Current and Future Display Technology

NBA 6120

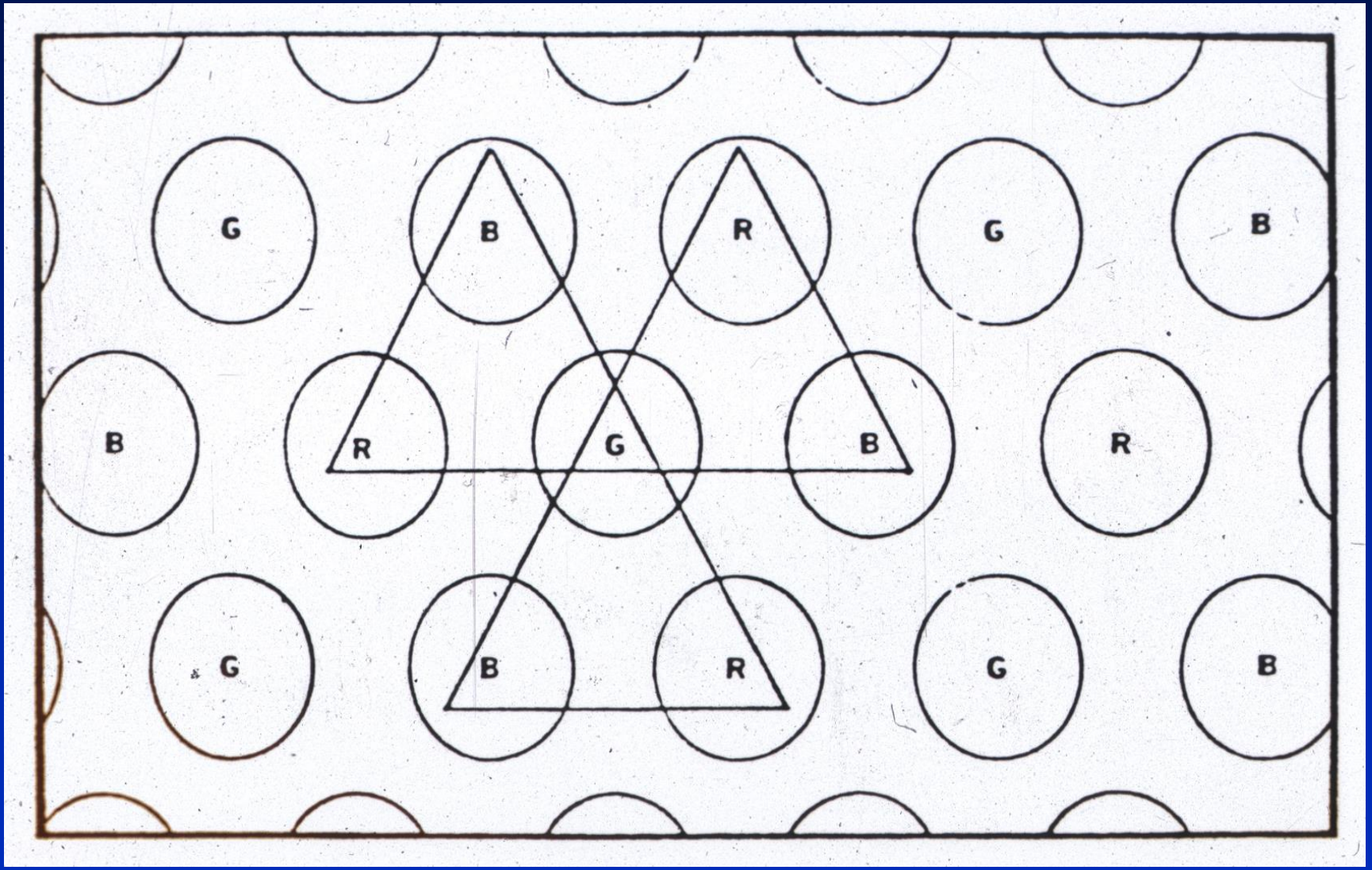
Donald P. Greenberg

September 9, 2015

Lecture #4

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

A Pixel Consists of Approximately 2 2/3 Triads



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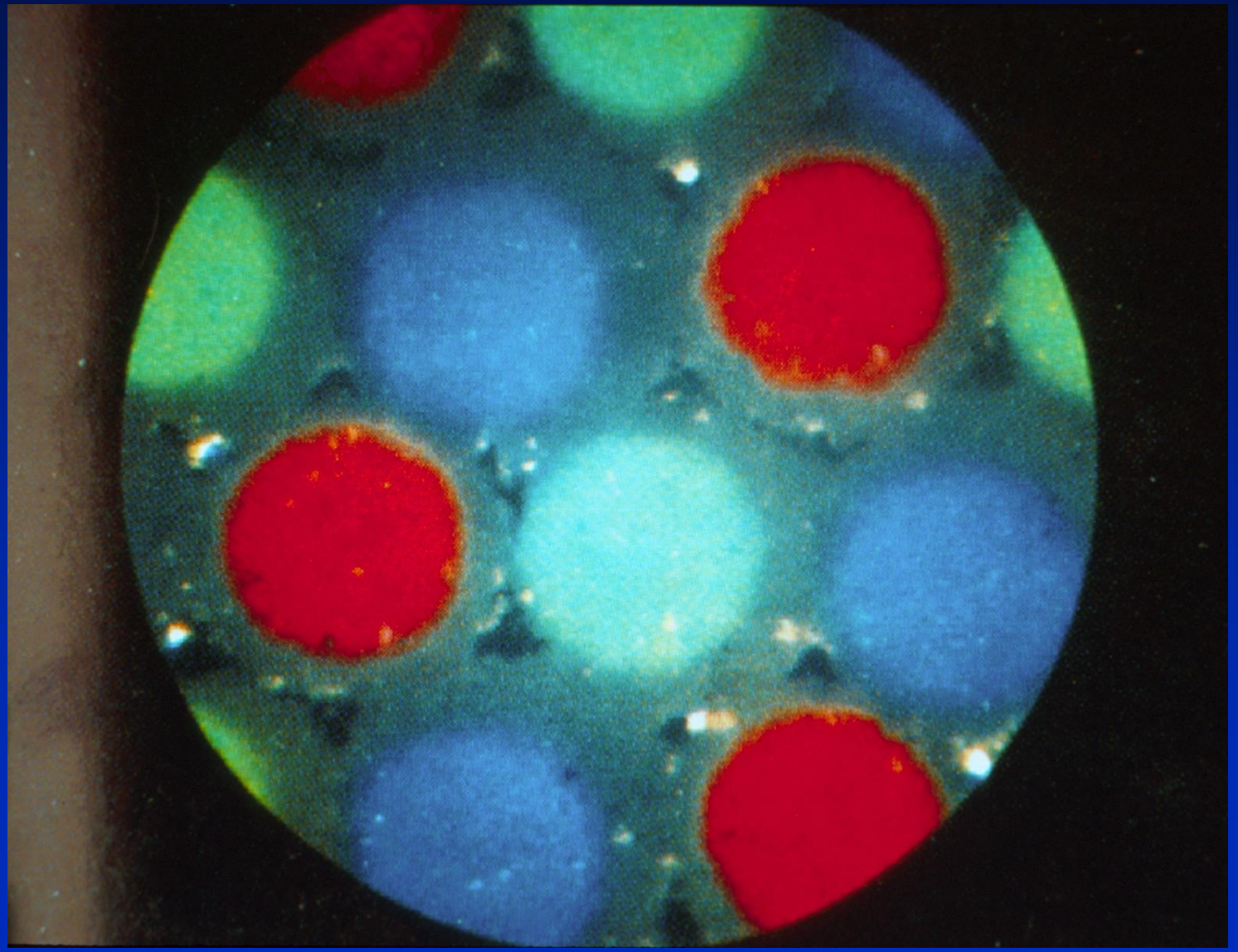
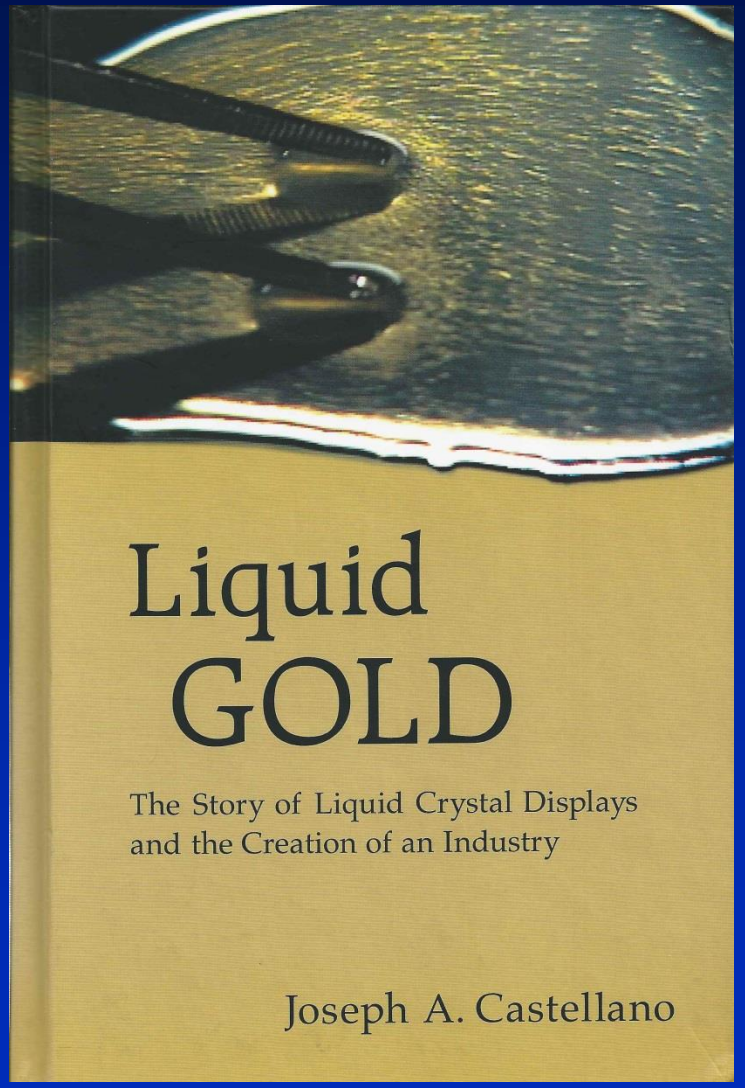
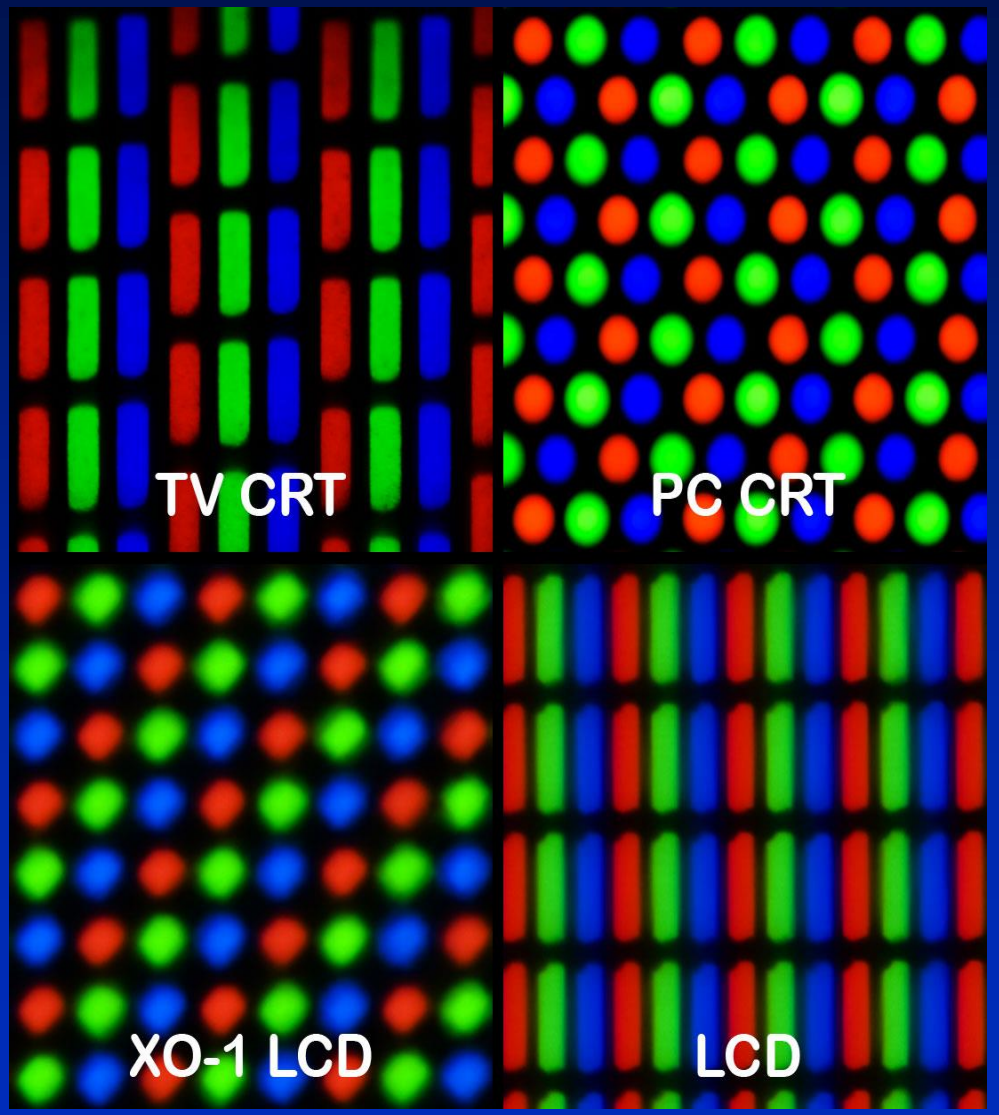


Liquid Crystal Color Displays

Liquid Gold


Liquid
GOLD
The Story of Liquid Crystal Displays
and the Creation of an Industry
Joseph A. Castellano

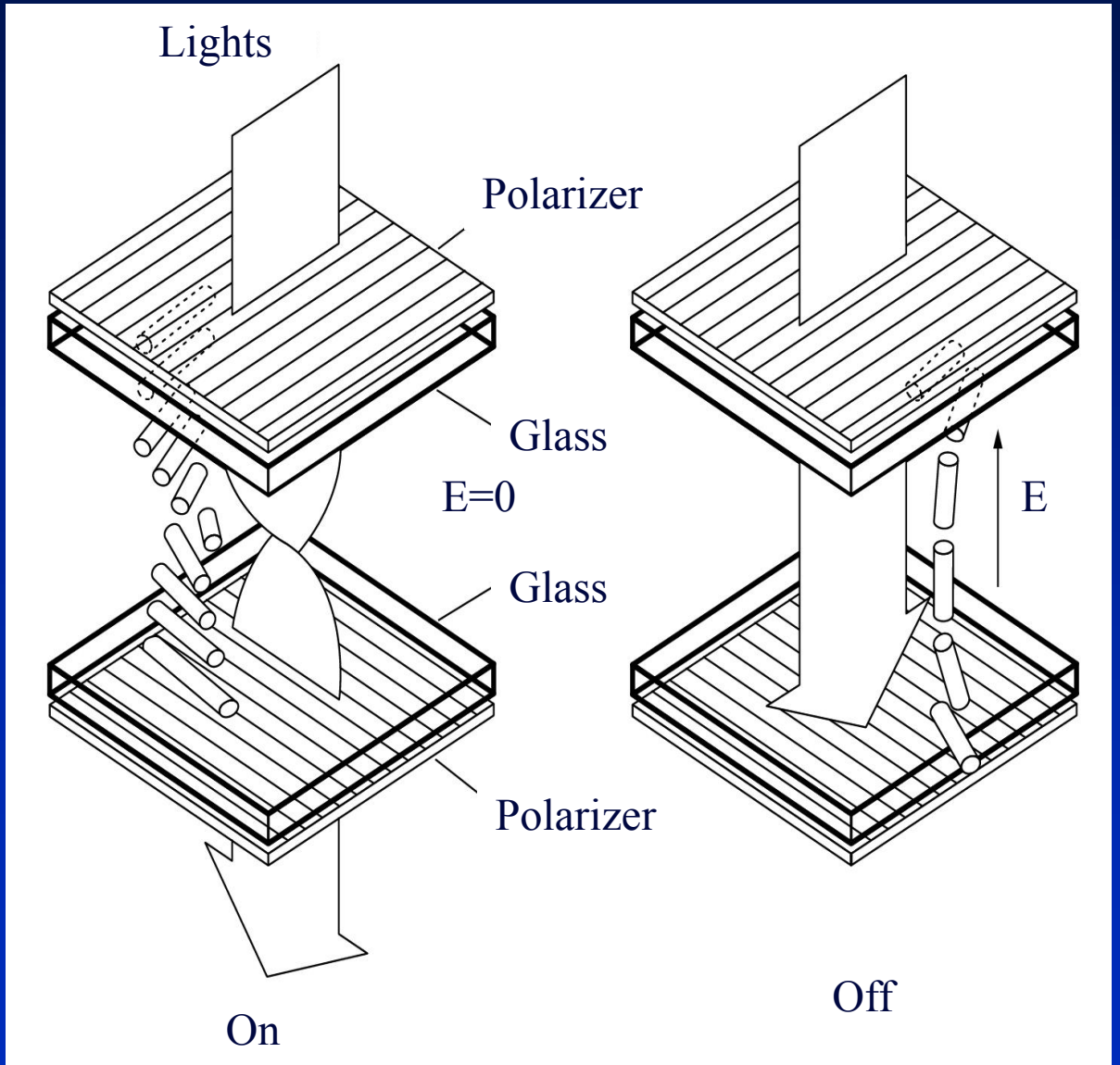
Different Pixel Configurations



Important Properties of Liquid Crystals

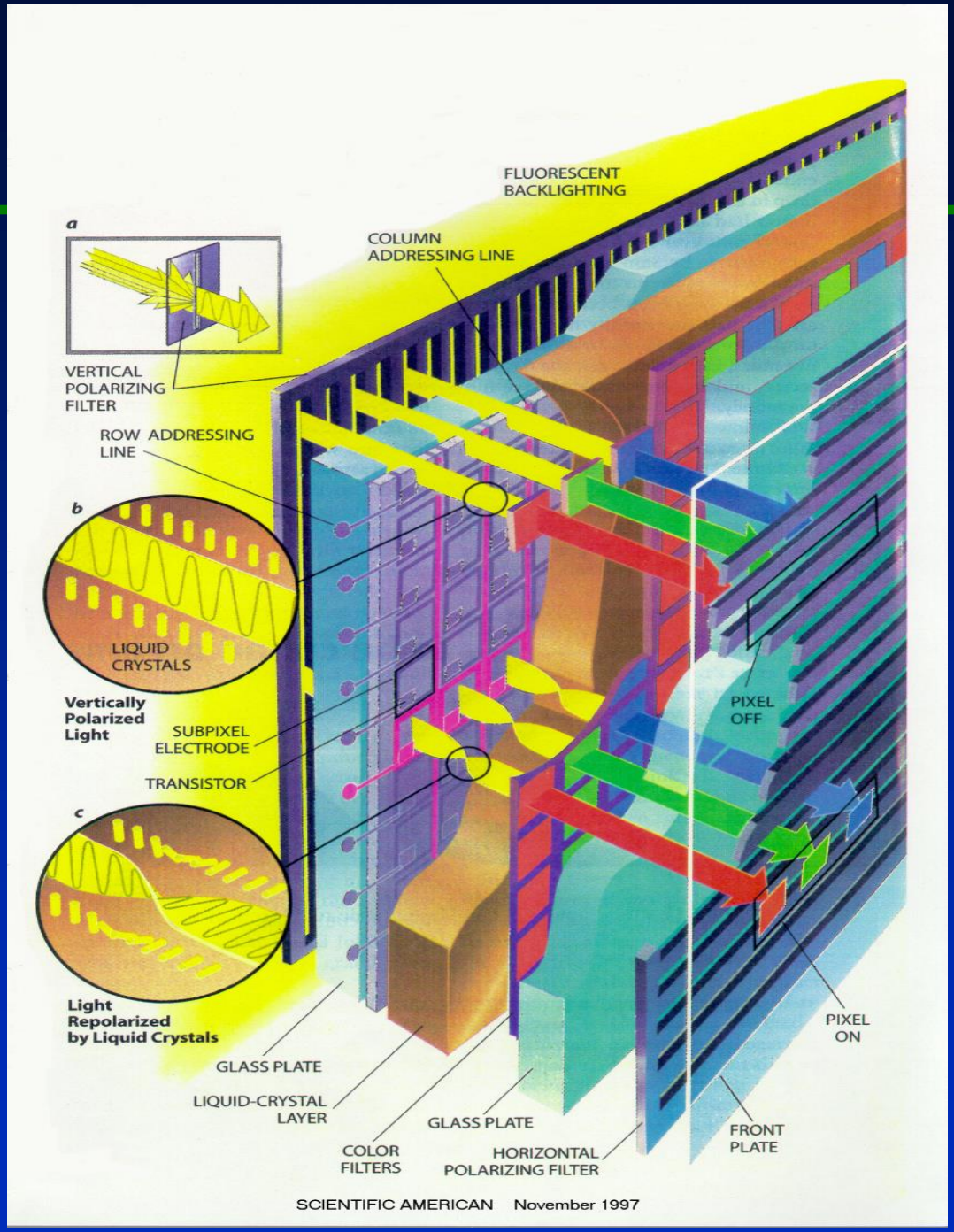
- Crystals are transparent
- Can alter the orientation of polarized light passing through them
- Polarization properties can be changed by applying electrical field
- Switching can be done fast

Polarization of Liquid Crystal



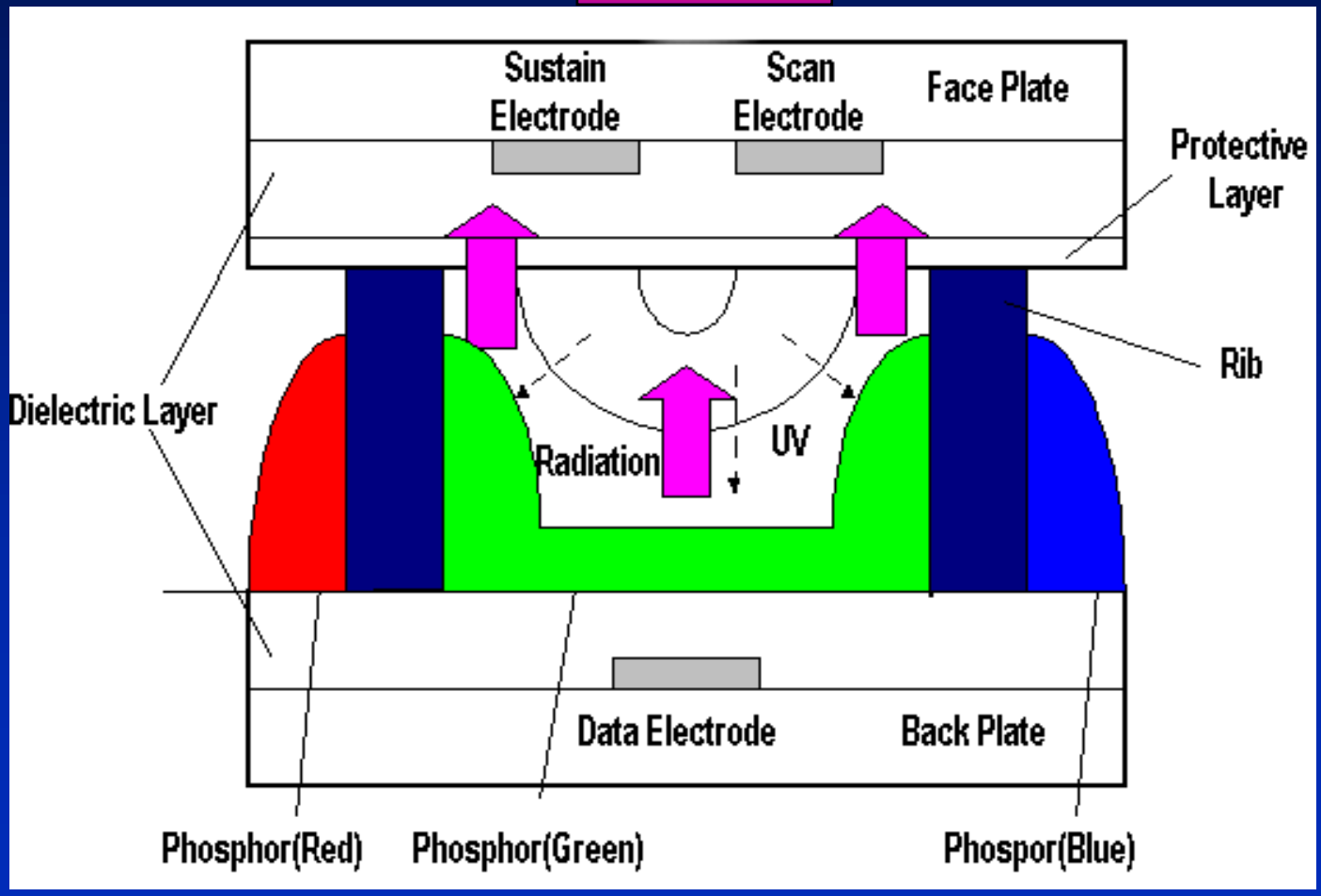
Scientific American, November 1997

Liquid Crystal Color Display



Scientific American, November 1997

Plasma Display Technology

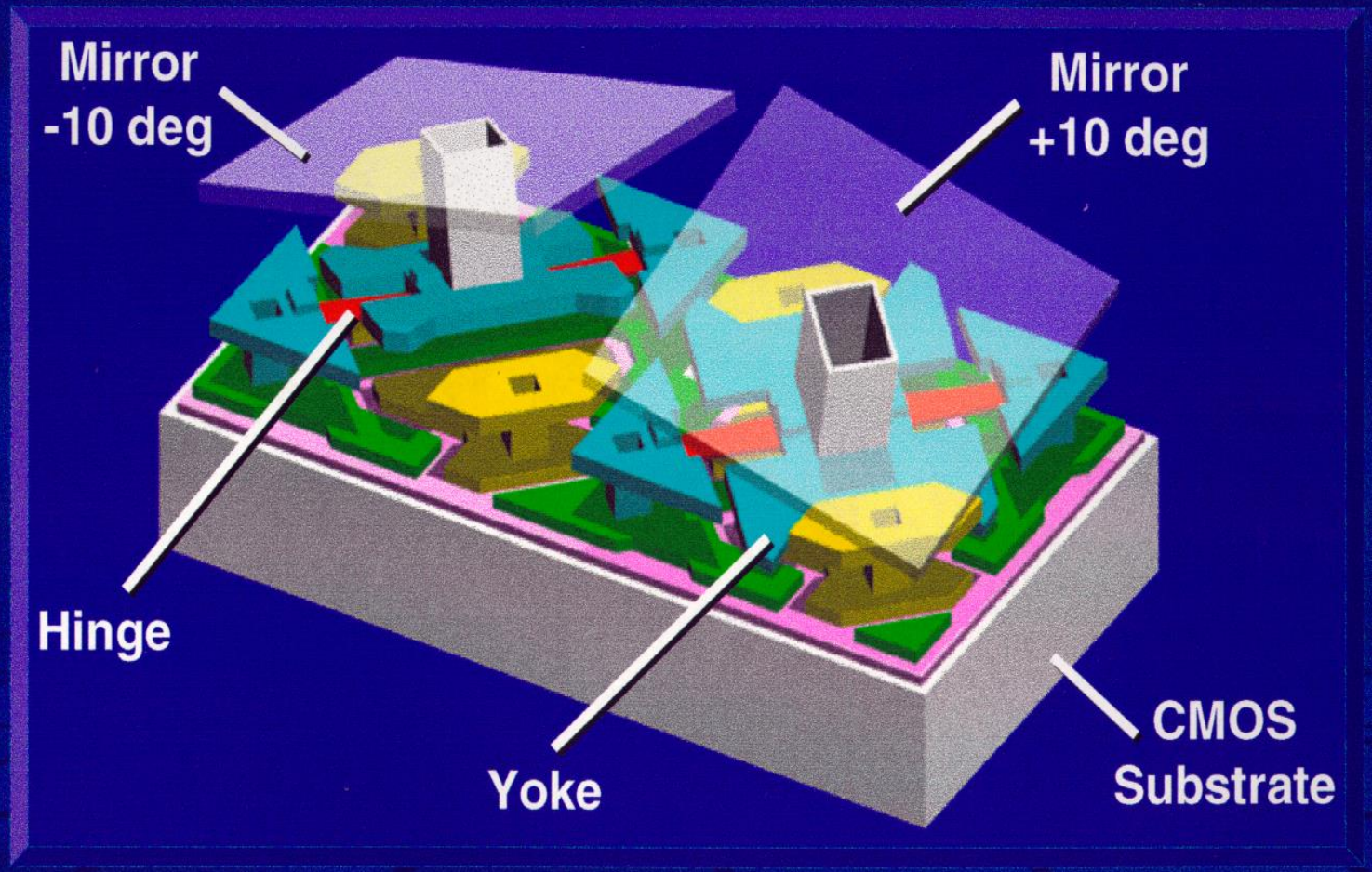


Plasma Display: Advantages & Disadvantages

- 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.

DMD Structure

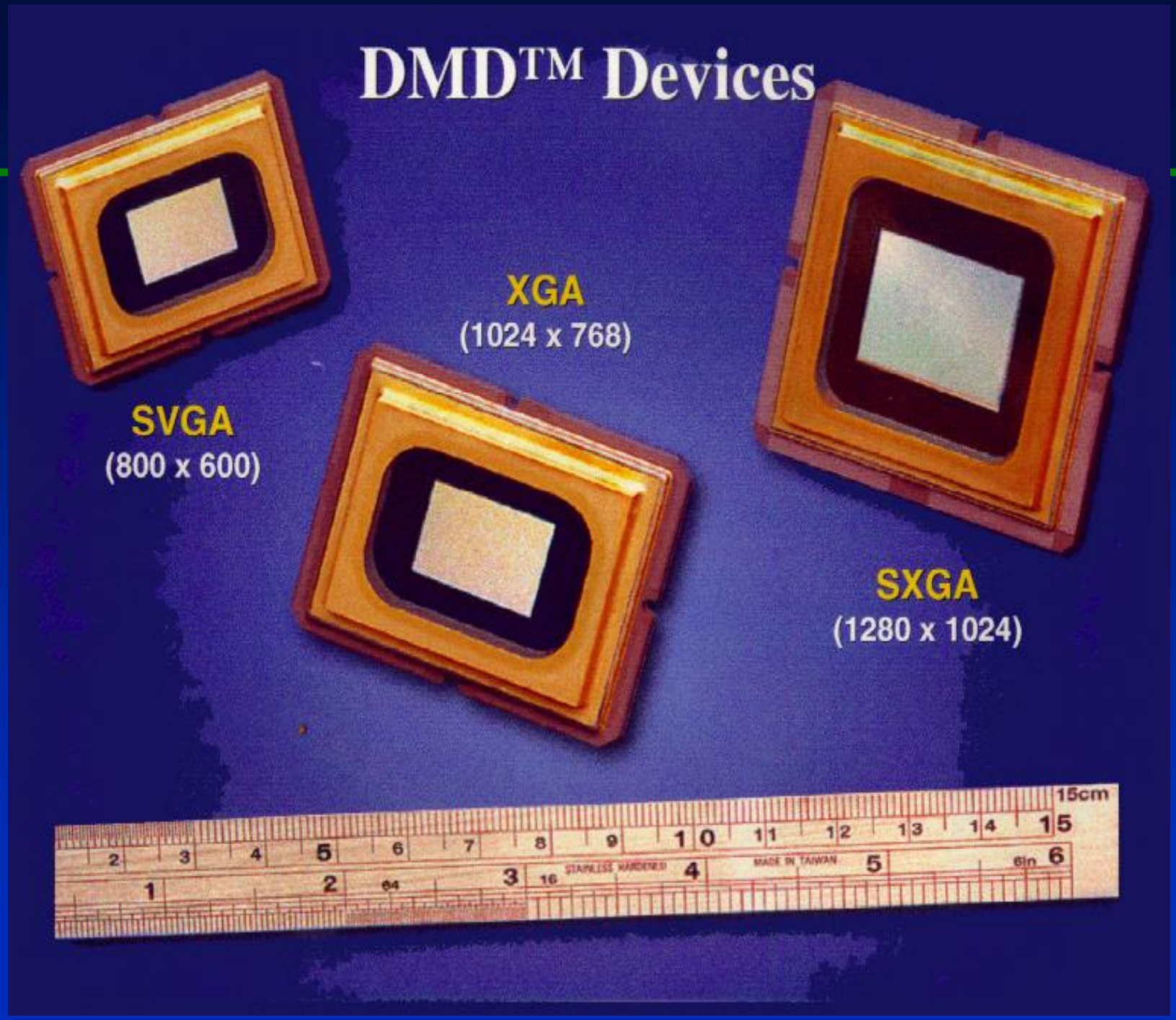


Digital Micromirror Device (DMD™)

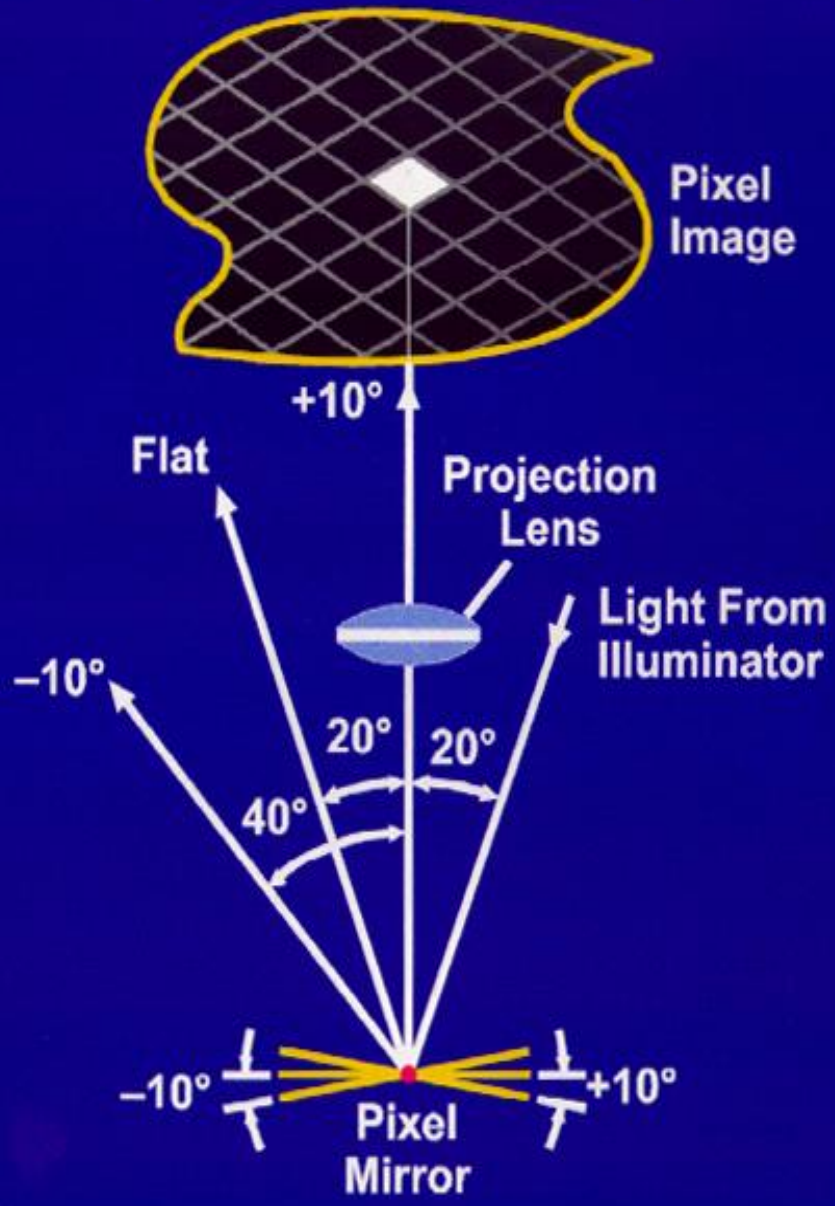
A True Microelectromechanical System

DLP™

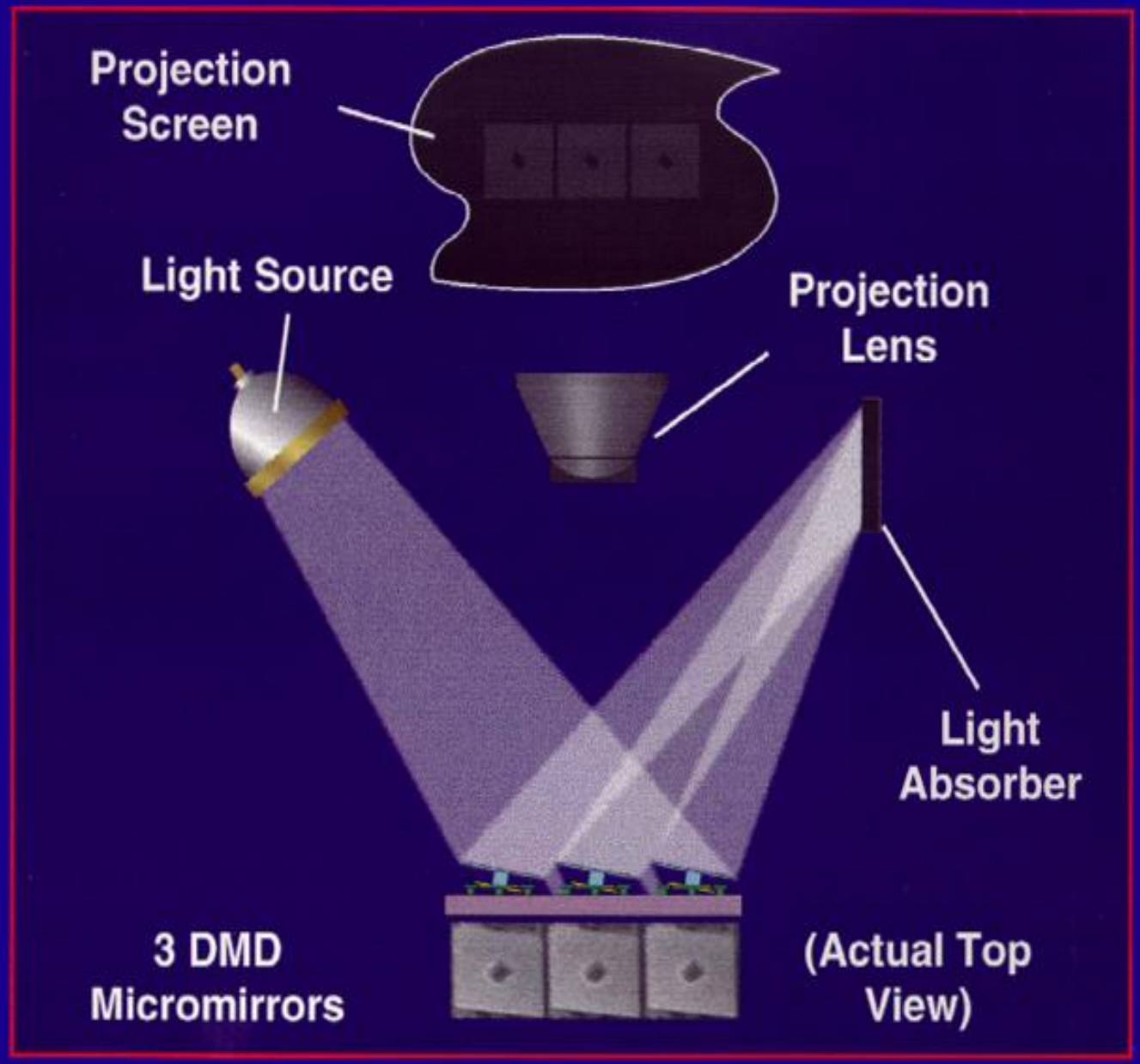
A TEXAS INSTRUMENTS TECHNO


DMD™ Devices
SVGA
(800 x 600)
XGA
(1024 x 768)
SXGA
(1280 x 1024)
15cm
STAINLESS HARDENED
MADE IN TAIWAN
6in

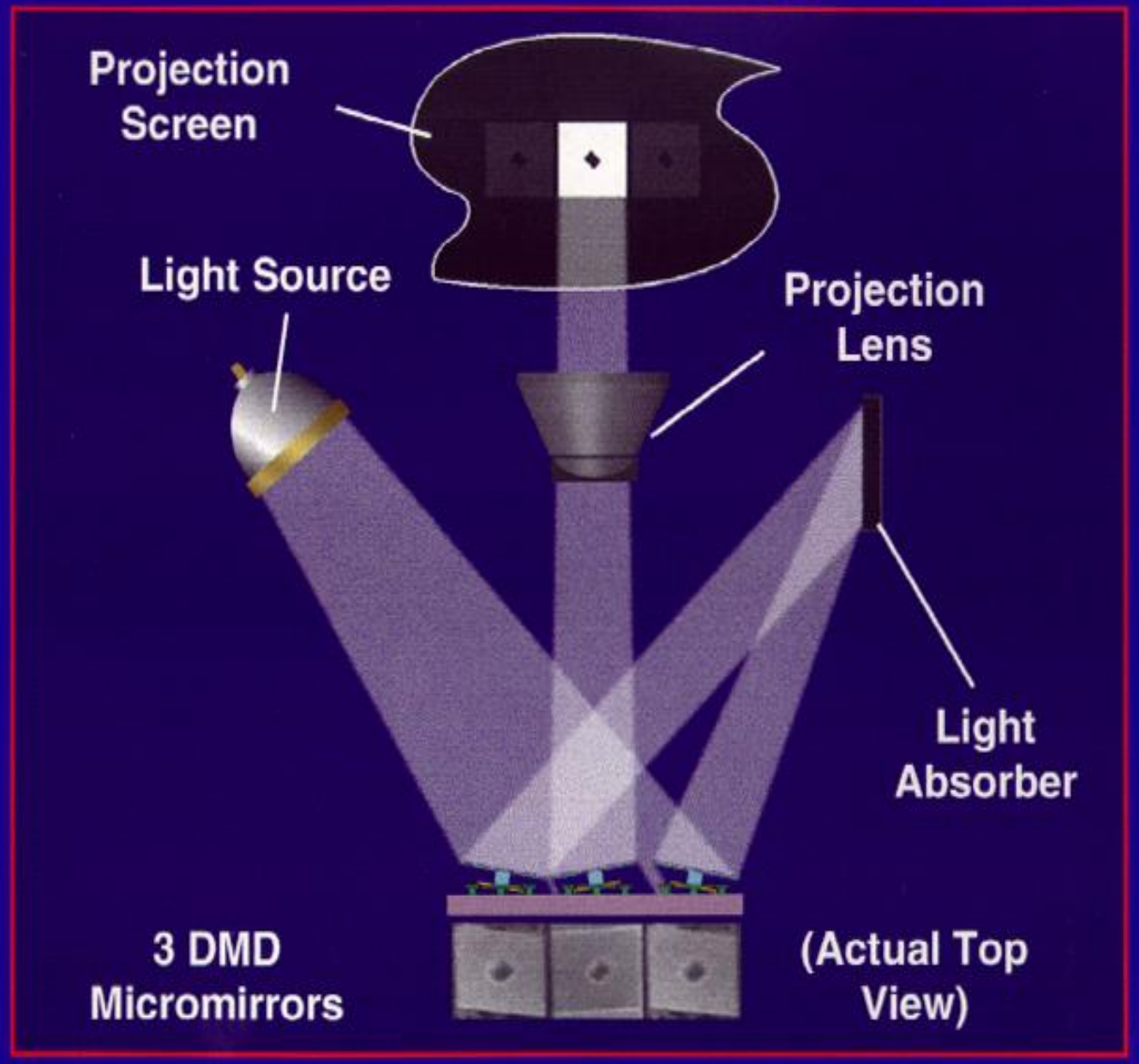
DMD™ Optical Switching Principle



DMD™ Switching Example (All Off)

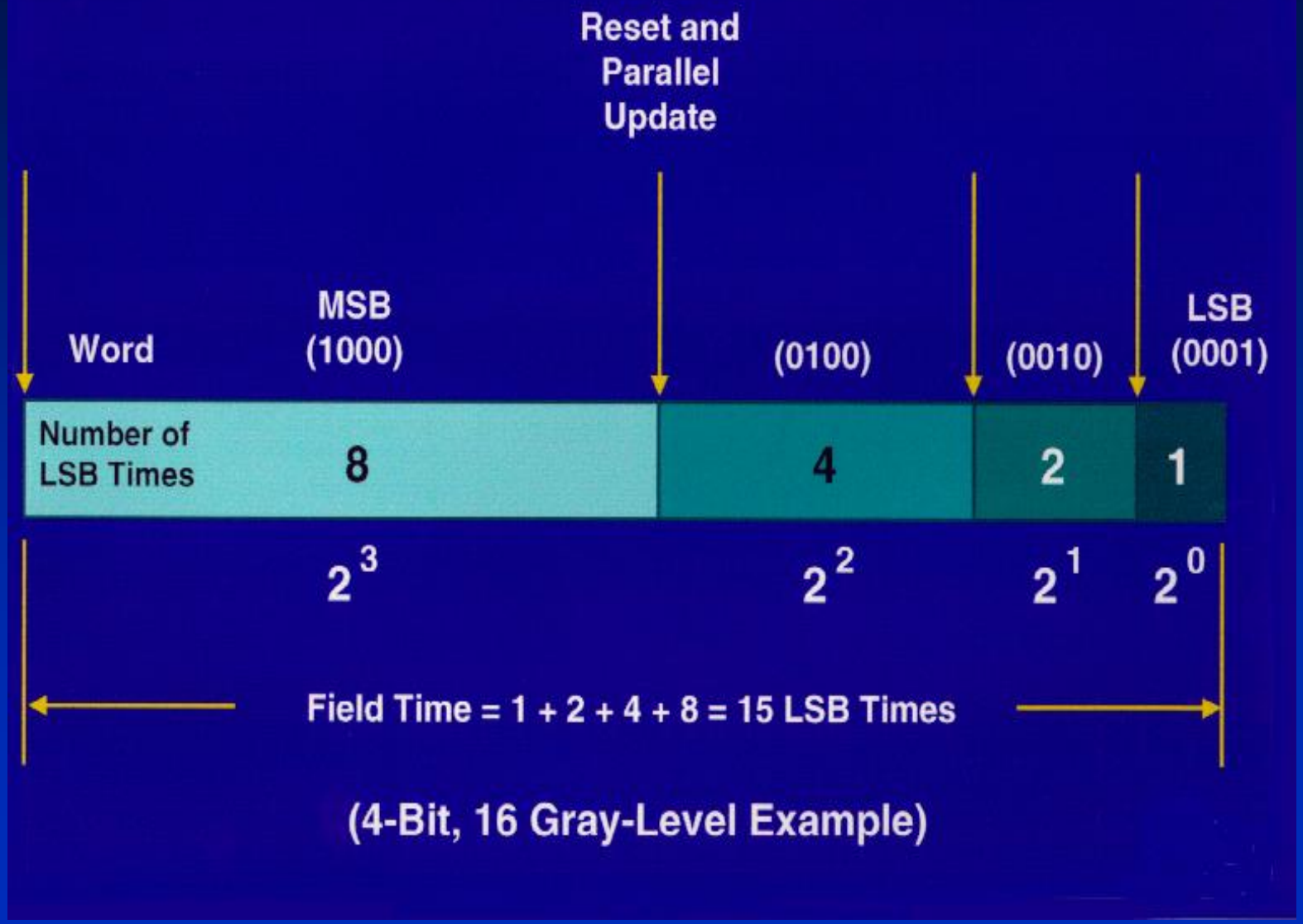


DMD™ Switching Example (1 On)



DMD™ Grayscale Projection

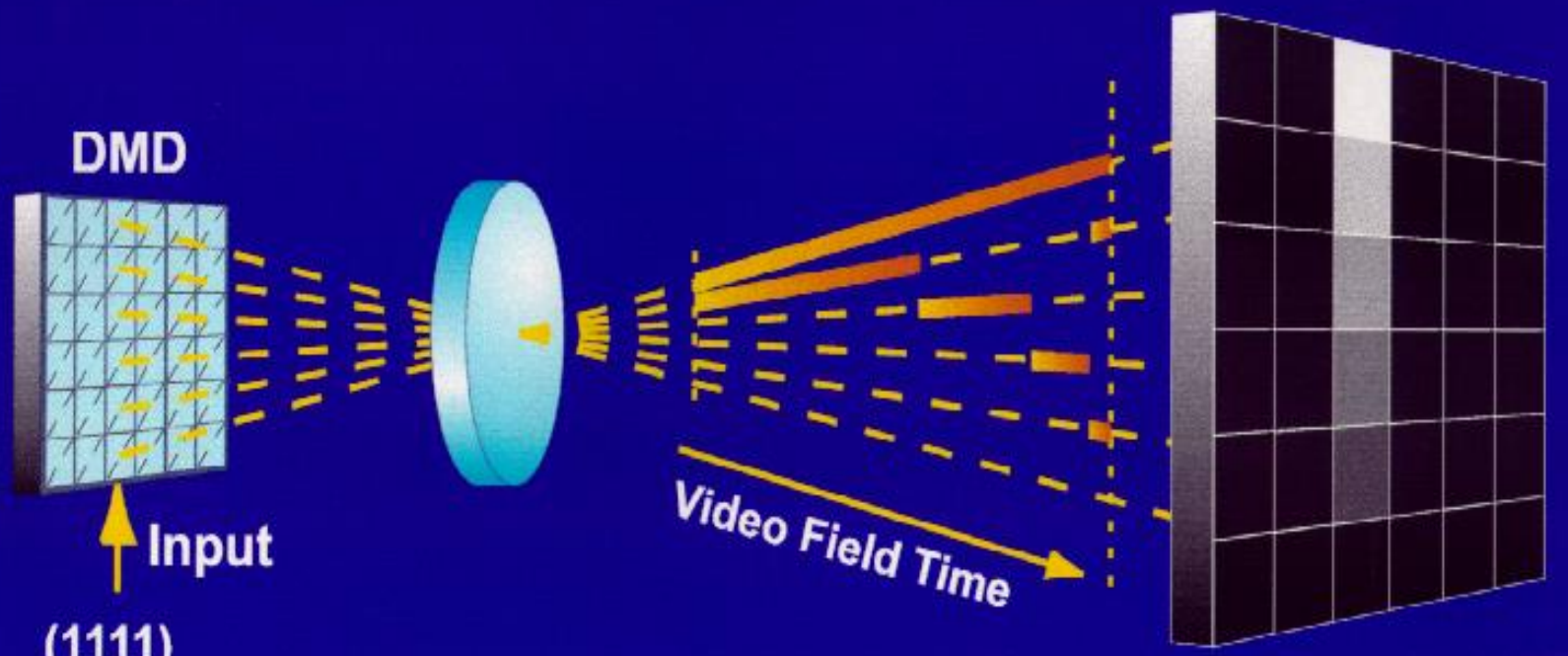
Pulsewidth Modulation



(4-Bit, 16 Gray-Level Example)

How Grayscale is Created

DMD™ Binary Pulsewidth Modulation

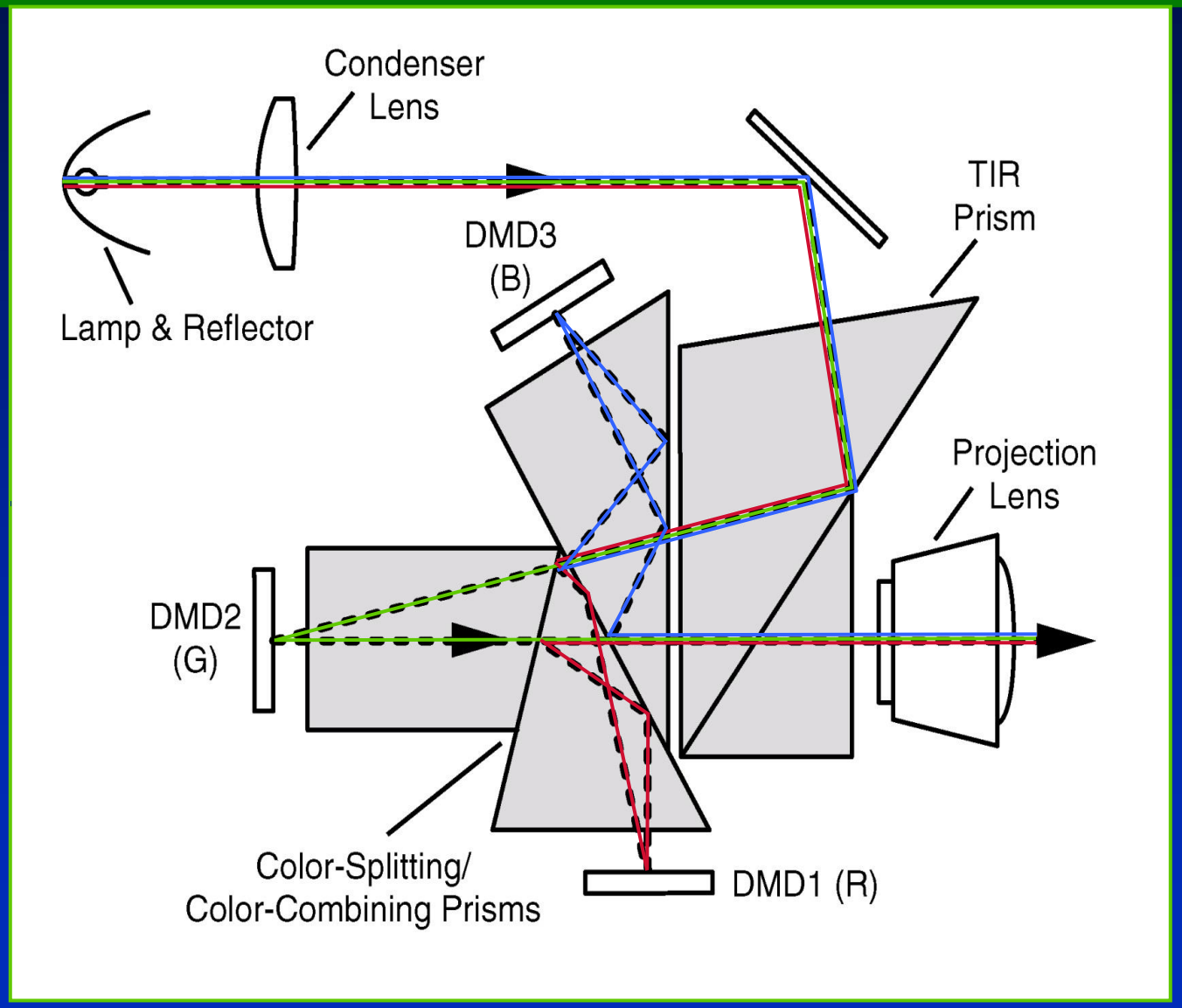


(1111)
(1001)
(0100)
(0010)
(0001)
(0000)

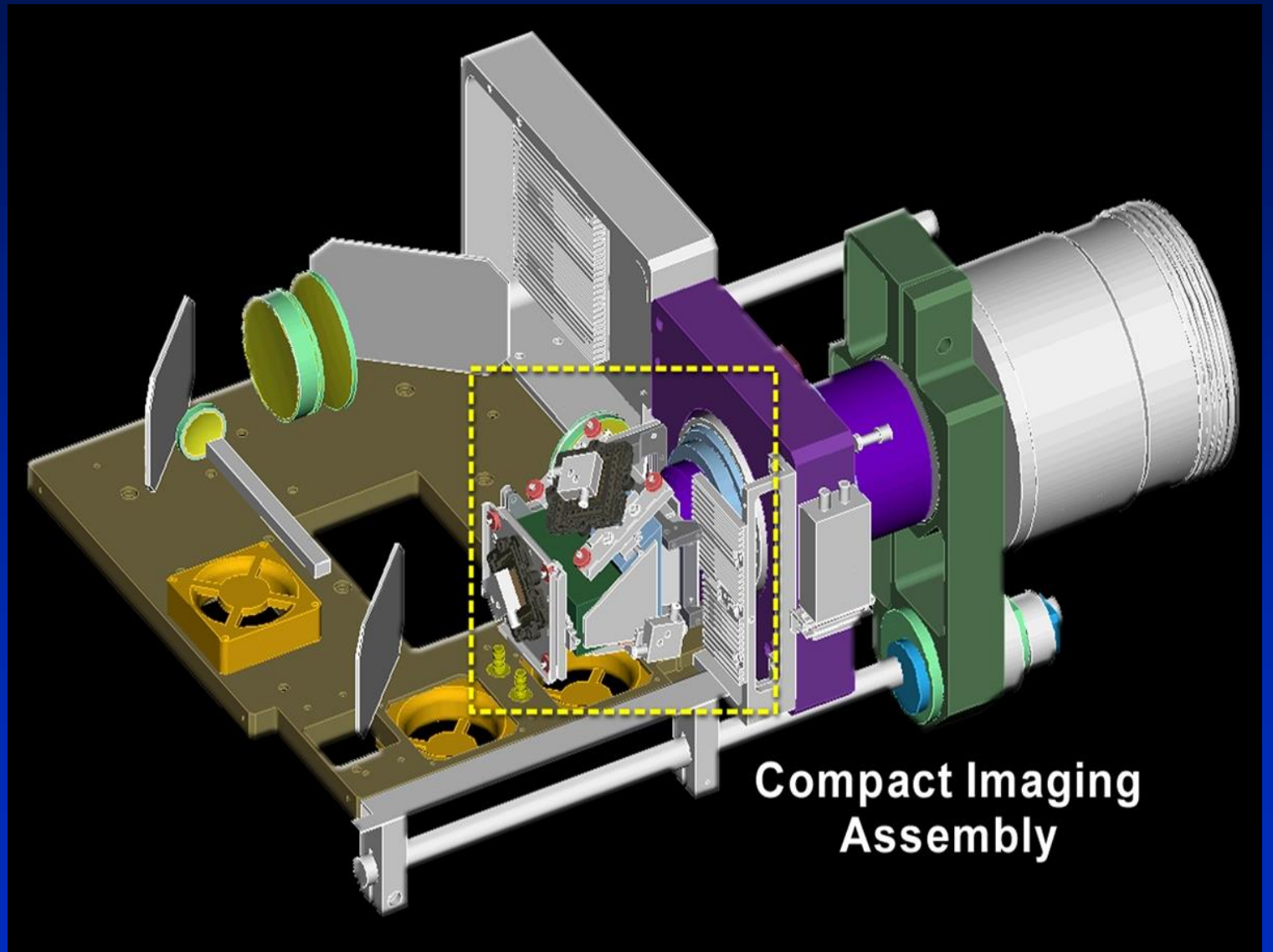
(Sensations of Gray Shade By Viewer's Eye)

4-Bit, 16 Gray-Level Example

3-Chip DLP Optical System



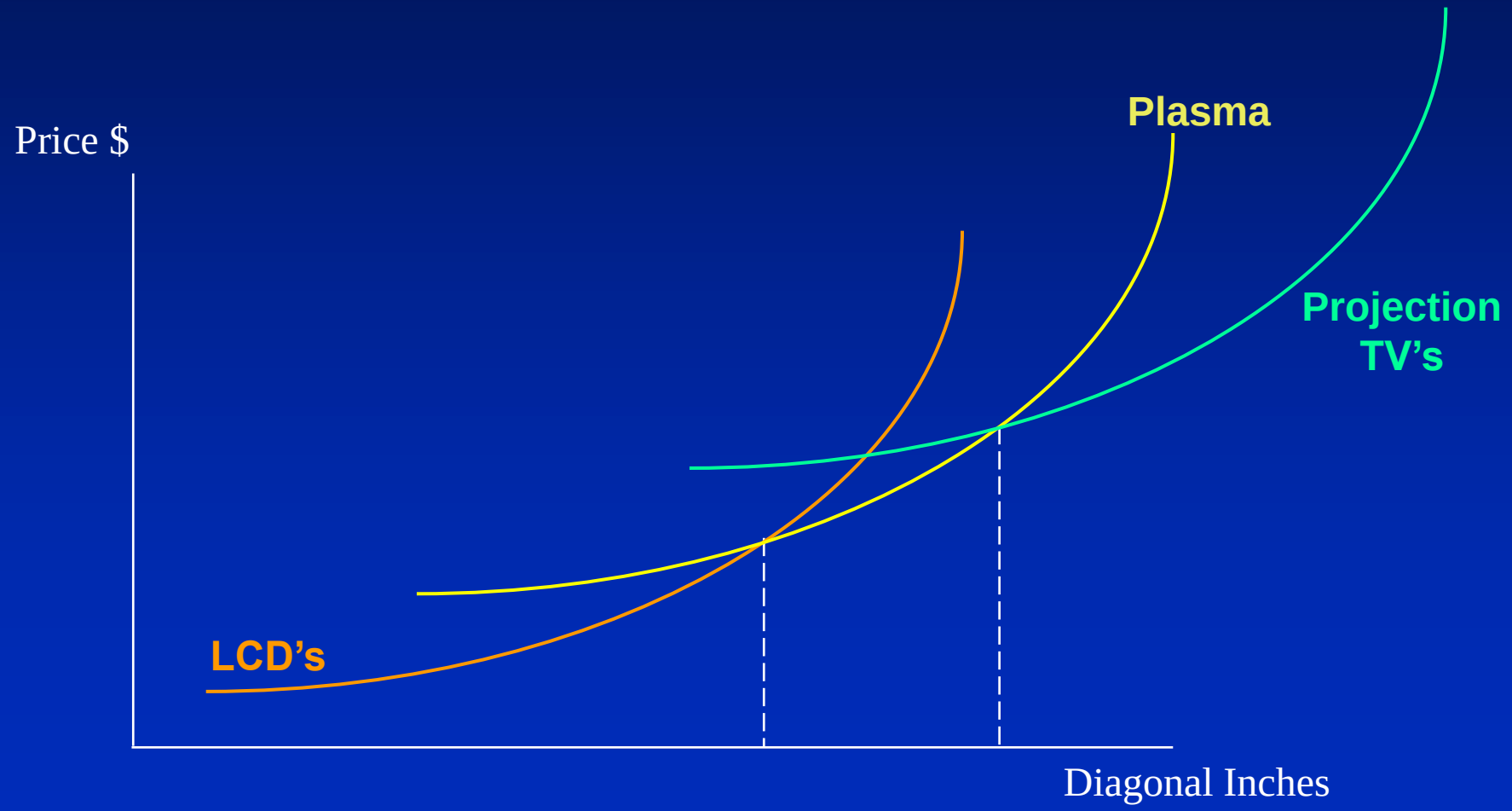
DLP Projection System



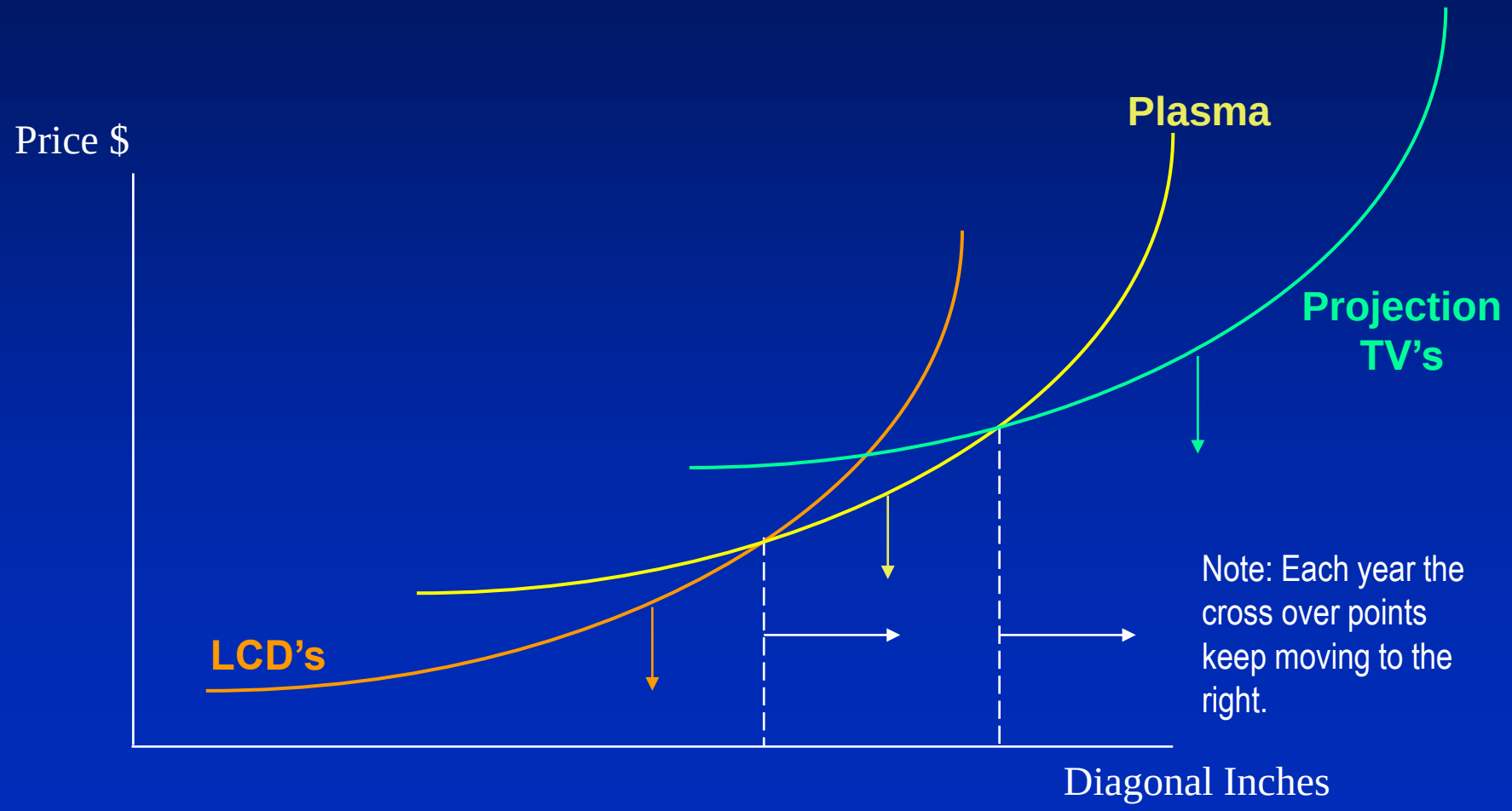
Christie CP4230 Digital Cinema Projector

- 4K DLP
- Screen size up to 105ft (32m)
- 4096 x 2160 resolution
- 2100:1 contrast

Cost of HDTV Displays



Cost of HDTV Displays



Modifications to Existing Technology

- The quest for size
- The quest for brightness
- The quest for energy reduction

Cornell Panoramic Projection System

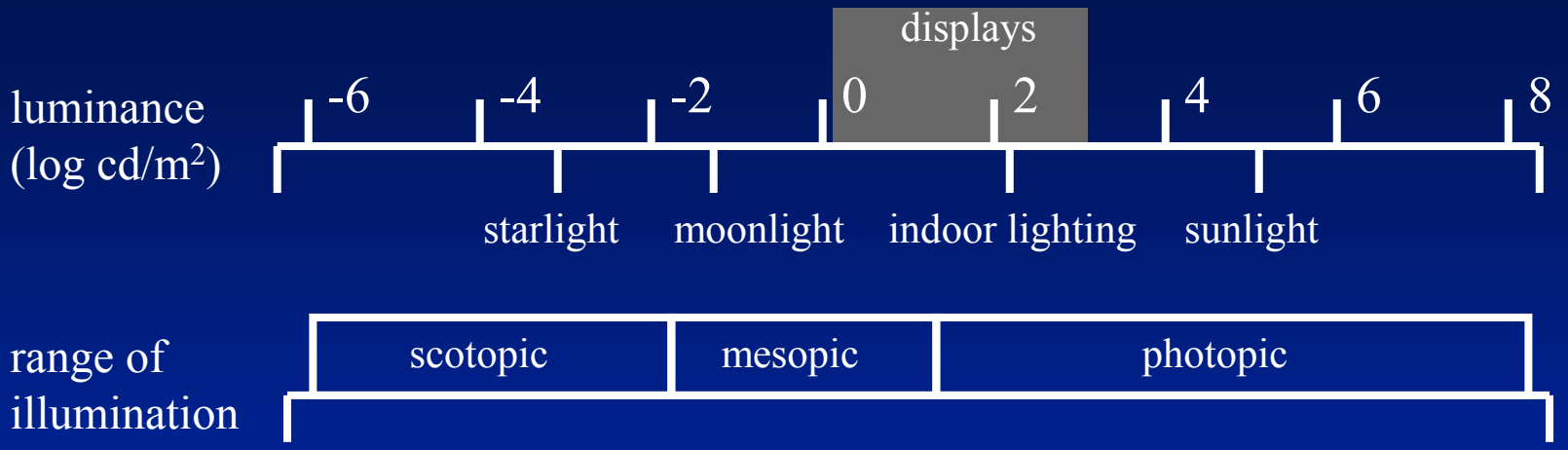
NASA Ames Control Room

FutureFlight Center at NASA-Ames

Stonybrook's Reality Deck

Samsung 110-inch 4K UHD TV 2014

Visual Adaptation



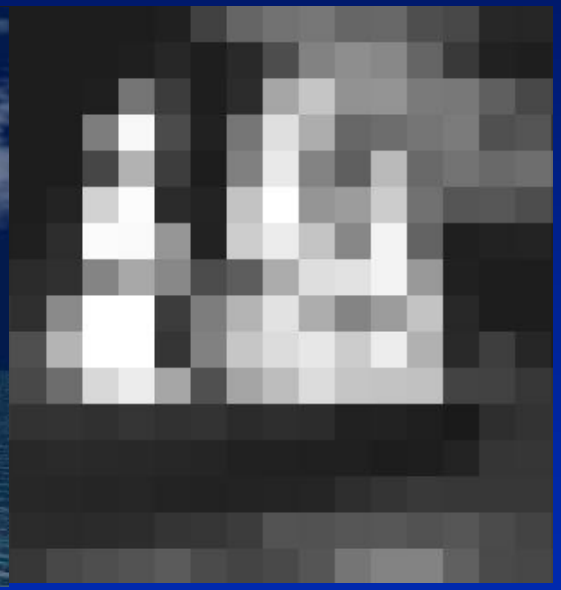
- poor contrast
- no color
- low acuity

- good contrast
- good color
- high acuity

Sunnybrook Display Technology

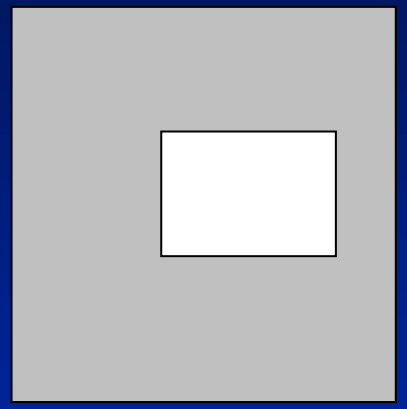
High resolution
colour LCD

High Dynamic Range
Display

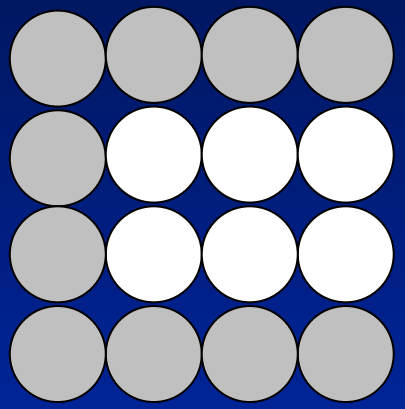


Low resolution
Individually Modulated
LED array

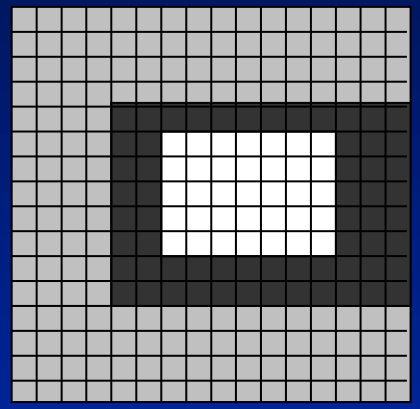
Sunnybrook Display Technology



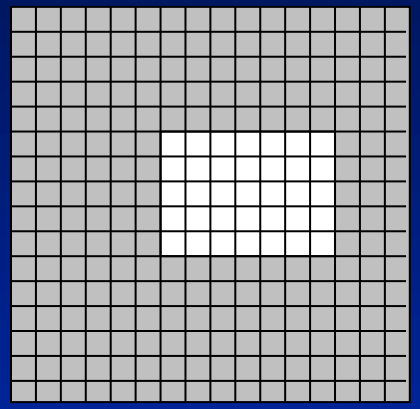
HDR Image



LED array

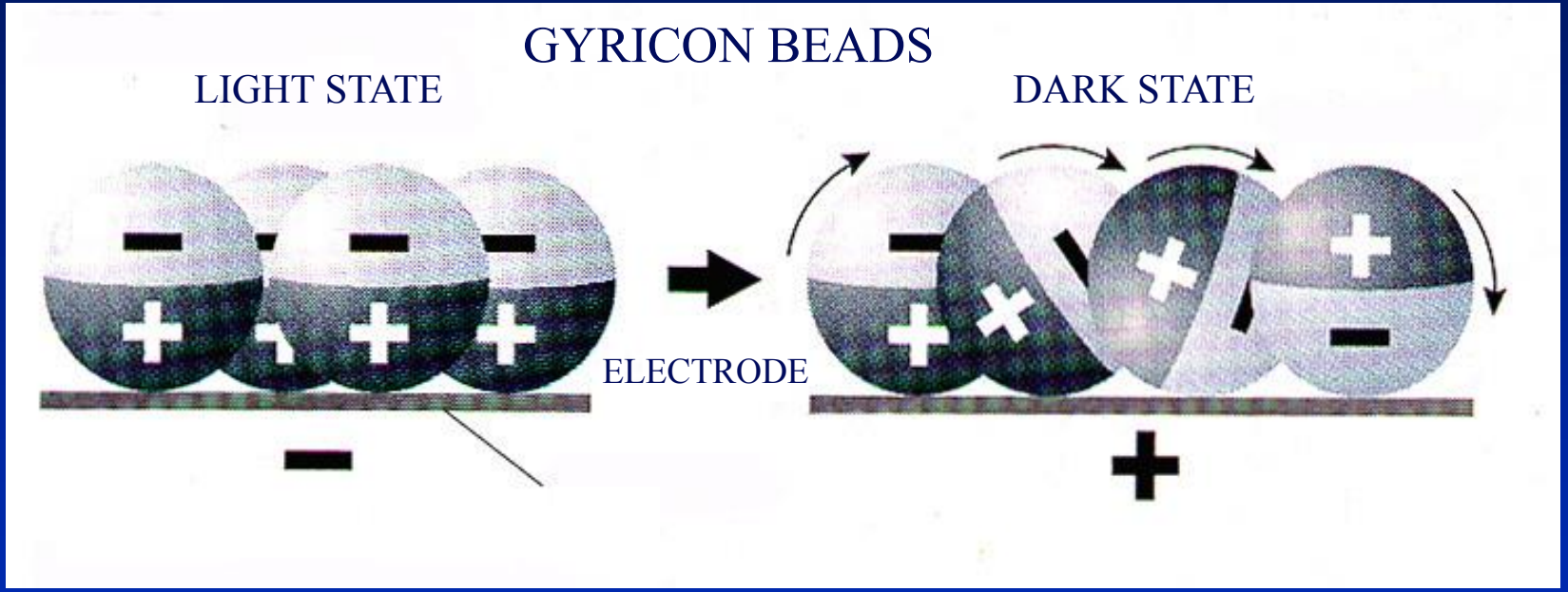


LCD with correction



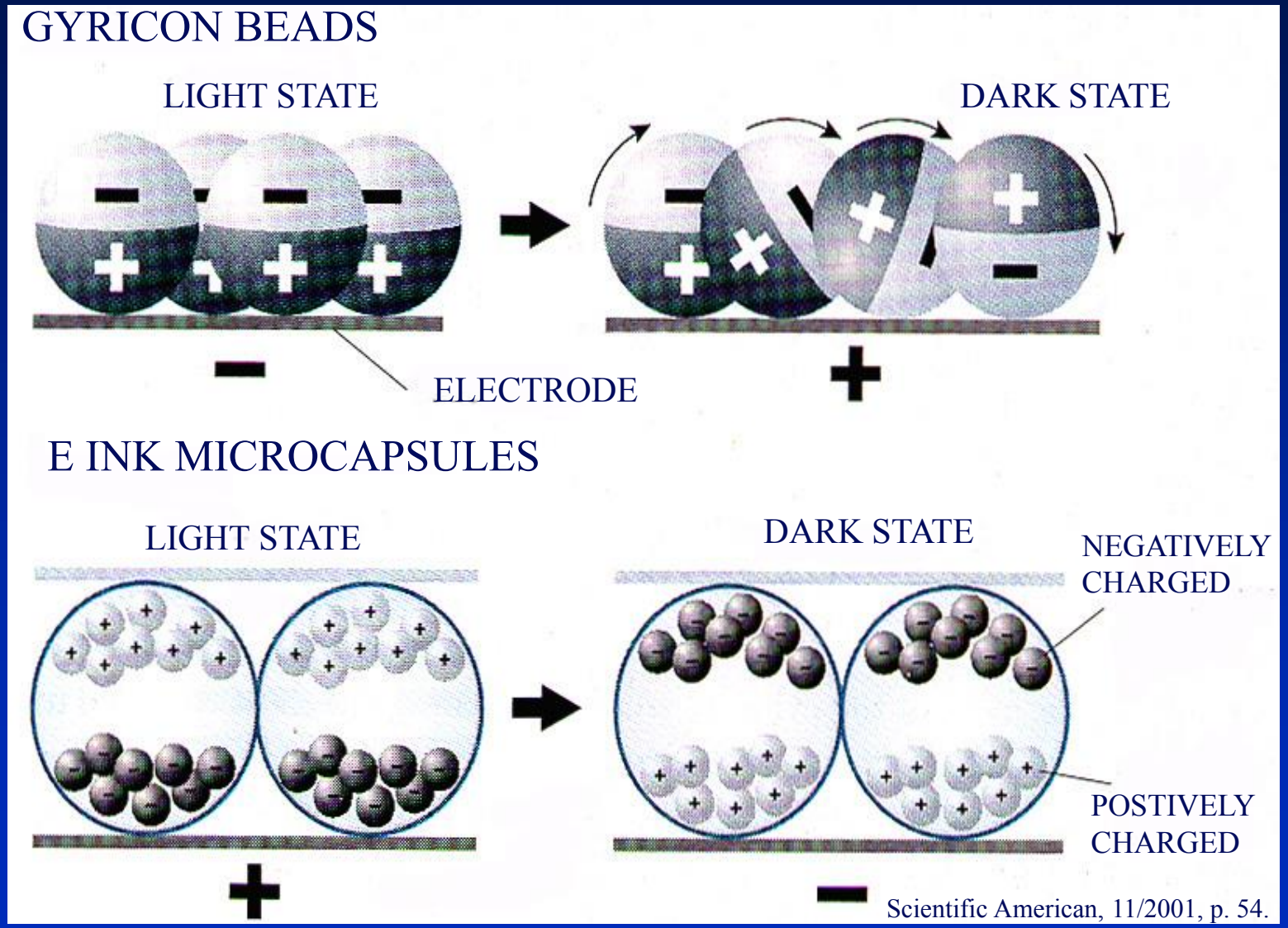
Output image

How E-Paper Works



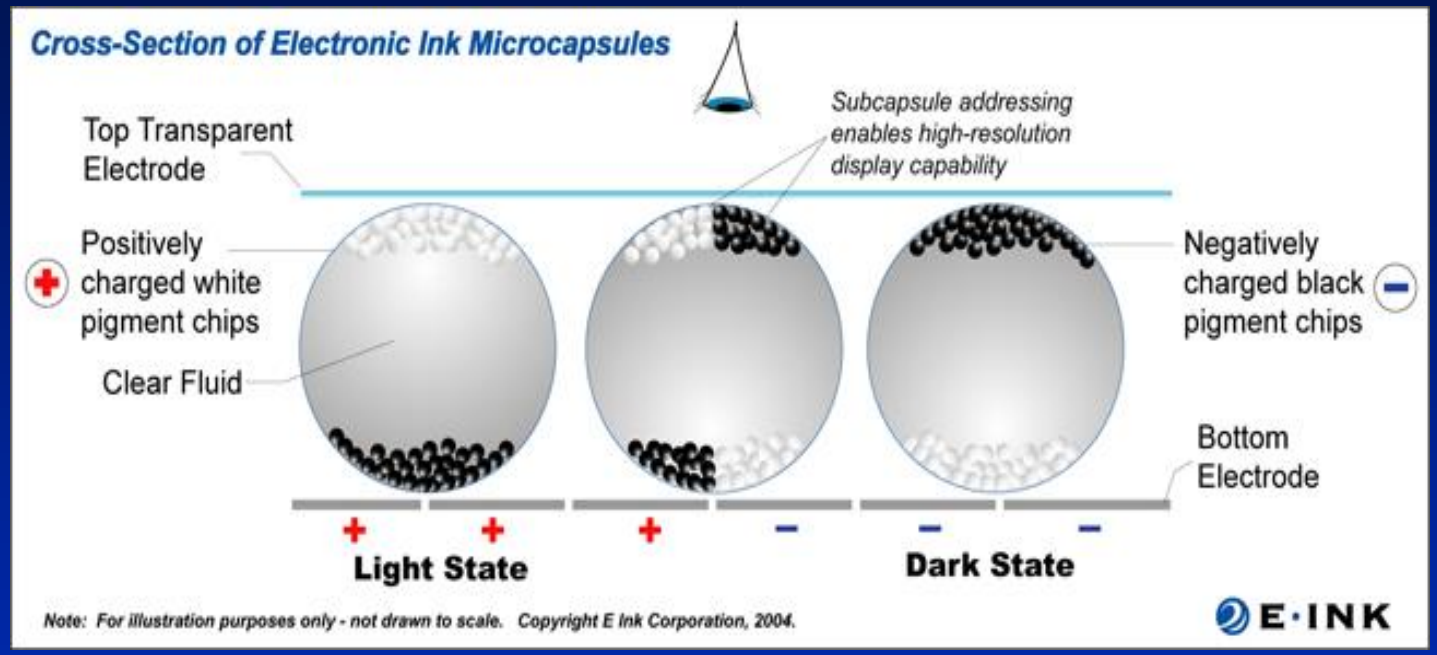
Scientific American, 11/2001, p. 54.

How E-Paper Works



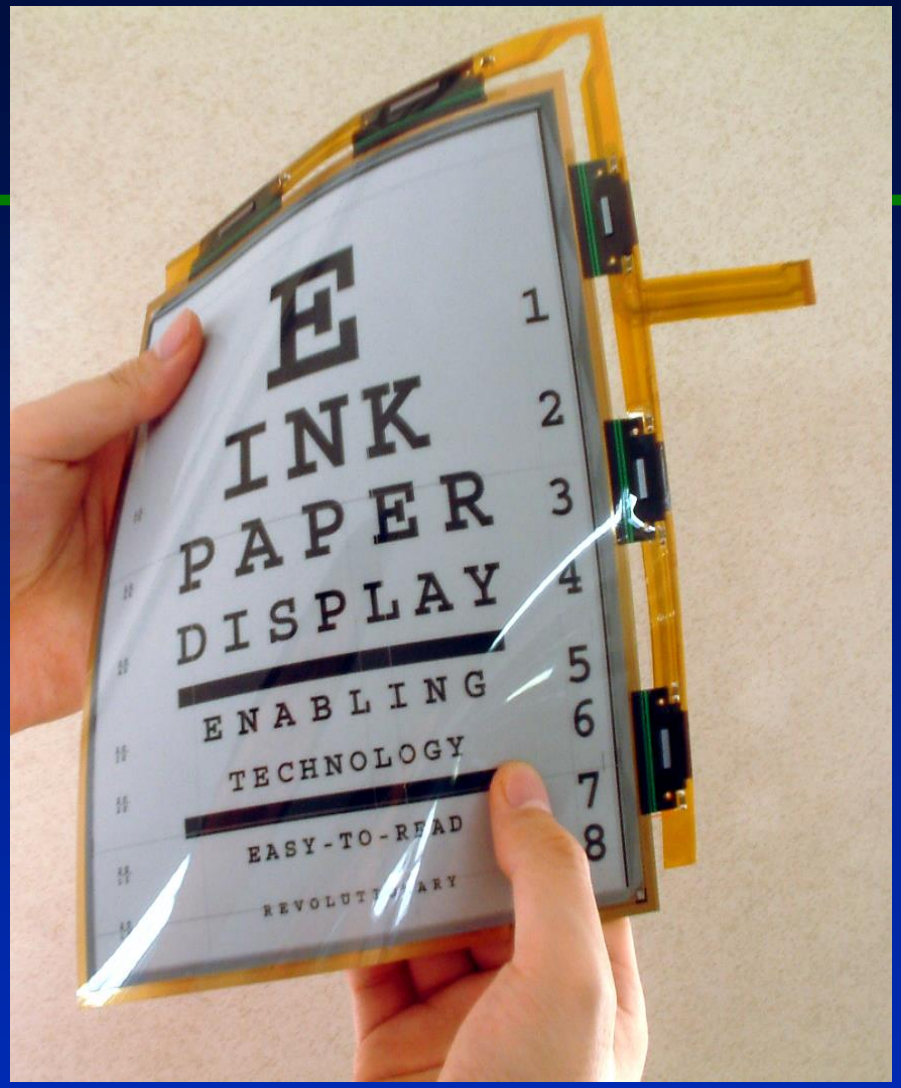
Scientific American, 11/2001, p. 54.

Flexible Electronic Paper Display



Electronic ink is a straightforward fusion of chemistry, physics and electronics to create this new material.

http://www.eink.com/technology/howitworks.html

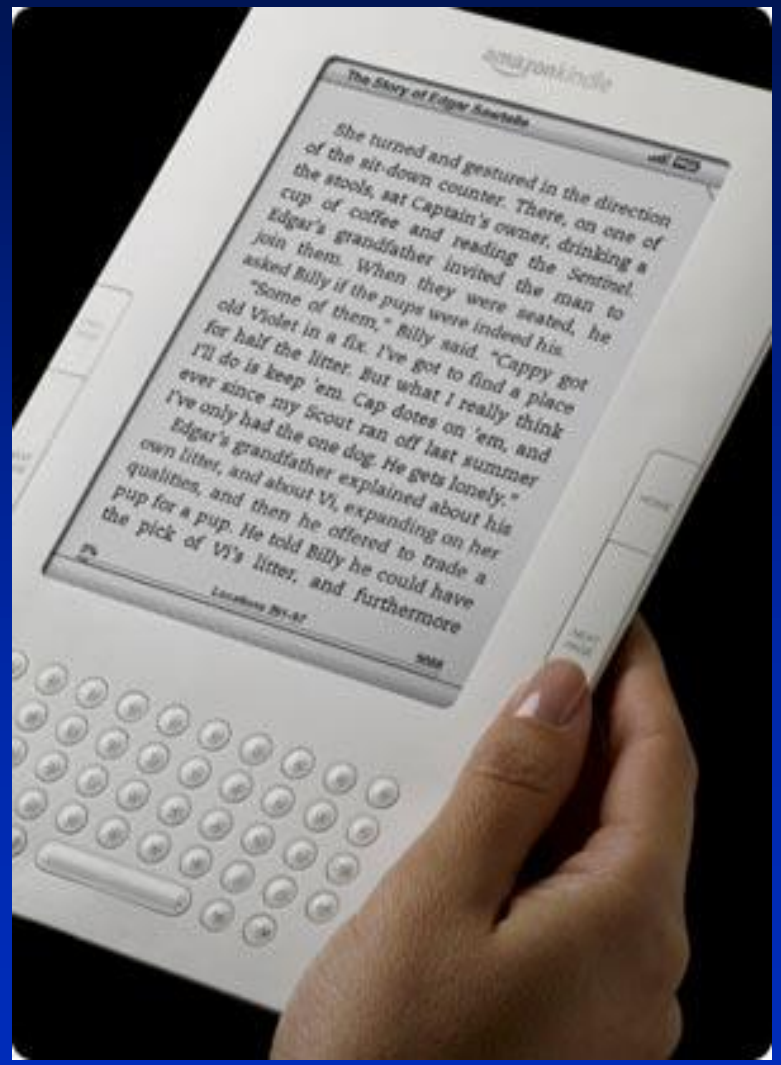


Flexible Tablet-Sized Display From L.G. Philips LCD and E Ink Corporation

http://www.eink.com/

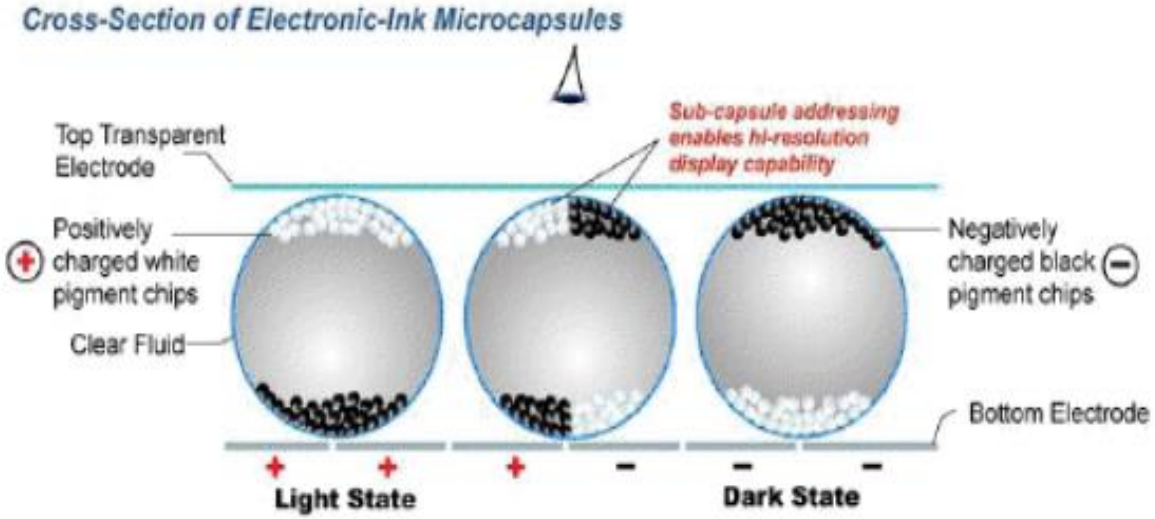
Plastic Logic

Kindle 2



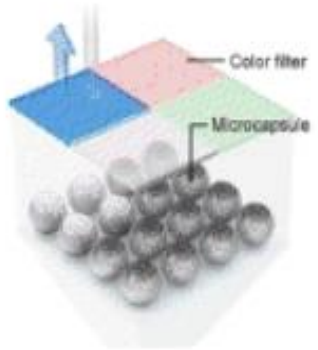
http://www.amazon.com/Kindle-Amazons-Wireless-Reading-Generation/dp/B00154JDAI

E-ink Triton Technology



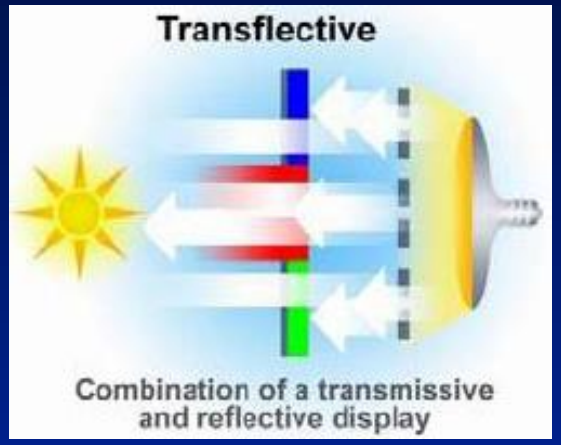
E Ink Triton Color Imaging Film

With the E Ink Triton color configuration, a thin transparent colored filter array (CFA) is added in front of the black and white display. The CFA consists four sub-pixels – red, green, blue, and white – that are combined to create a full-color pixel. The result? A low-power, direct-sunlight, readable reflective display that is mass manufactured in a practical way.



The color filter overlay on the monochrome display

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


FULL-SIZE
MICROSOFT ZUNE HD
Playing
Pins
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

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

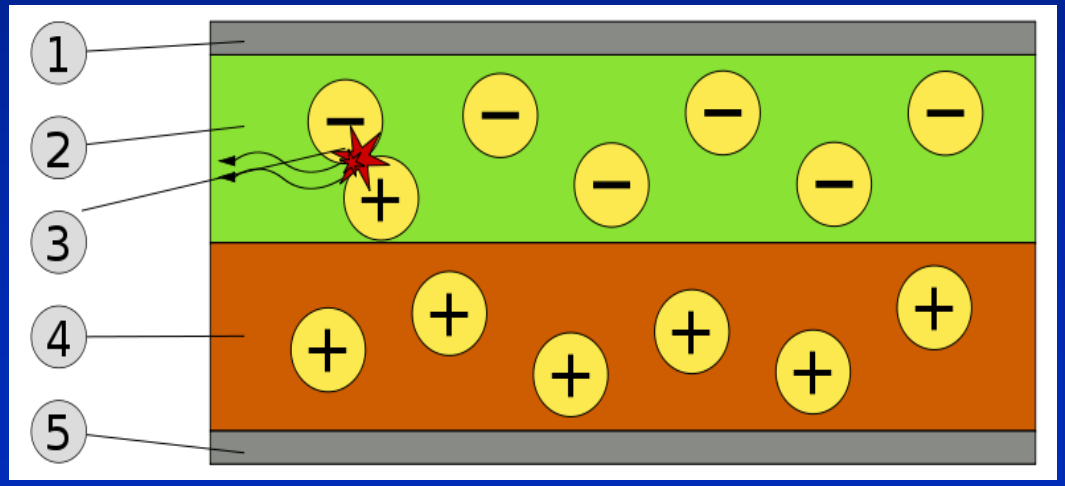
- Could be applied as wallpaper for illumination purposes
- Very bright and can replace light bulbs – already 4x more efficient than light bulbs in terms of lumens/watt
- With ability to produce red, green, and blue (new), can be used for displays

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).

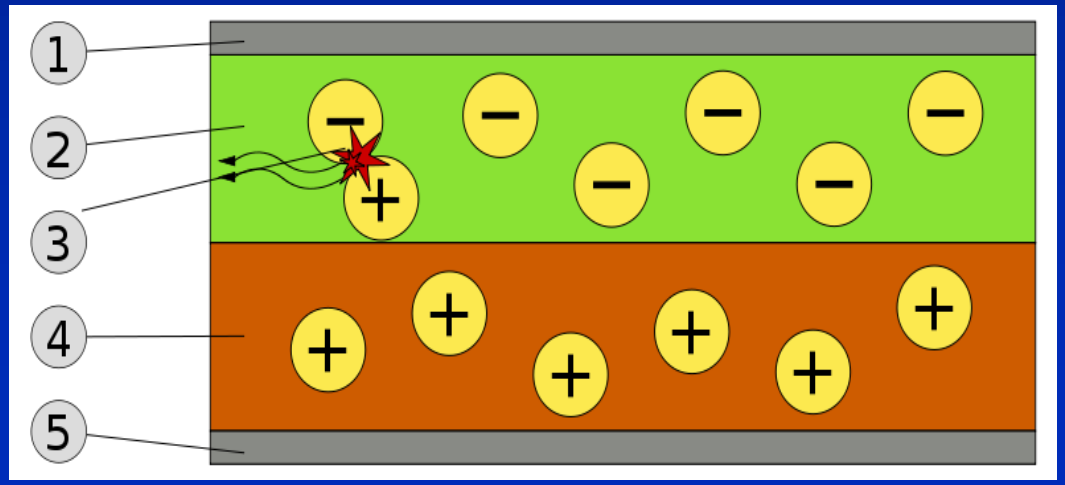


OLED Explanation

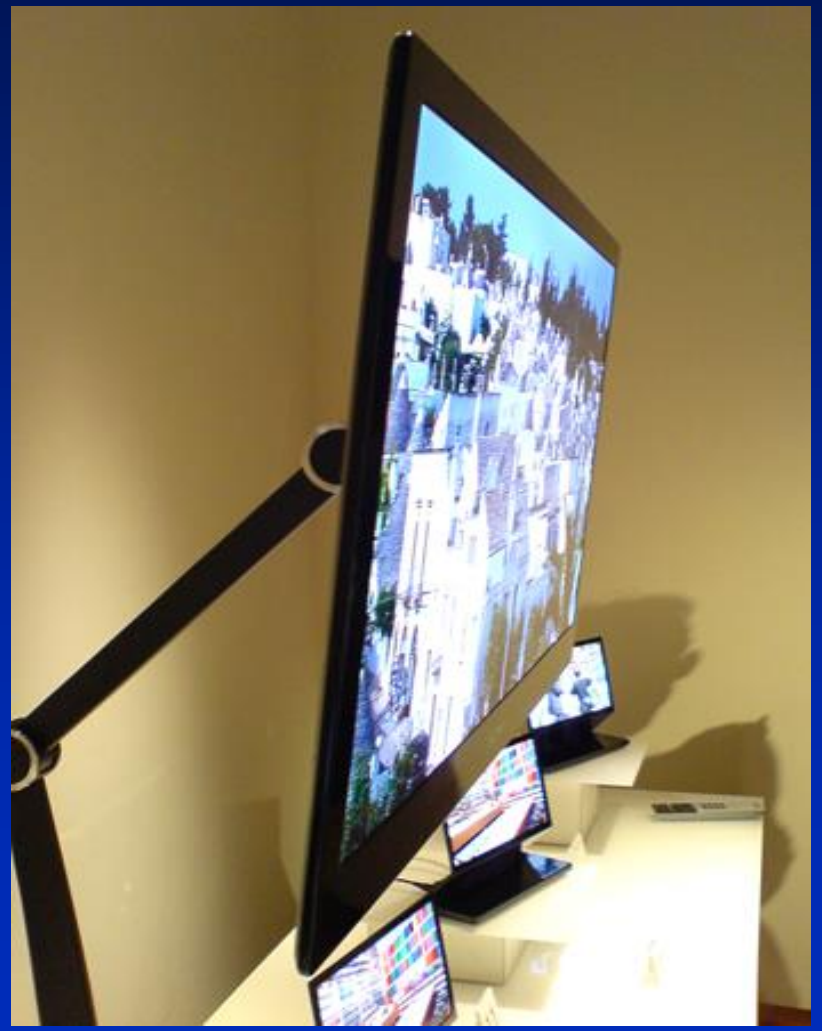
C. Electrostatic forces bring the electrons and holes together and they recombine.

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 27-inch OLED Panel 2007



SAMSUNG's 40" OLED Display 2012

LG 55” curved OLED TV LG 2013

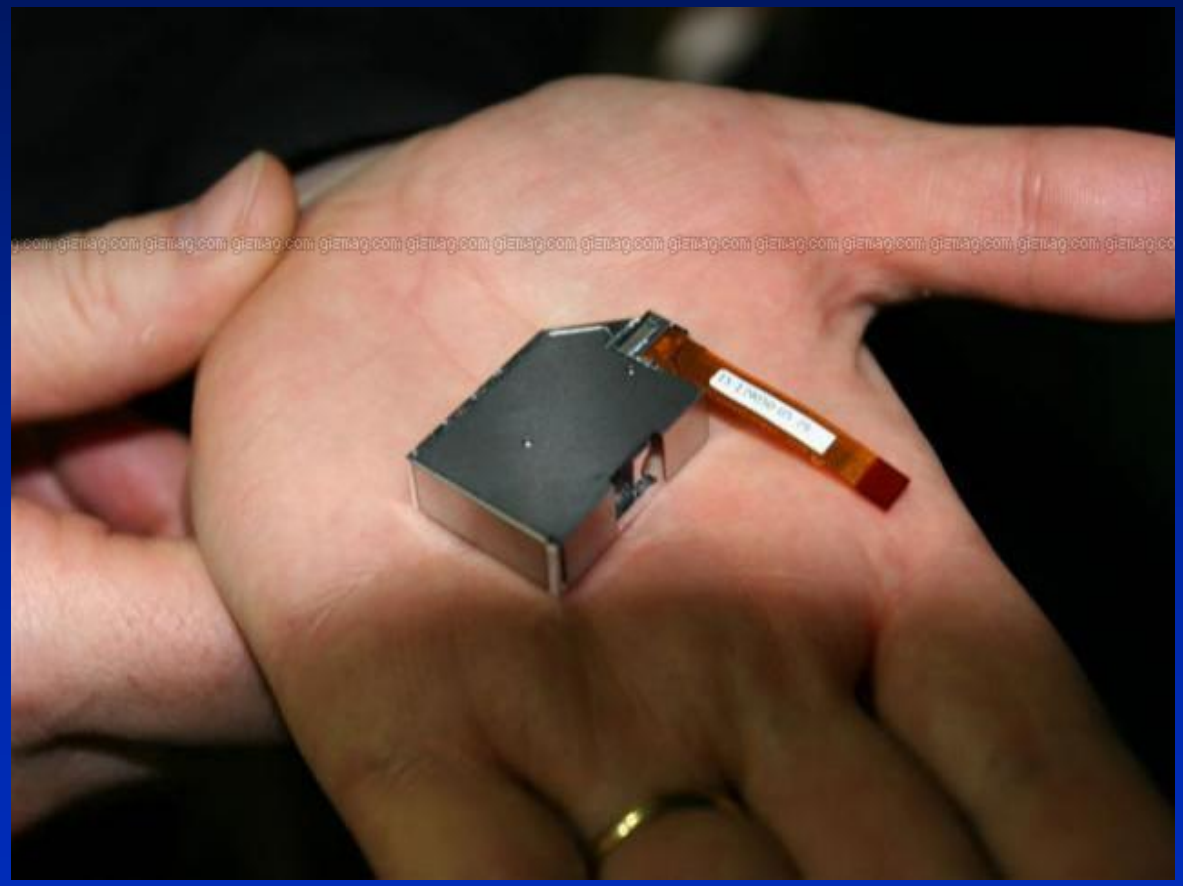
4mm thin

1000x faster refresh compared to LCDs

Samsung Curved OLED TV

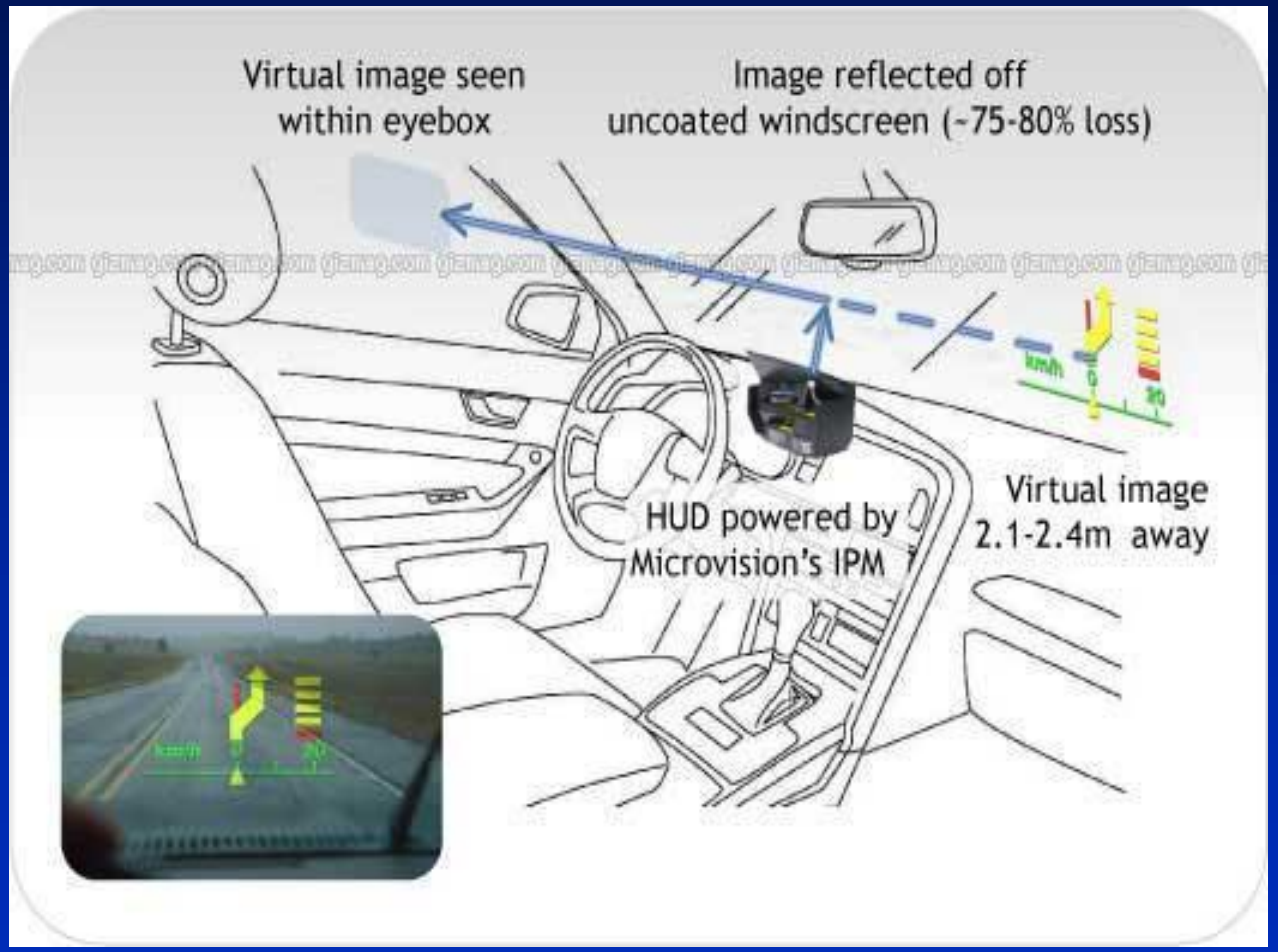
“It’s a small world after all”

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/

Microvision

http://www.microvision.com/pico_projector_displays/index.html

Potential Smart Device Designs

Sci Techie.com, May 5, 2010

Sony Smartwatch 2 (SW2) 2013

1.3 inch OLED screen

220 x 176 resolution

Battery life of 3-4 days or
14 hours of continual use

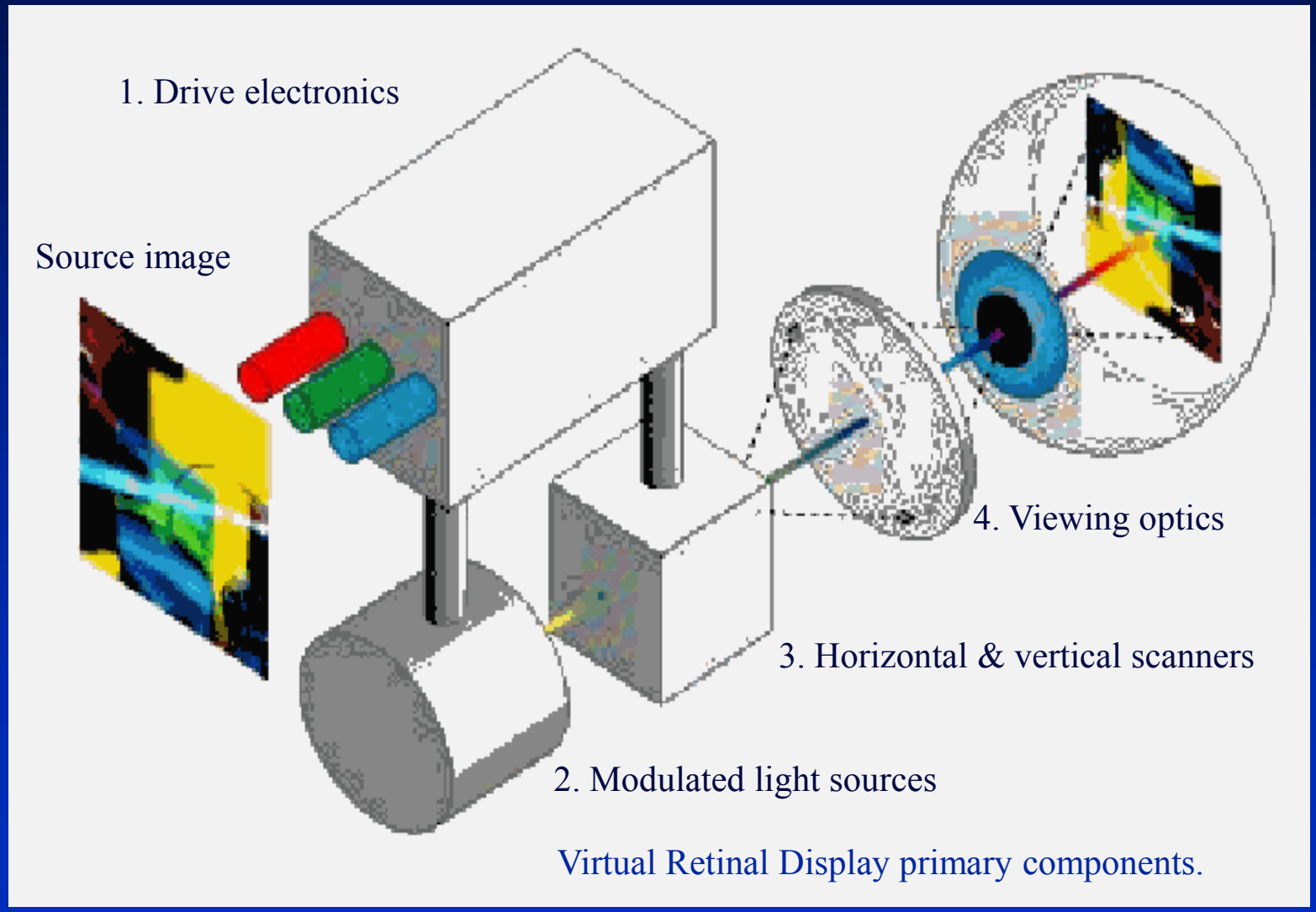
Communicates with
Android 2.1+
smartphones

http://www.engadget.com/2013/09/04/sony-smartwatch-2/

Apple Watch

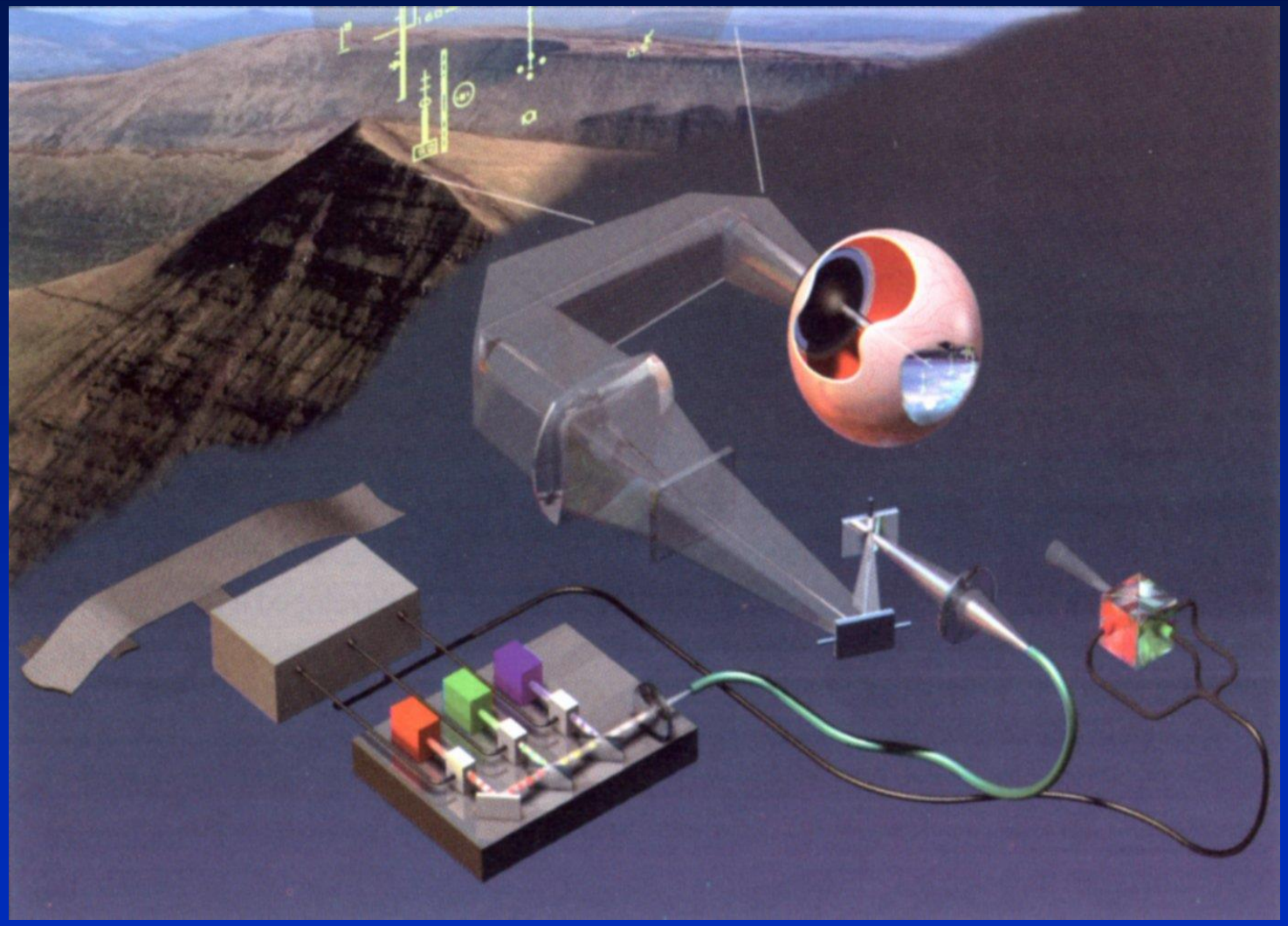
OLED Display

Retinal Displays



Virtual Retinal Display primary components.

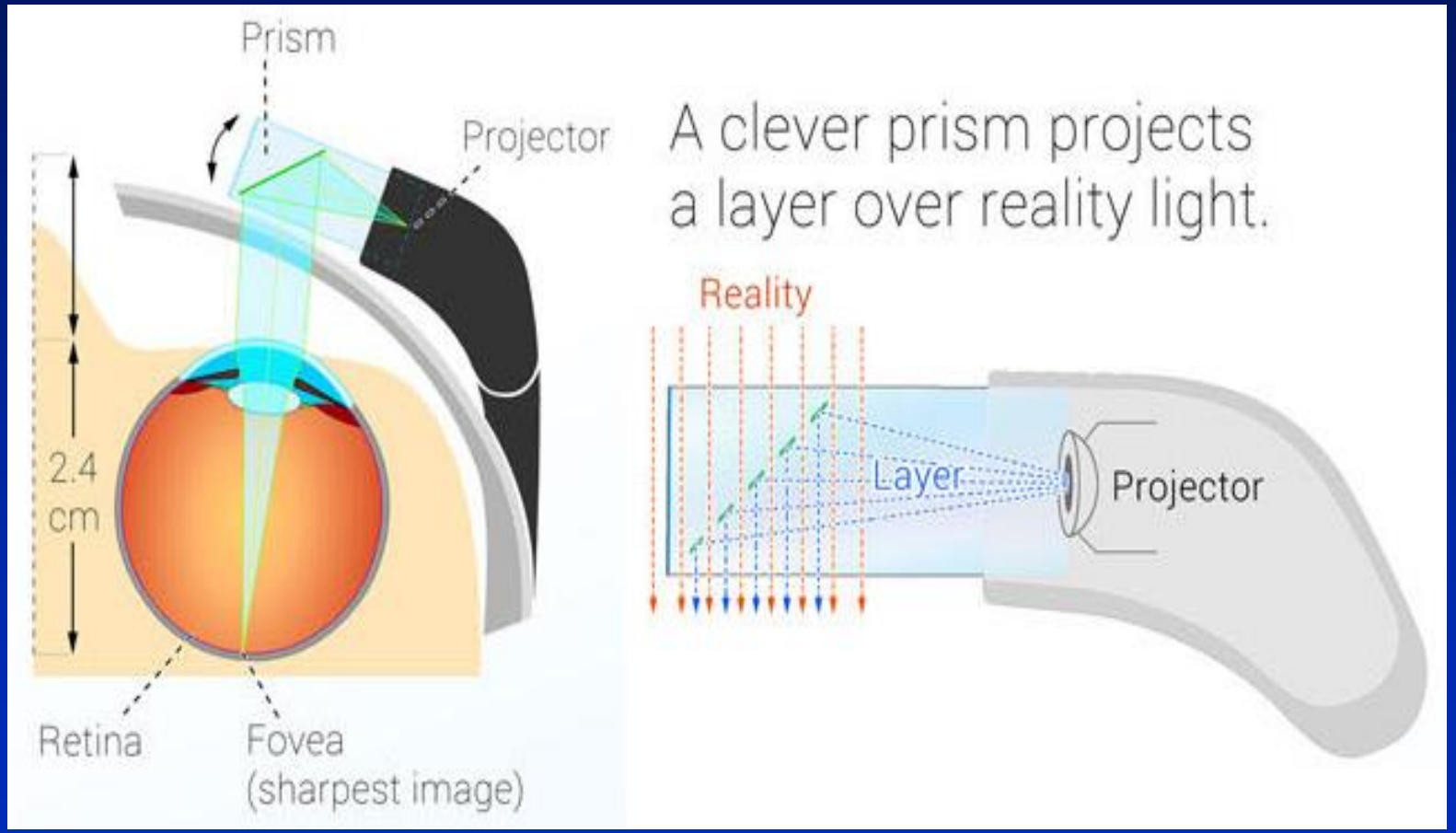
This schematic diagram illustrates the functional components of a laser-scanned display system.



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

Sergey Brin with Google Glass

Google Glass Projection System



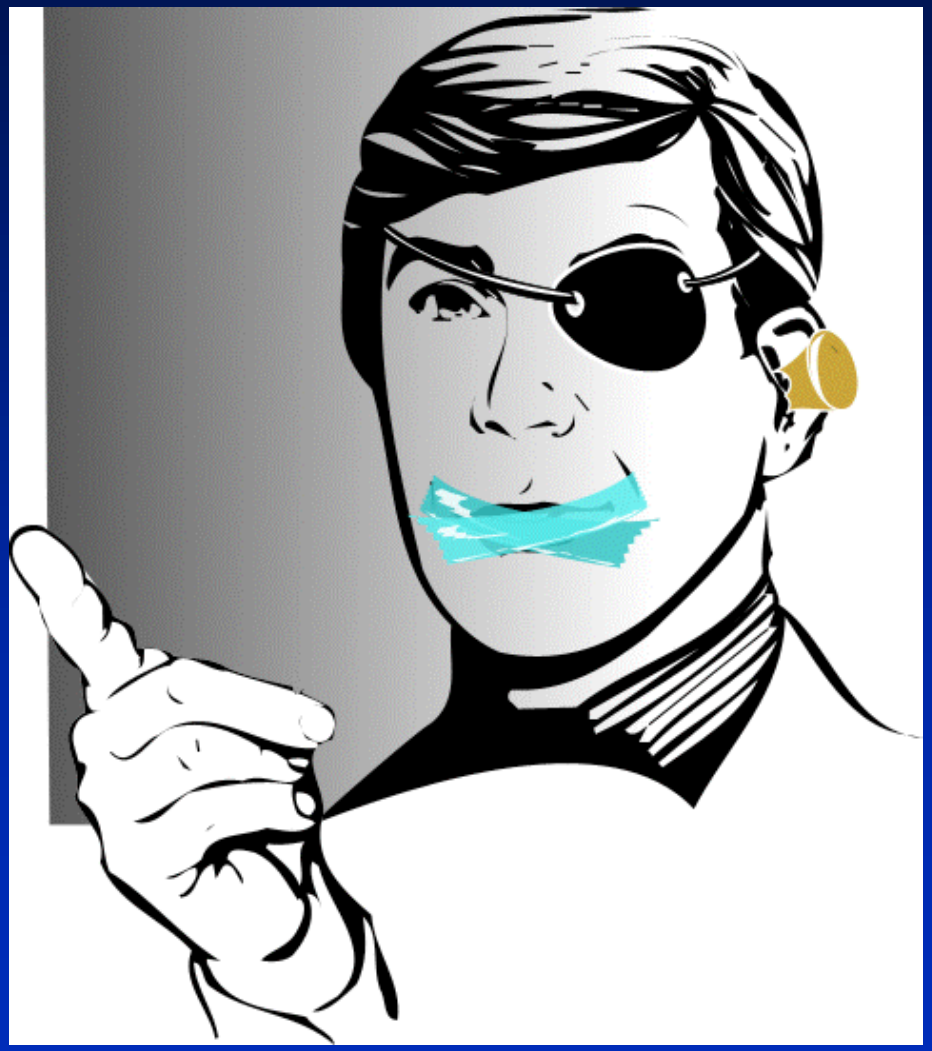
Human Computer Interfaces

Impedance-matching our Senses: Limitations of WIMP GUI

Limited Vision (Flat, 2D)

No Speech

No Gestures



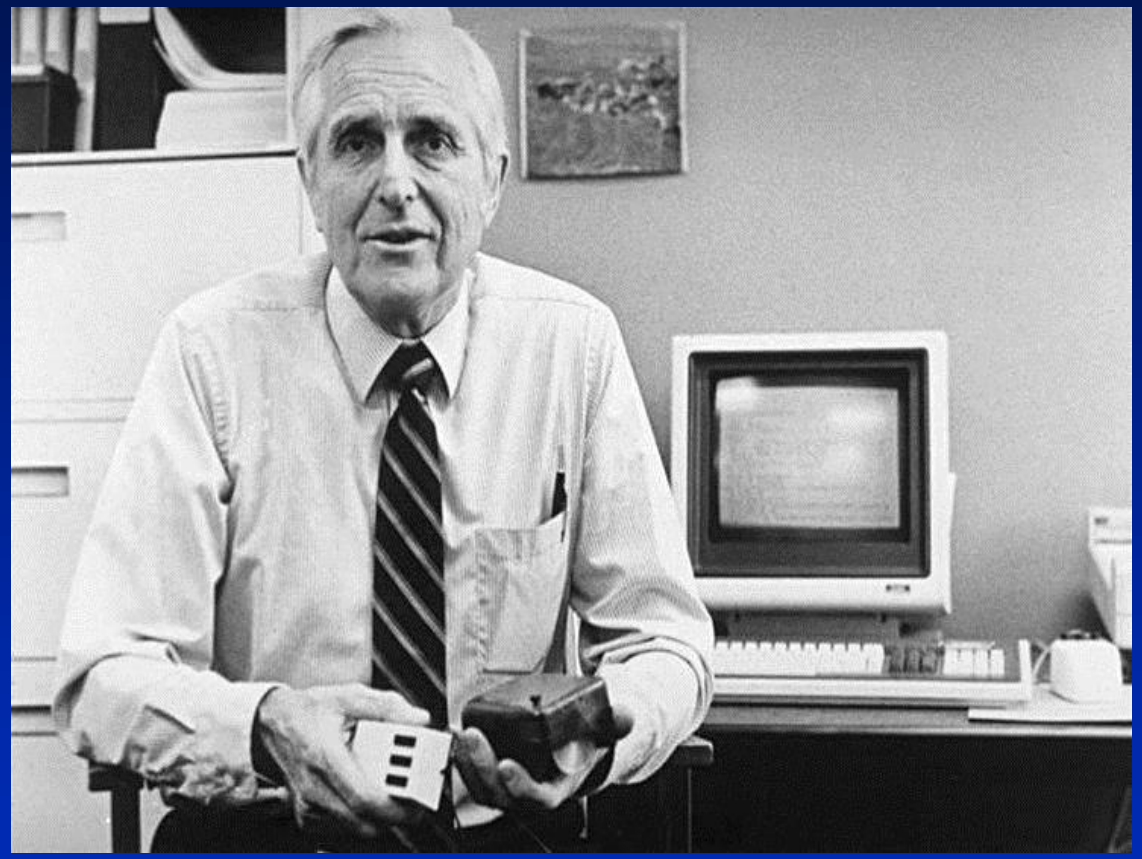
Limited Audio

One Hand Tied Behind Back

Limited Tactile

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

Crossing the Chasm: Time from Concept to Mass Adoption

1965

First Computer Mouse

1982

1995

Contemporary Computer Mouse

1982

Multi-touch Tablet

2008

iPhone

Touch Panel Displays

- The ability to display dynamic color images on a flat, rigid surface has enabled new modes of interaction – Touch Panel Displays
- The most popular are:
  - Resistive systems
  - Capacitive systems
  - Infra-red optical systems
  - Frustrated total internal reflections
- There are many others such as:
  - Surface acoustic waves
  - Strain gauges
  - Thermal
  - Etc.

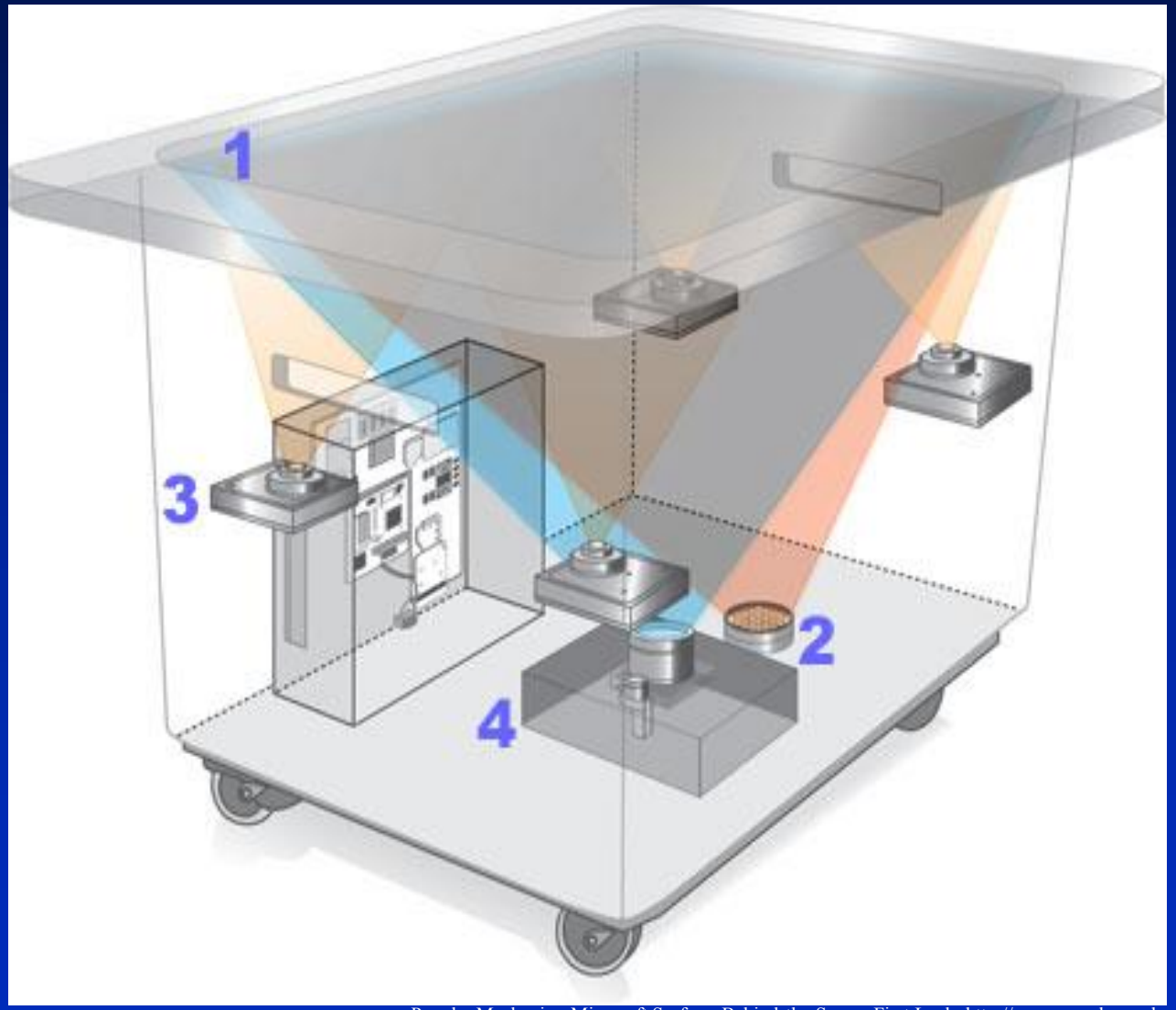
Daniel Turner. “Apples iPhone,” Technology Review, September/October 2007 .

Infra-red optical systems

- Surface is bathed with near infra-red light at 850 nanometers so that it is not visible to the human eye
- When an object touches the table top, light is reflected to multiple infra-red cameras with a net resolution of 1280 x 960 allowing it to sense and react to items touching the table top

Microsoft Surface (old): Behind the Scenes

1) Screen
2) Infrared
3) CPU
4) Projector



Popular Mechanics: Microsoft Surface: Behind-the-Scenes First Look http://www.popularmechanics.com/technology/industry/4217348.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?”

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 .

SONY's Crystal LED Display 2012 CES

3 LEDs per pixel

End