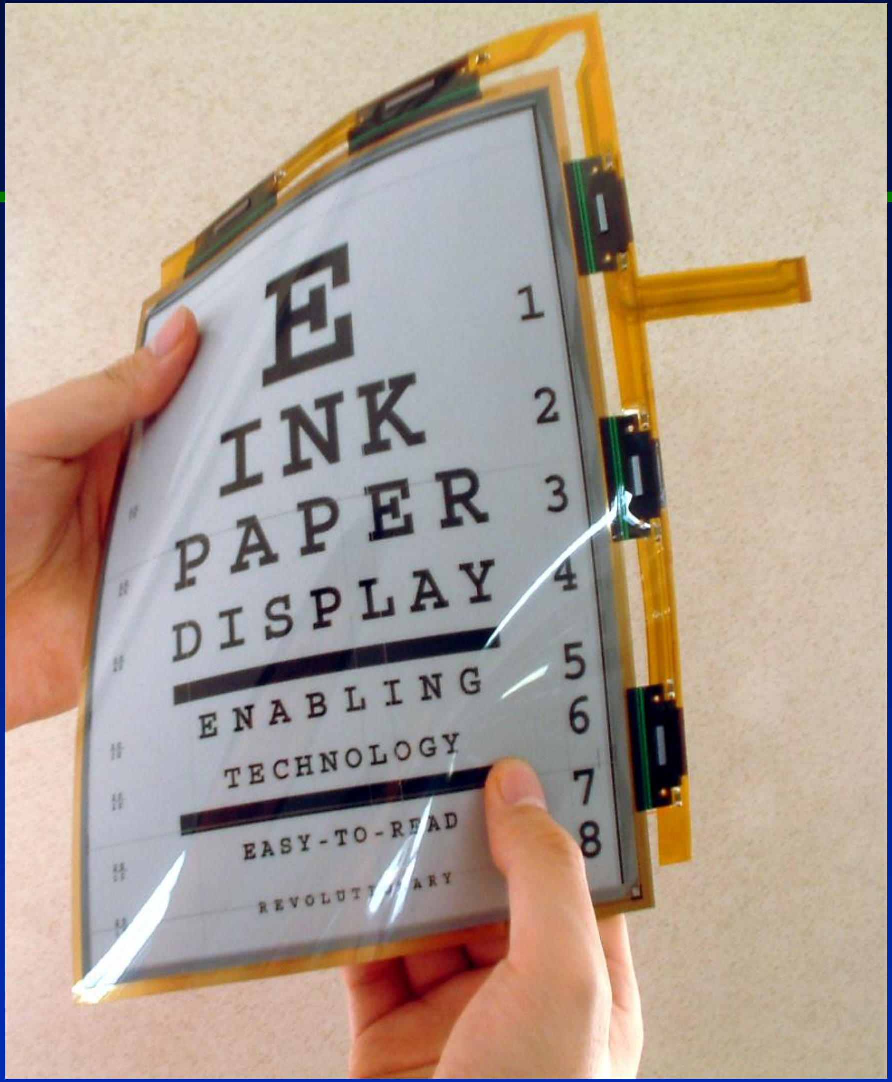


Electronic Paper

2005 Verizon Advertisement

How E-Paper Works

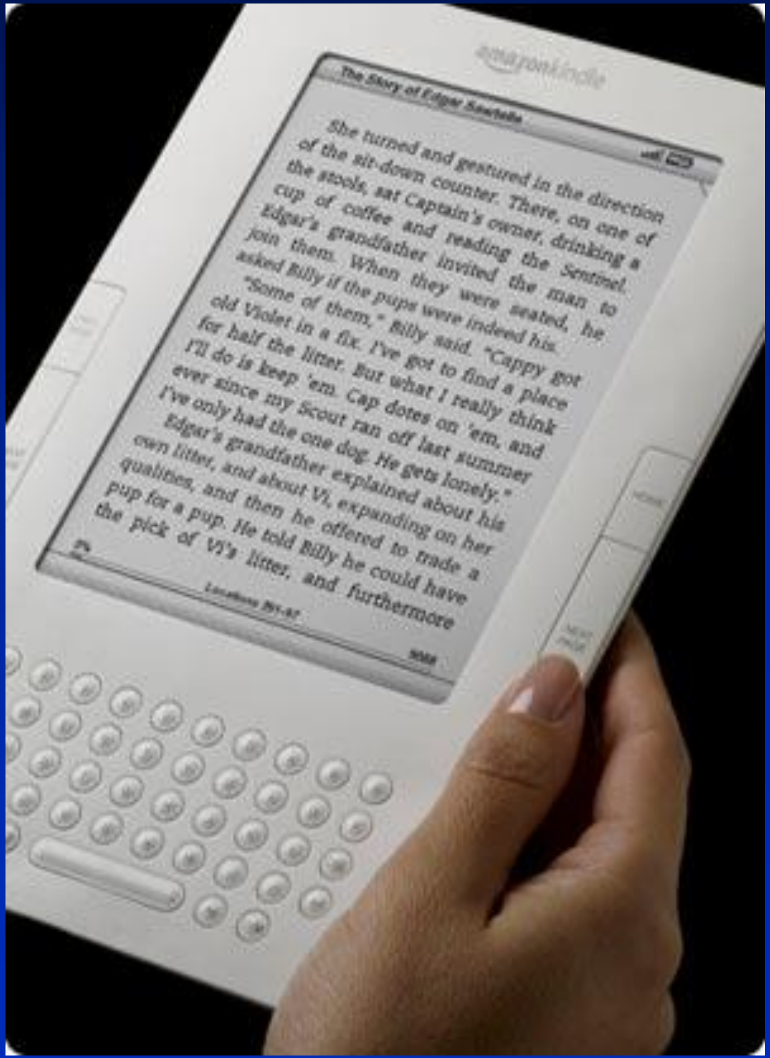


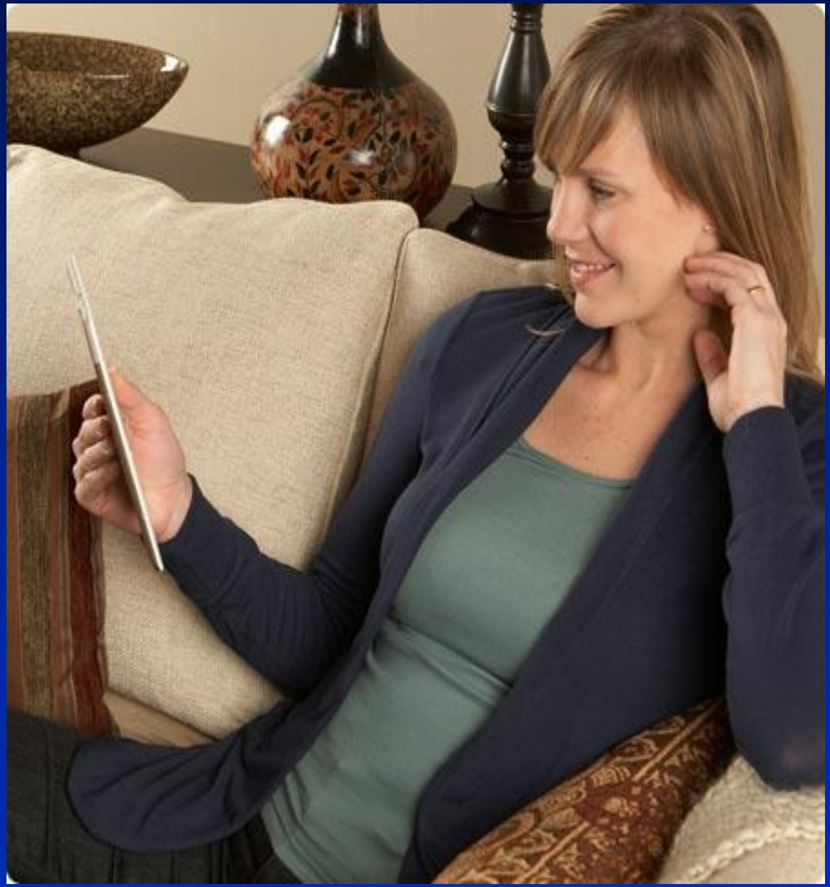


Flexible Tablet-Sized Display From L.G. Philips LCD and E Ink Corporation

http://www.eink.com/

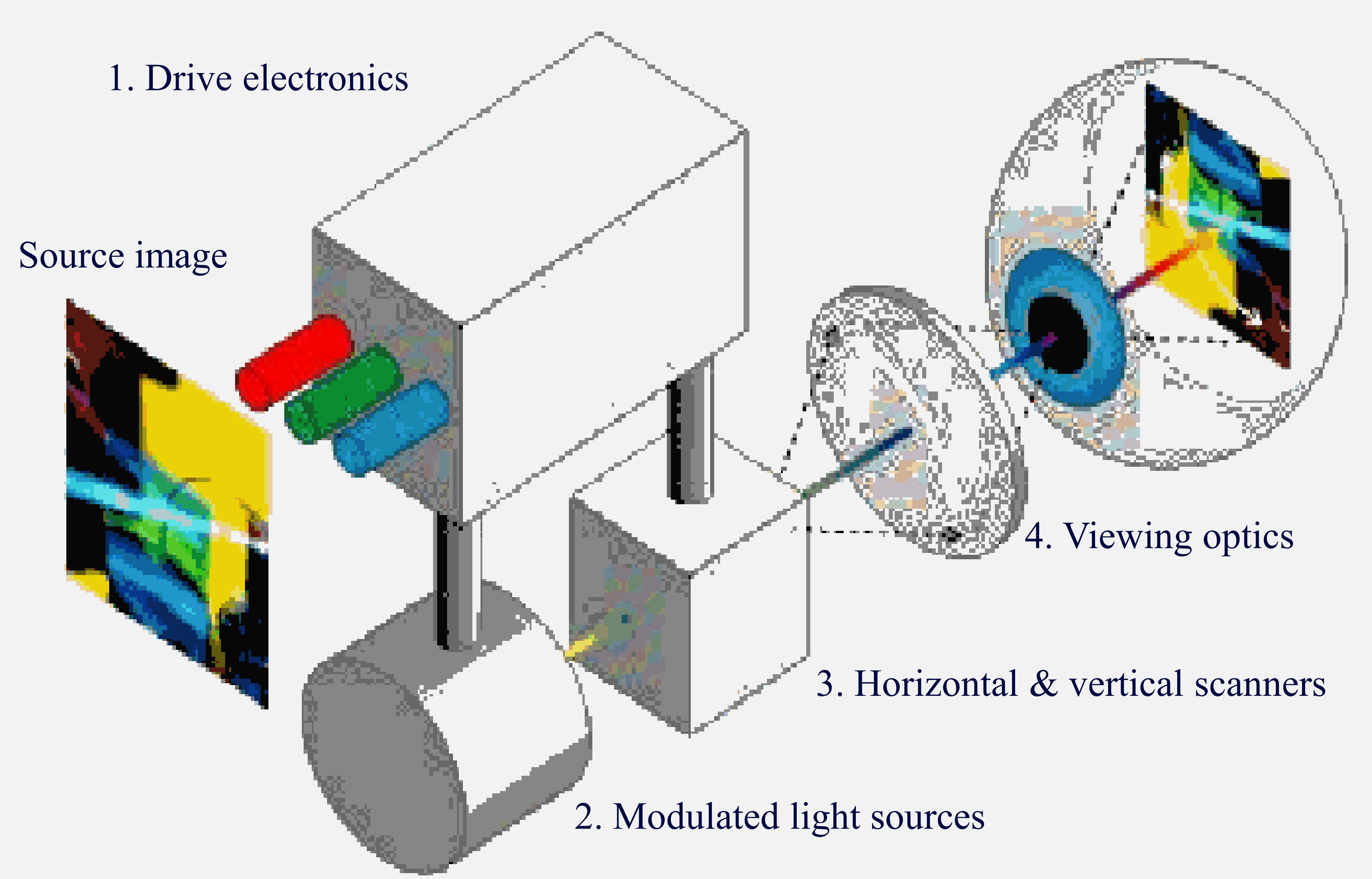
Kindle 2





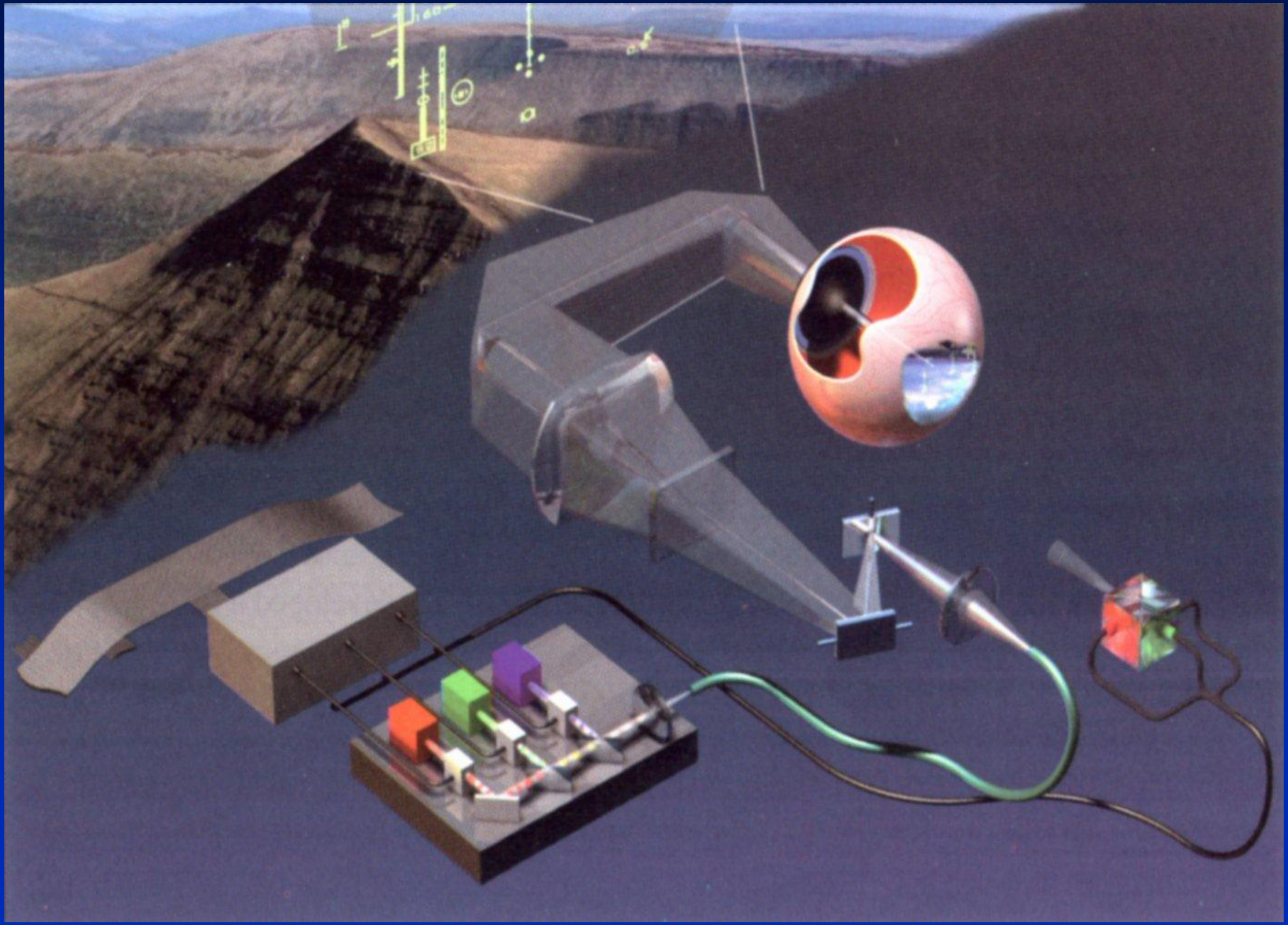
http://www.amazon.com/Kindle-Amazons-Wireless-Reading-Generation/dp/B00154JDAI

Retinal Displays



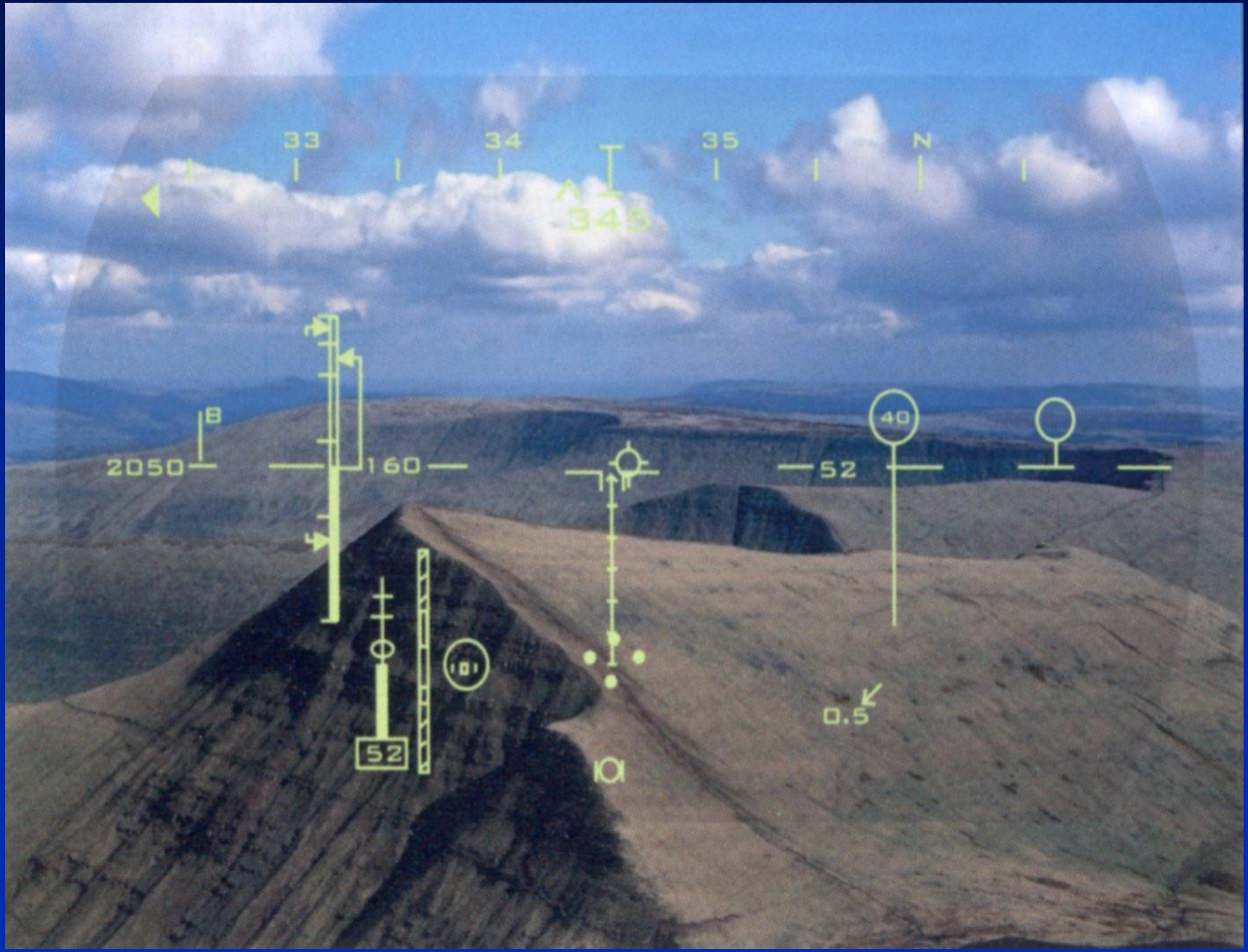
Virtual Retinal Display primary components.

This schematic diagram illustrates the functional components of a laser-scanned display system.



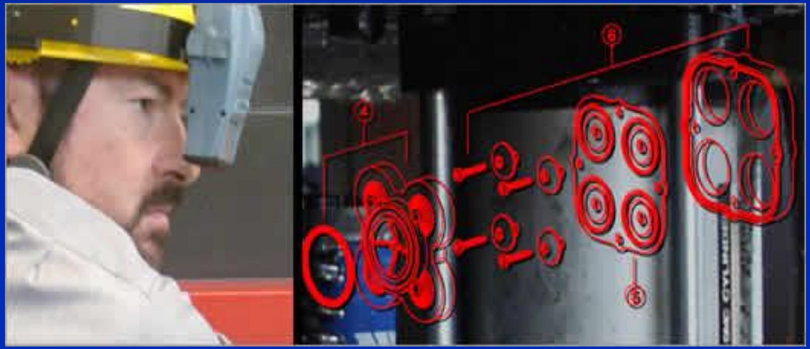
Information Display, “A Helmet-Mounted Laser Display,” January 2000, vol. 16, no. 1, p. 13.

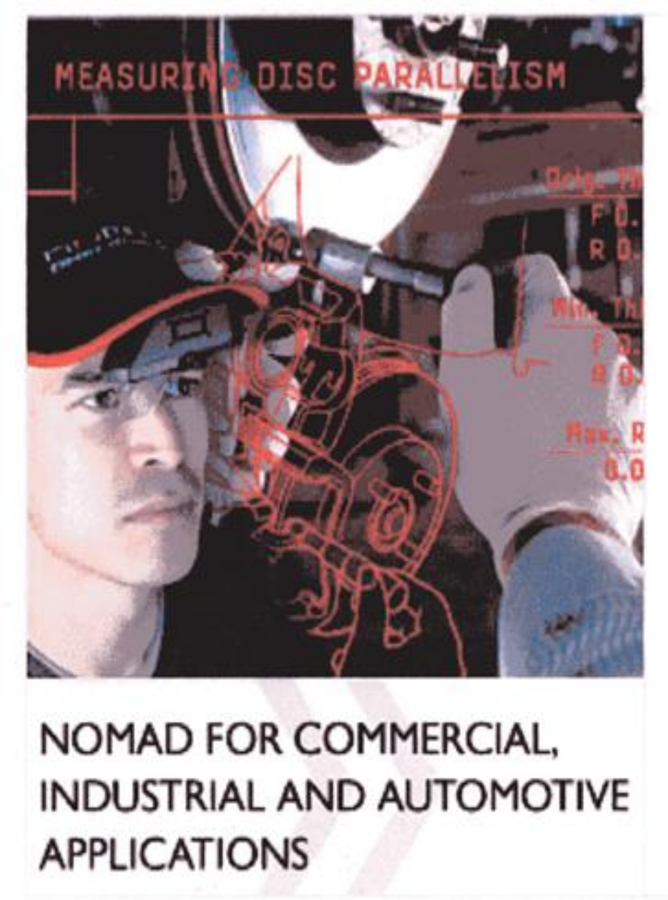
HMD information must have sufficient luminance to be seen when overlayed on realworld views.



Information Display, "A Helmet-Mounted Laser Display," January 2000, vol. 16, no. 1, p. 12.

Nomad for Commercial, Industrial and Automotive Applications

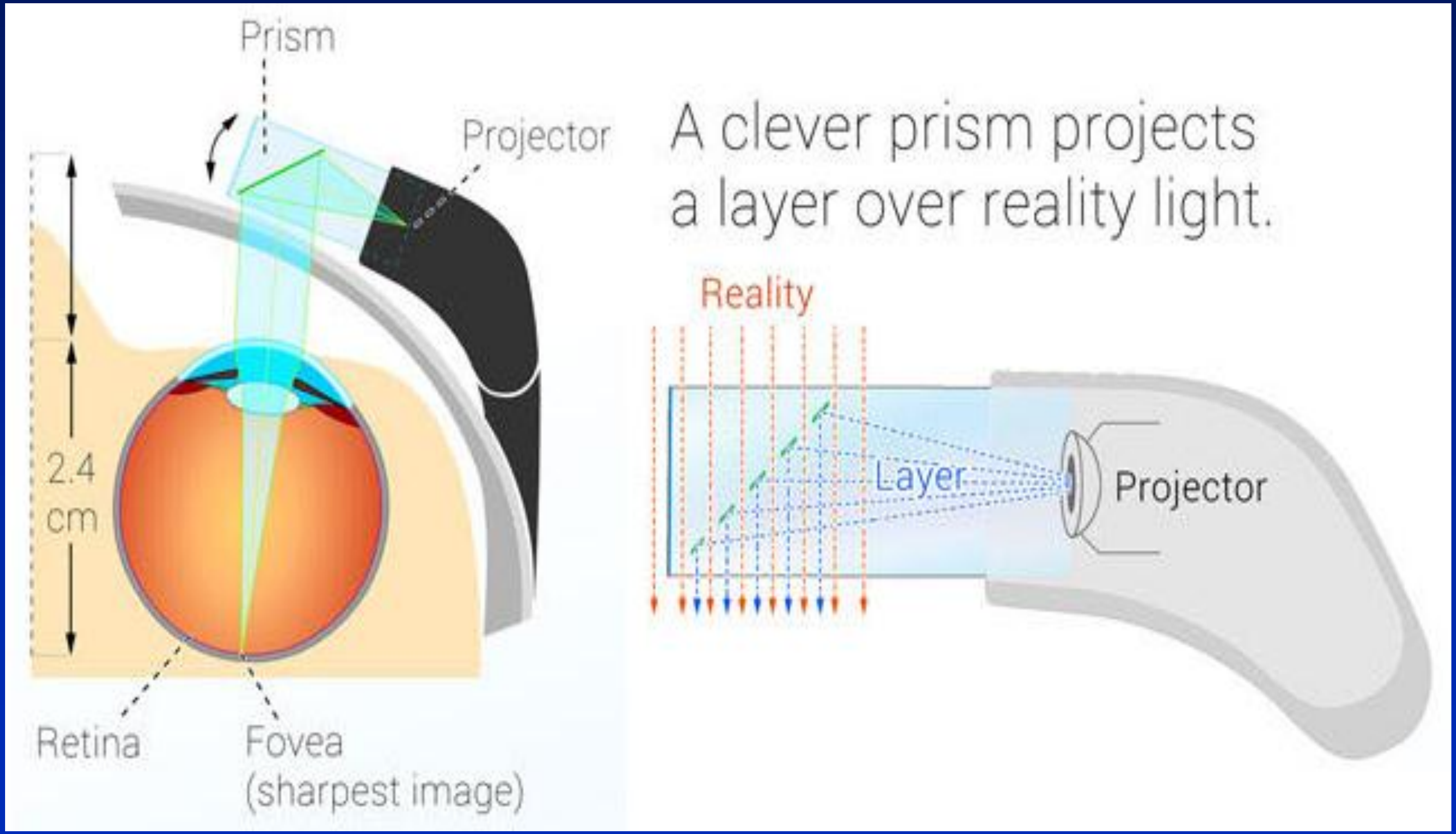




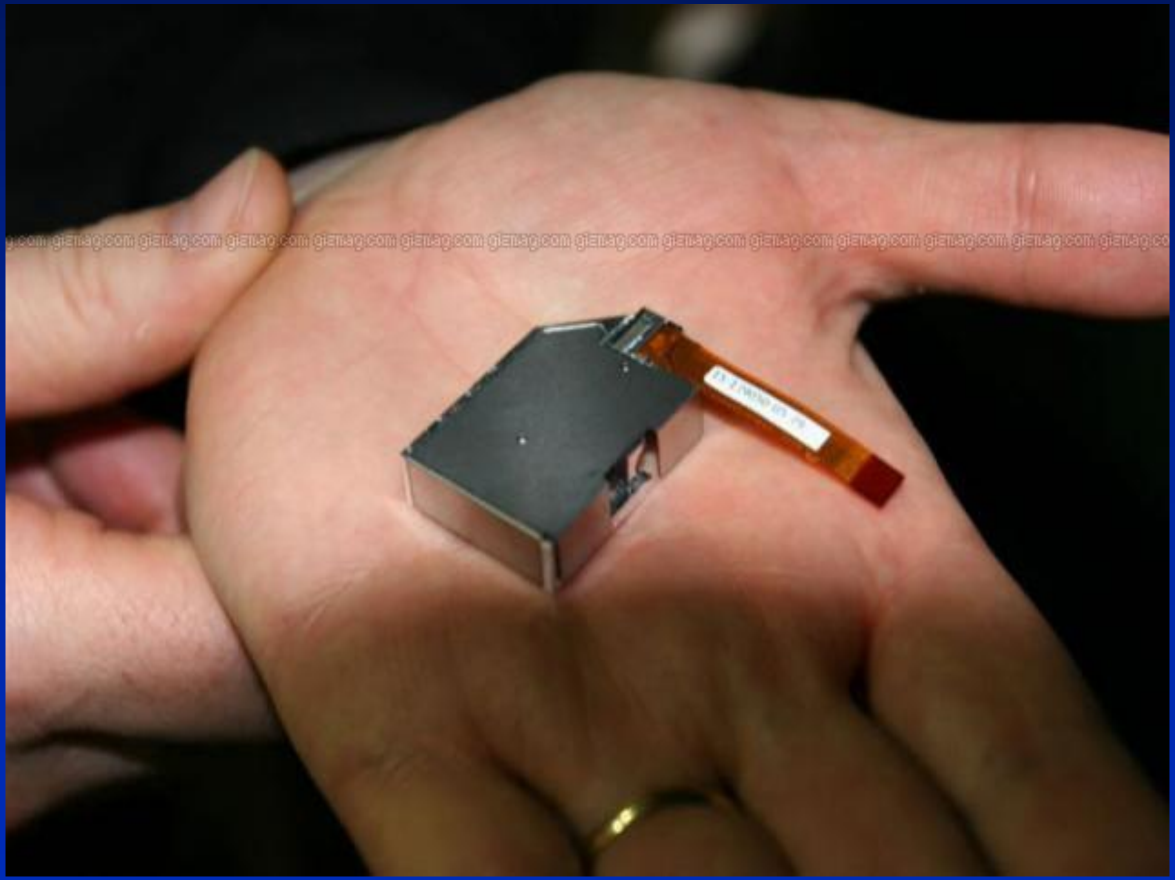
http://www.microvision.com/nomad/

Sergey Brin with Google Glass

Google Glass Projection System

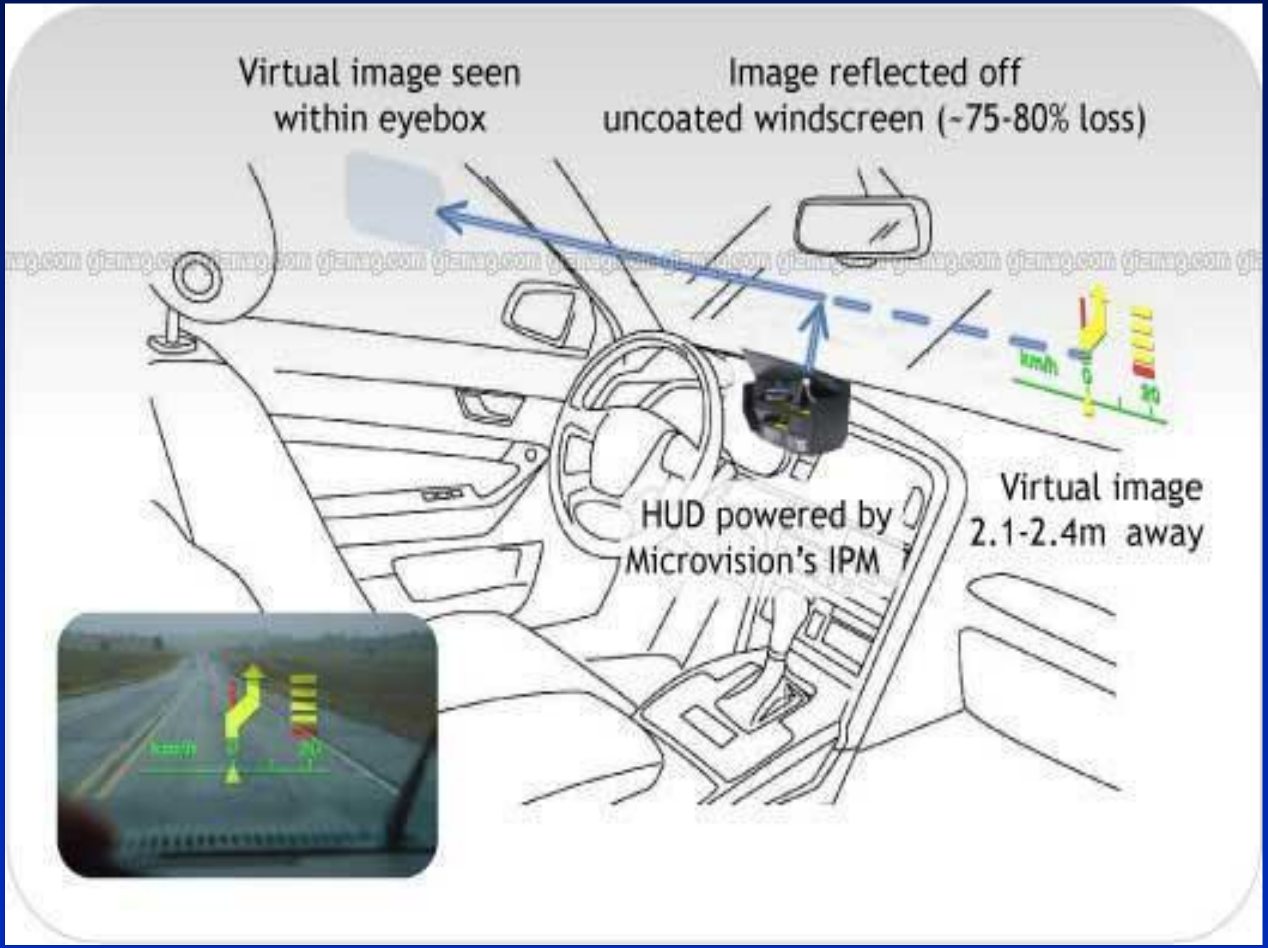


Ultra-Miniature Projection Display Prototype 1/9/07



"Ultra-Miniature Projection Display for Mobile Devices" http://www.gizmag.com/go/6685/

Ultra-Miniature Projection Display Prototype 1/9/07



"Ultra-Miniature Projection Display for Mobile Devices" http://www.gizmag.com/go/6685/

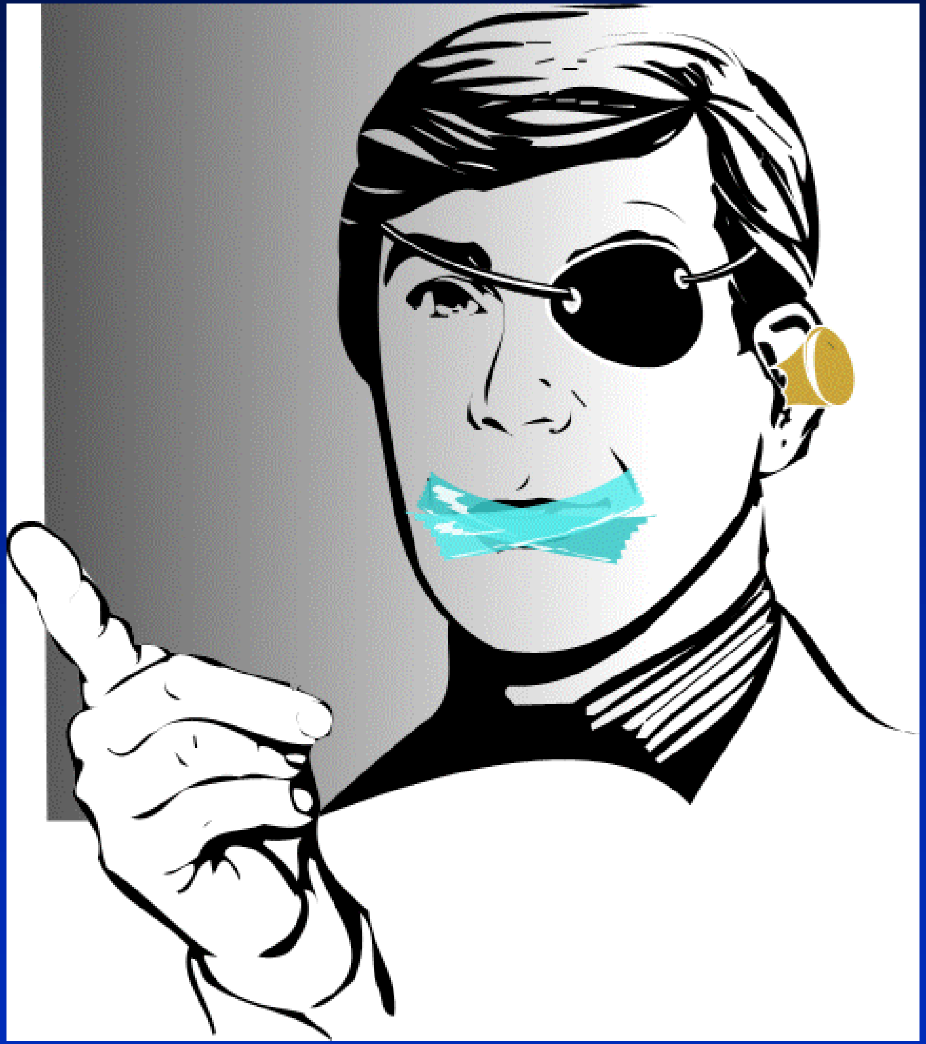
Human Computer Interfaces

Impedance-matching our Senses: Limitations of WIMP GUI

Limited Vision
(Flat, 2D)

No Speech

No Gestures

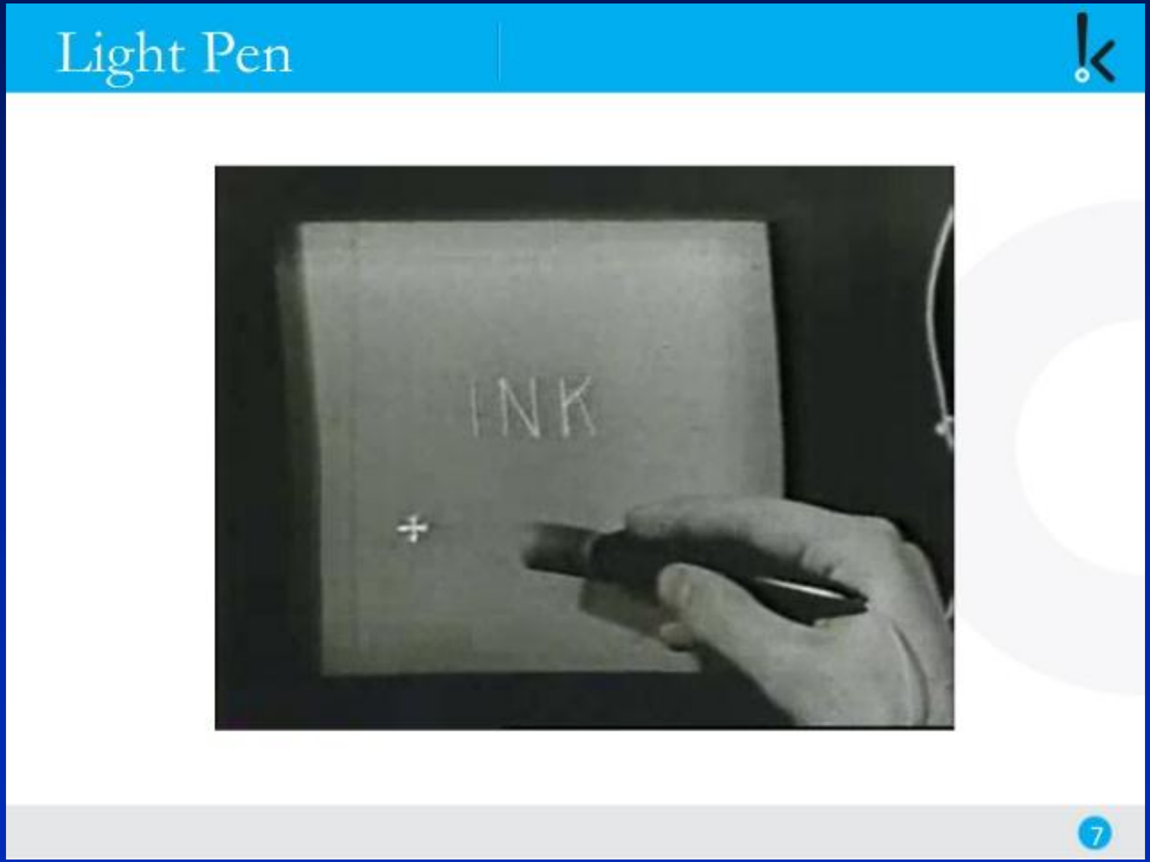


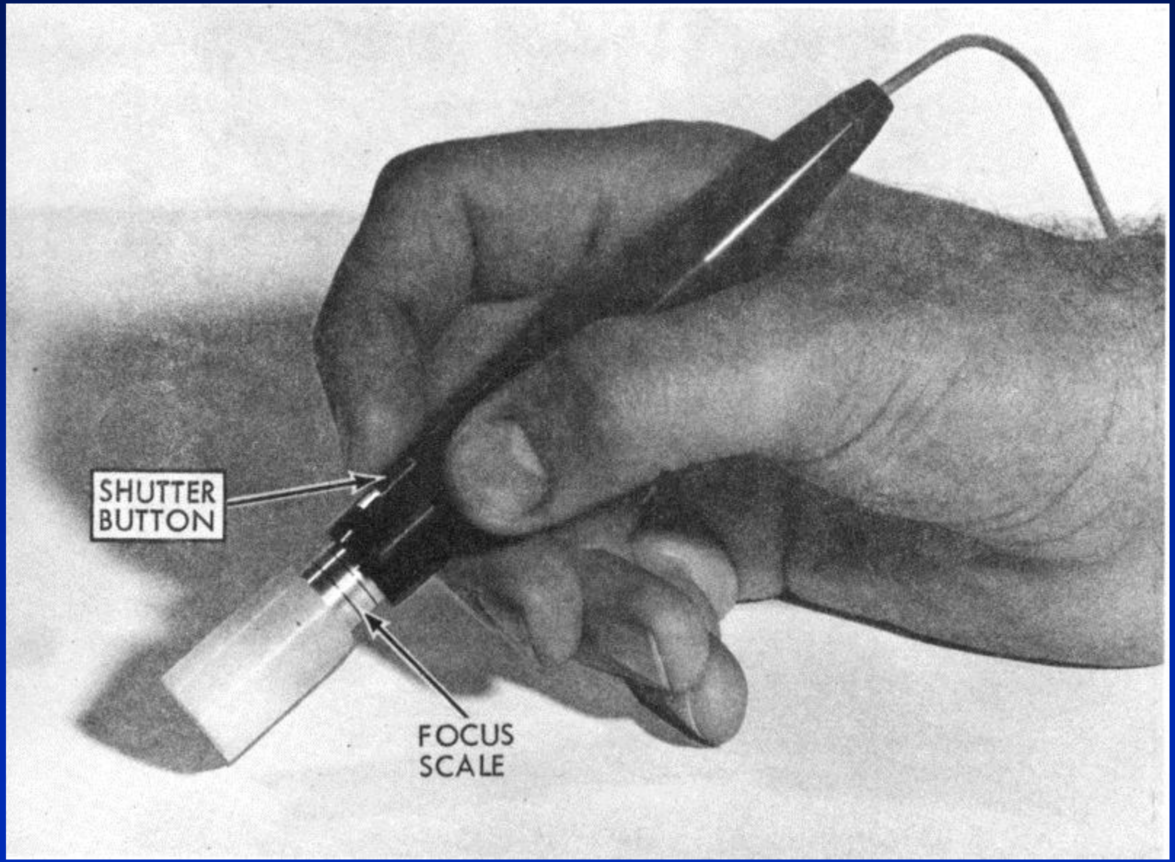
Limited Audio

One Hand Tied Behind Back

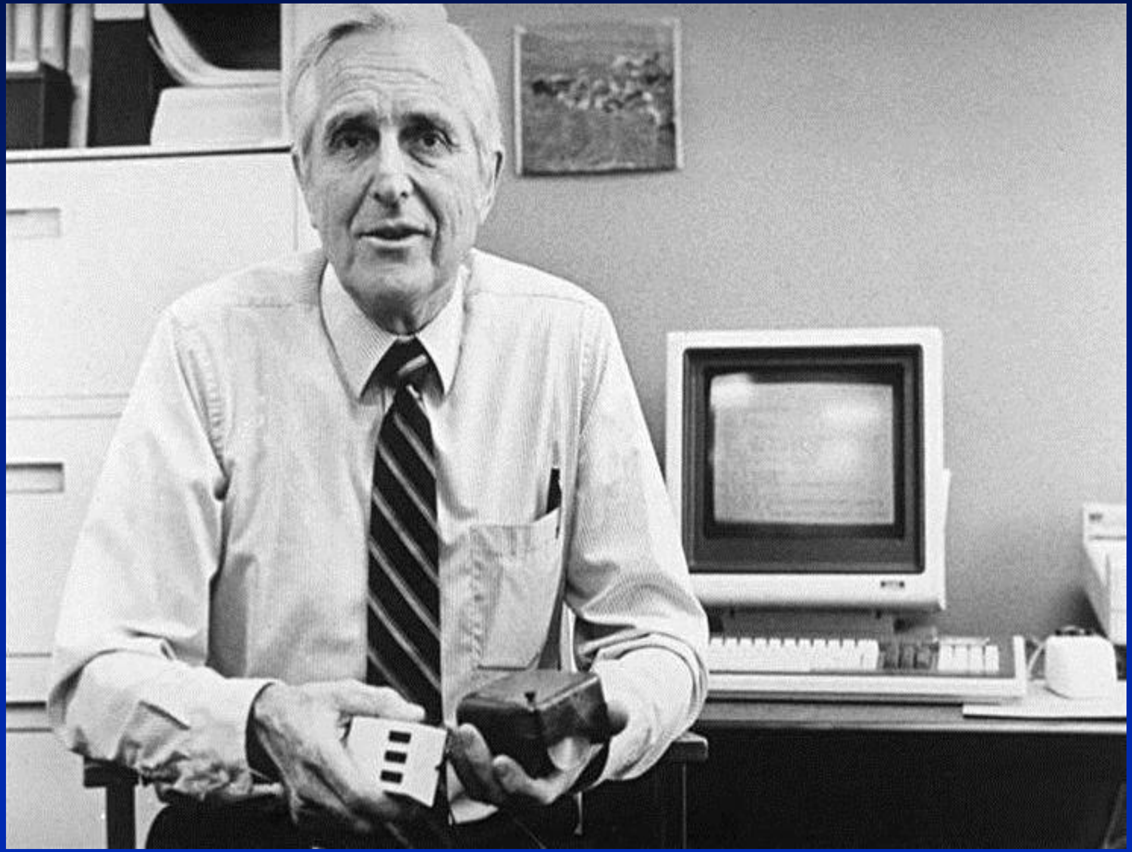
Limited Tactile

Ivan Sutherland with Sketchpad


Light Pen
INK
7


SHUTTER BUTTON
FOCUS SCALE

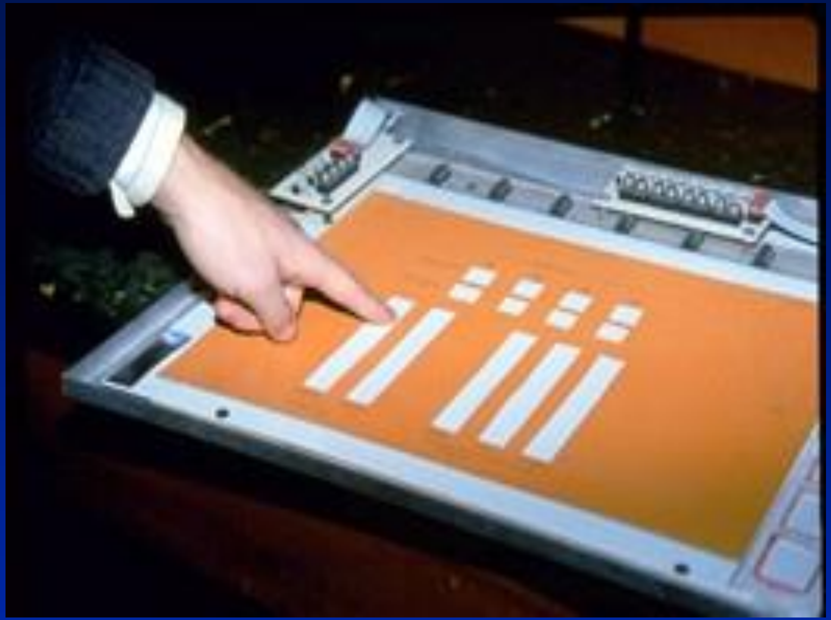
Dr. Douglas C. Englebart Computer Mouse



The first computer mouse held by Engelbart showing the wheels that directly contact the working surface.

http://en.wikipedia.org/wiki/Douglas_Engelbart

Bill Buxton, University of Toronto Multi-Touch Tablet 1985



- A touch tablet capable of sensing an arbitrary number of simultaneous touch inputs, reporting both location and degree of touch for each.
- This work was done in 1984, the same year the first Macintosh computer was introduced.
- Used capacitance, rather than optical sensing and thus was thinner and much simpler than camera-based systems.

http://www.billbuxton.com/multitouchOverview.html

Capacitive Systems

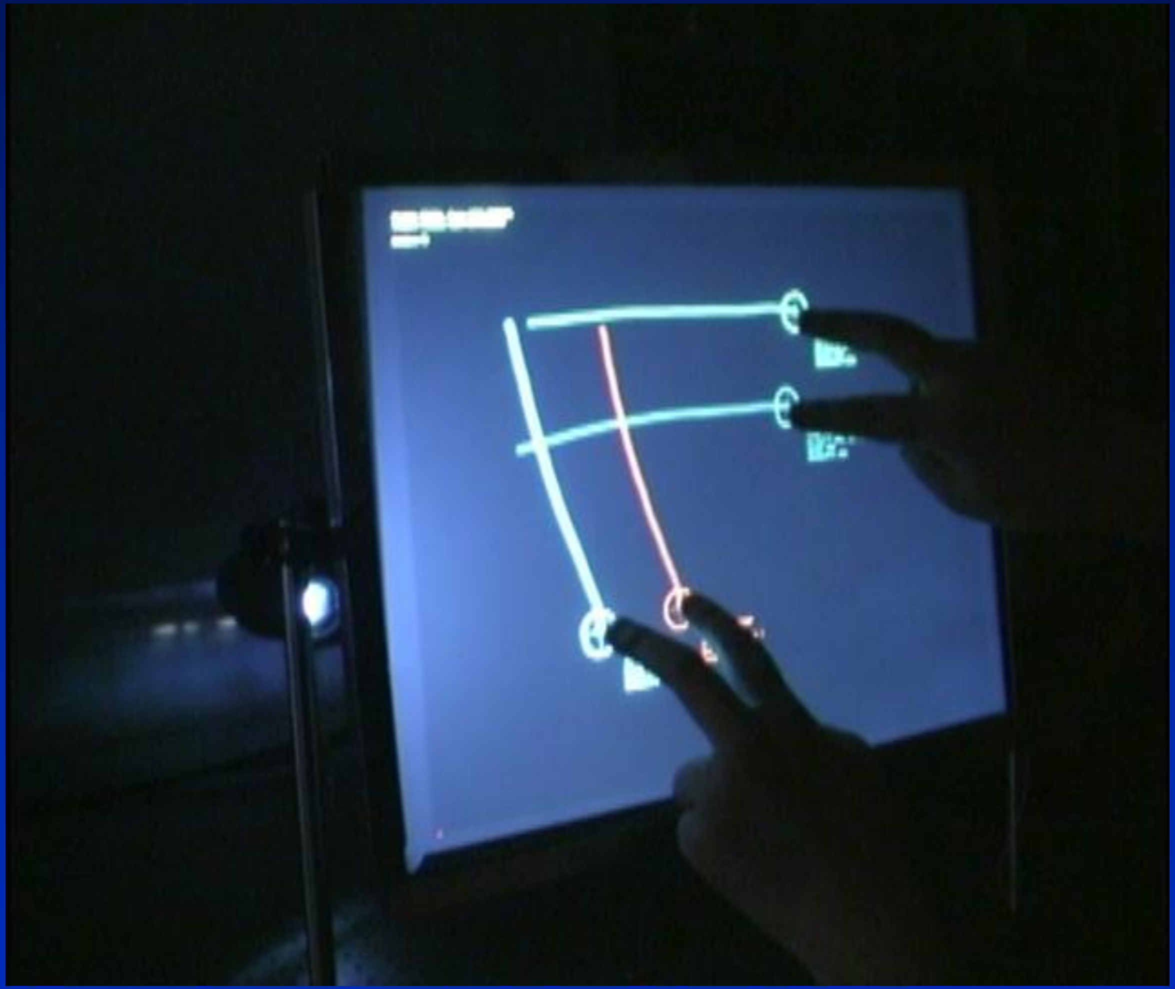
- In the capacitive system, a layer that stores electrical charge is placed on the glass panel of the monitor
- When the user touches the monitor with his/her finger, some of the charge is transferred to the user
- The decrease is measured by circuits located at the corners of the display and the coordinate of the touch event are calculated
- Advantage – Transmits 90% of light from the monitor

Howstuffworks “How do touch-screen monitors know where you’re touching?”

Projected Capacitance Touch (PCT) Techology

- PCT touch screens are composed of a matrix of rows and columns of conductive material, layered on sheets of glass
- Capacitance can be measured at every individual grid point
- The top layer is glass providing a cheap and stable solution

Multi- Touch Sensing



“*Multi-Touch Sensing through Frustrated Total Internal Reflection* “ http://cs.nyu.edu/~jhan/ftirsense/

iPhone

Apple's iPhone

- Uses a capacitive technology on an LCD manufactured by Balda (a German company)
- Users tap soft buttons on this display
- Eliminates the WIMP interface (Windows, Icons, Menus, Pointing)
- Uses accelerometers, similar to Nintendo's Wii game console interface
- Everything else is standard

Daniel Turner. "Apples iPhone," Technology Review, September/October 2007 .

Wacom Cintiq 22HD 1080p Stylus

Microsoft Surface Studio 2016

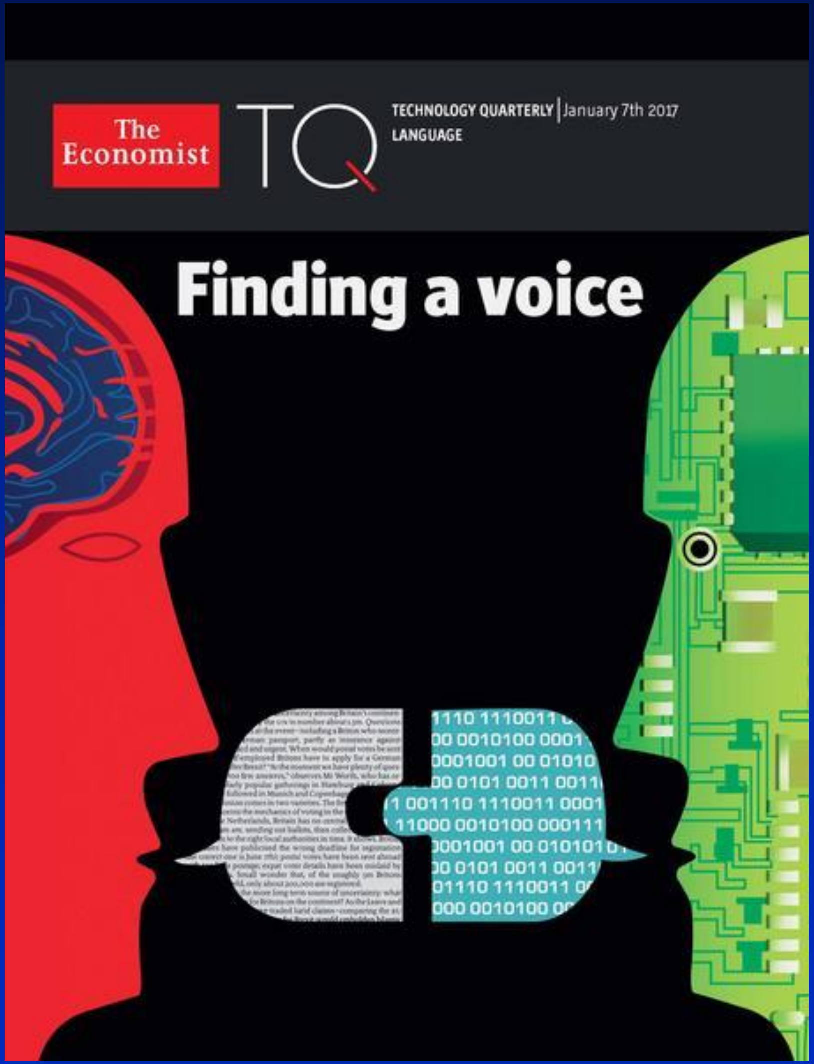
End

- J.C.R. Licklider, “Man-Computer Symbiosis.” IRE Transactions on Human Factors in Electronics. March 1960. IRE Transactions.

Digital Drafting Board Cornell & MSFT

Goodbye

Voice


The Economist
TQ
TECHNOLOGY QUARTERLY | January 7th 2017
LANGUAGE
Finding a voice

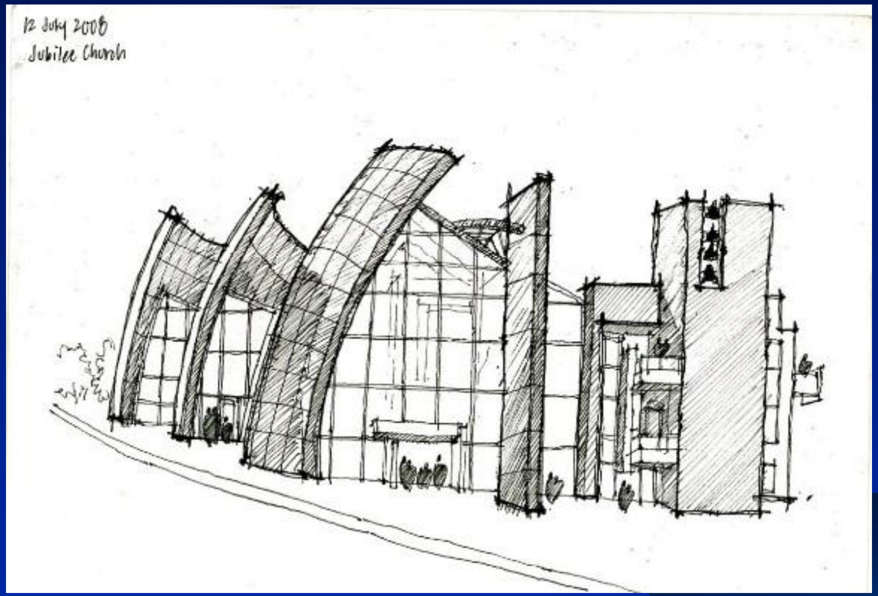

The Economist
Turkey torn apart
Theresa Maybe, Britain's indecisive PM
Nestlé goes on a health kick
Meet China's Shakespeare
Now we're talking
Voice computing comes of age

A System for 3D Conceptual Modeling for Architectural Design, 2002

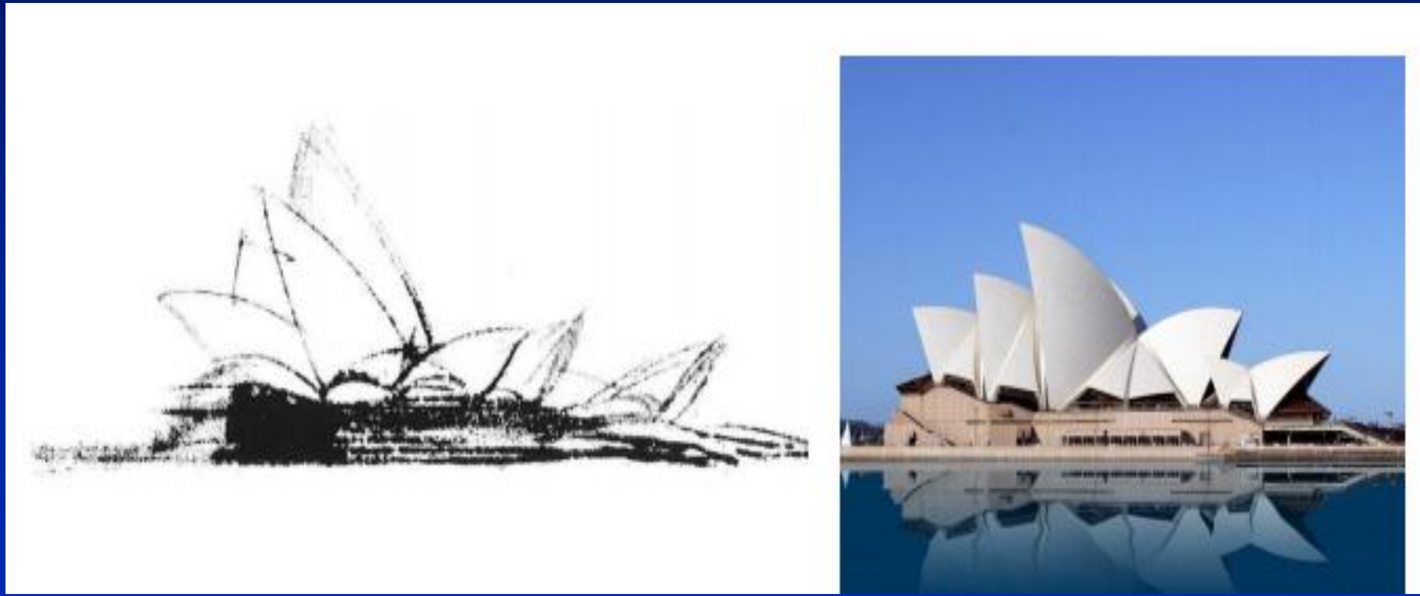
Gehry Model and Microscribe

Frank Gehry’s Walt Disney Concert Hall

Richard Meier's Jubilee Church



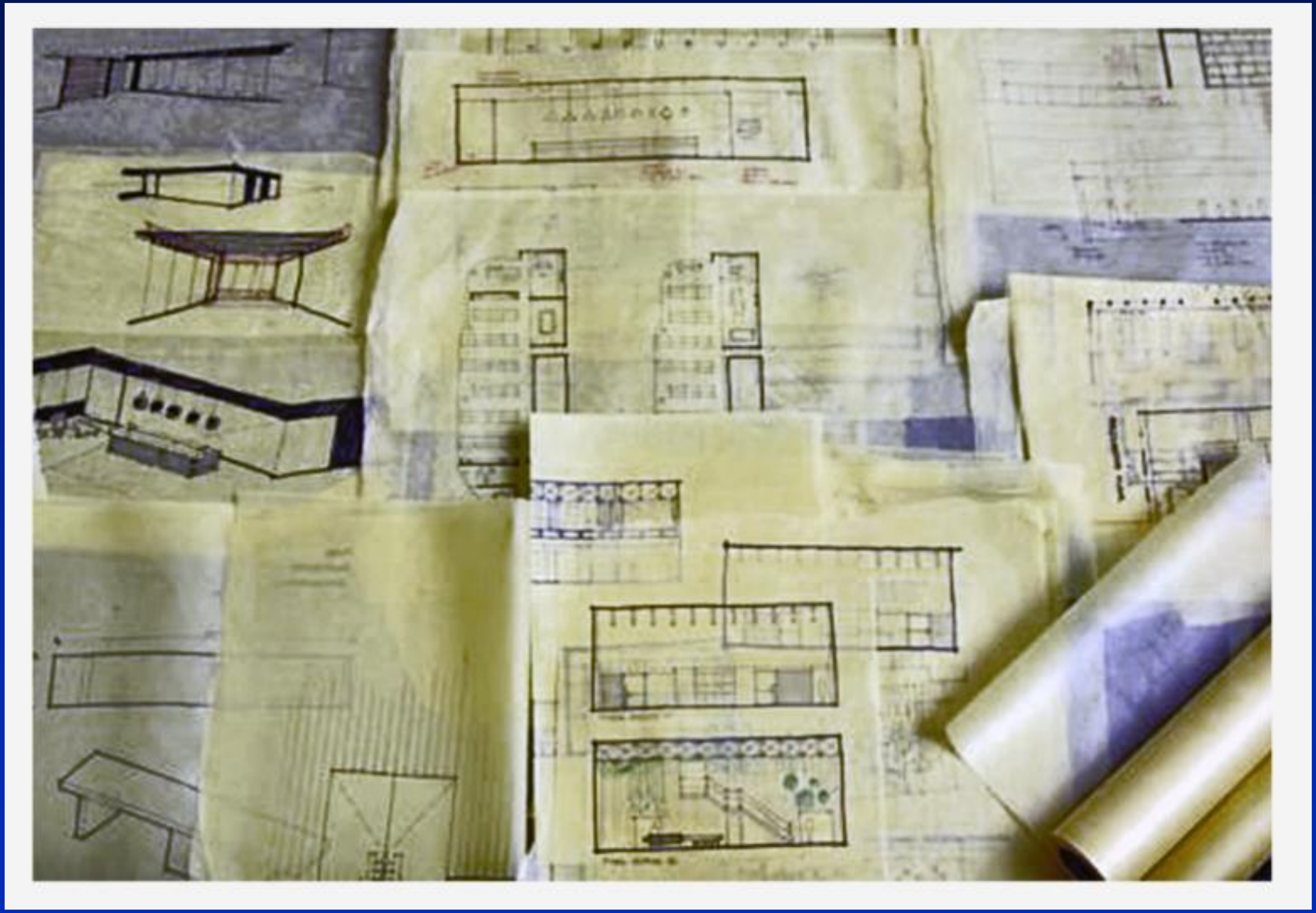
Utzen’s Sydney Opera House



Early Design Studios

Tracing Paper and Early Design Tools

Use of multiple sketches on trace during preliminary design.



End