NBA 6120: Disruptive Technologies

Display Technology

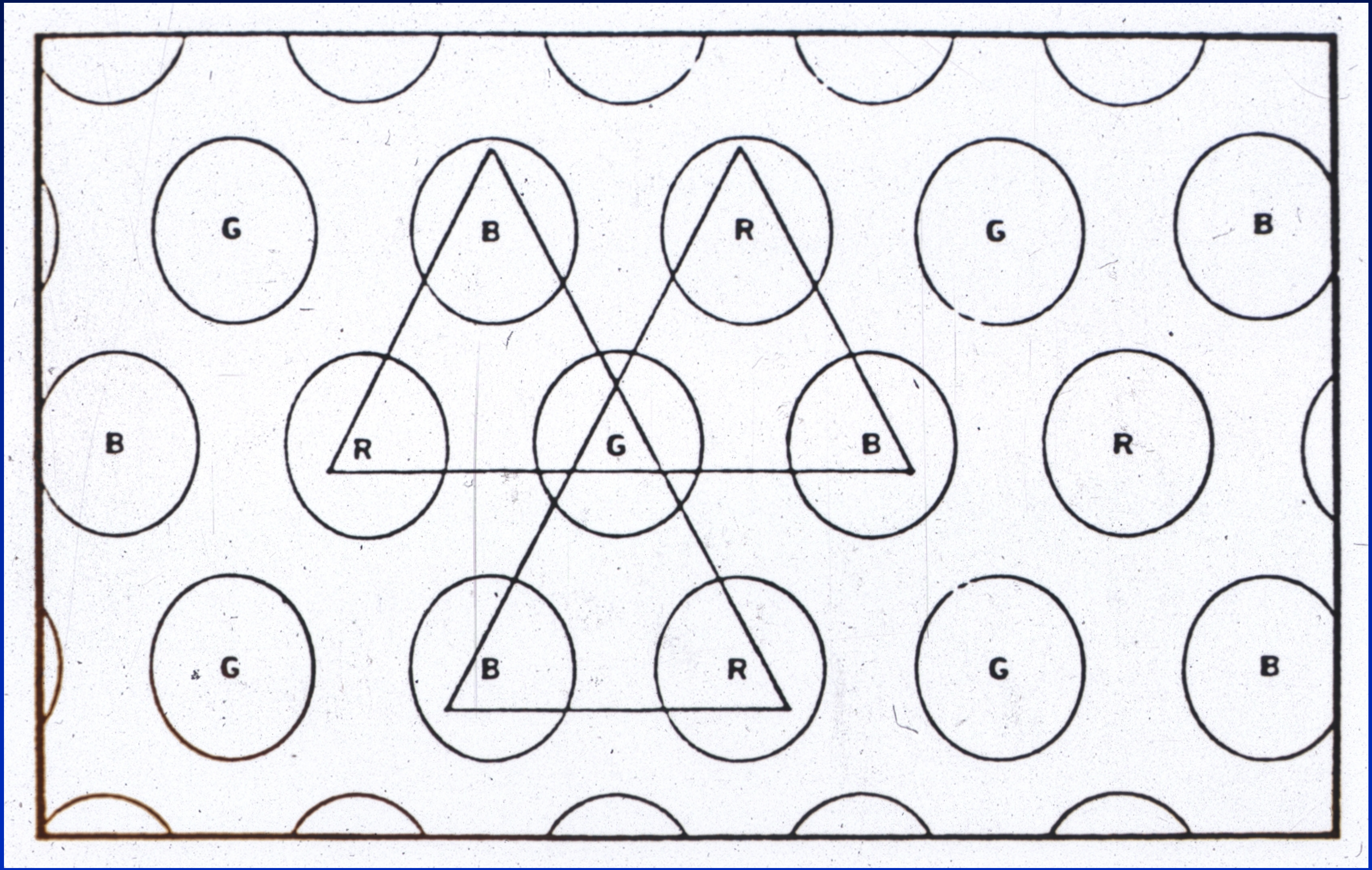
Lecture #4
February 5, 2018
Donald P. Greenberg

Required Reading

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

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

A Pixel Consists of Approximately 2 2/3 Triads



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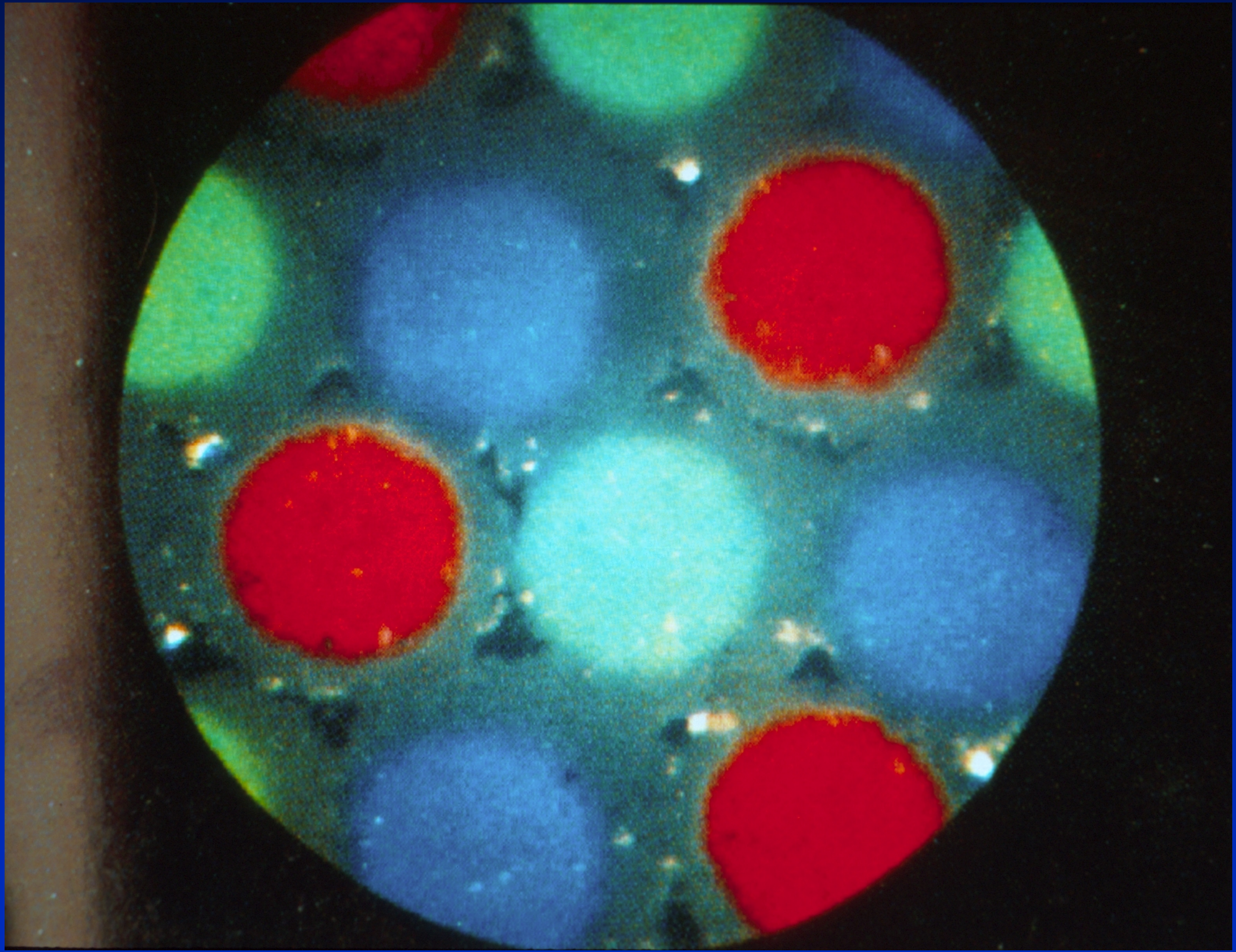


Perceptual Constraints

- Update rate
- Refresh rate

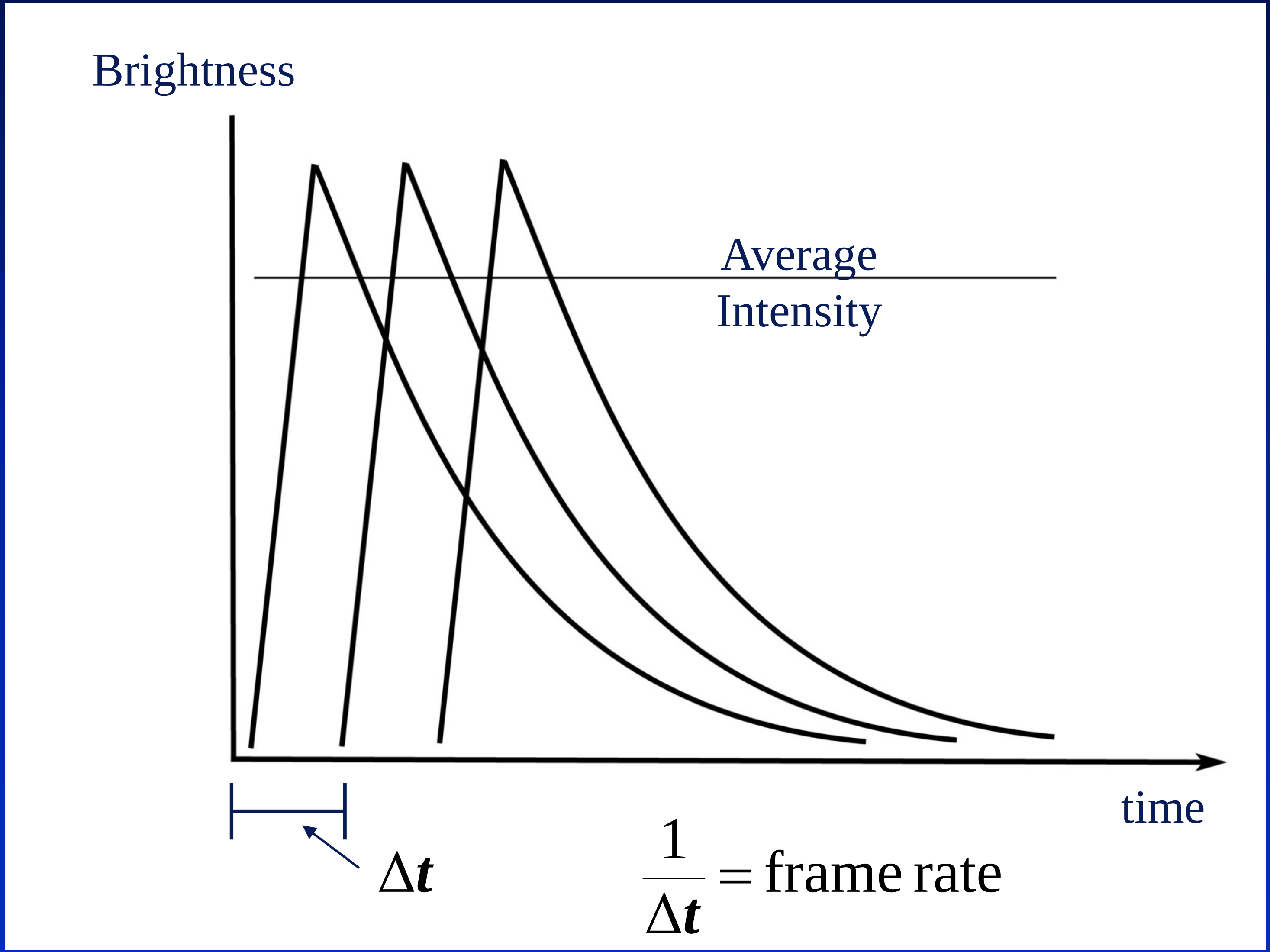
Update Rate

- 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 .

Flicker Fusion Frequency

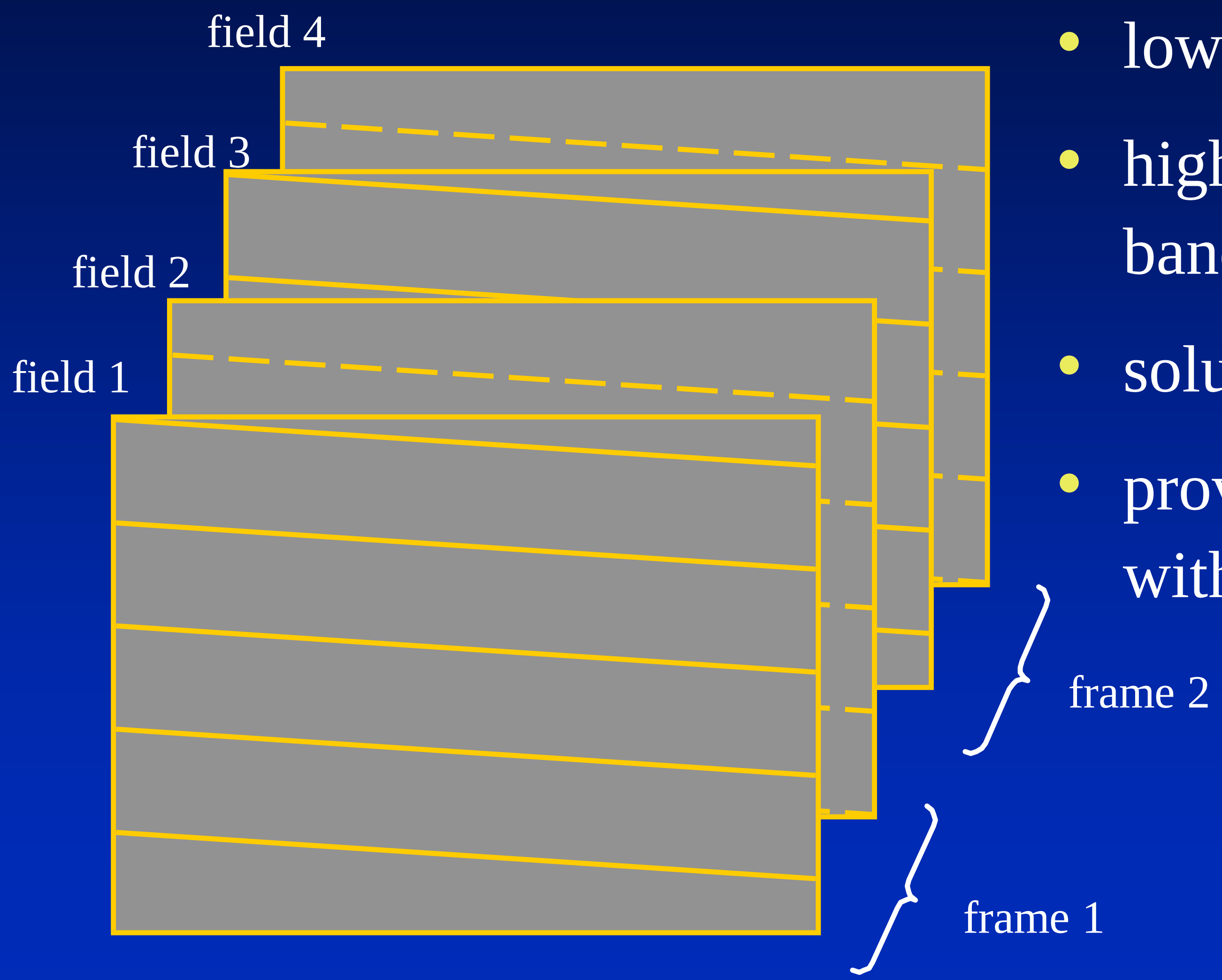
- The flicker fusion frequency of the average human observer is approximately 60 cycles per second.
- If the refresh rate is greater than this threshold, the observer sees a constant intensity.

Phosphor Decay Behavior



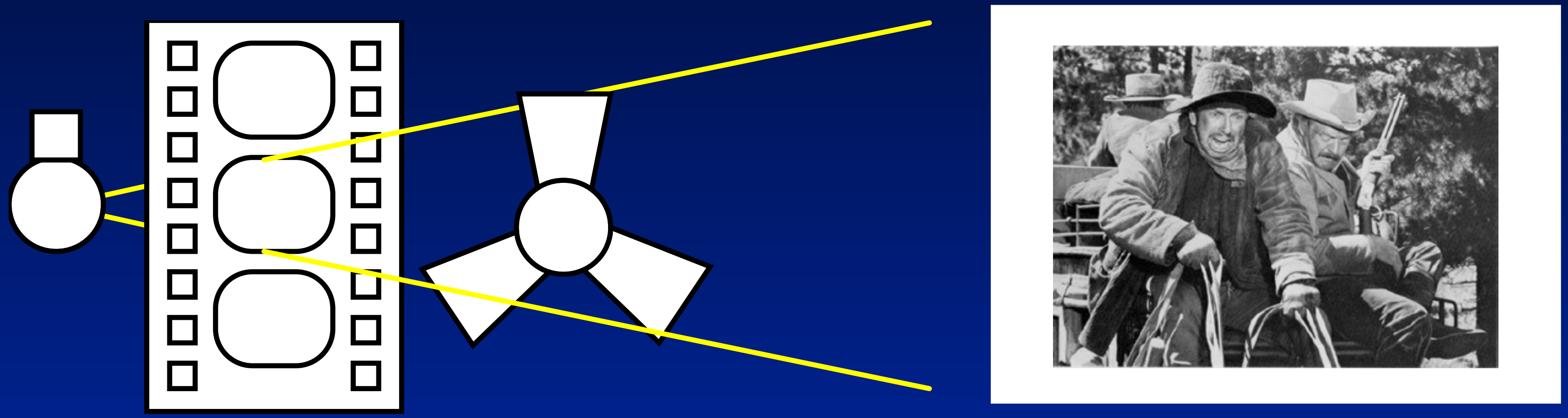
Temporal Properties of NTSC

REFRESH

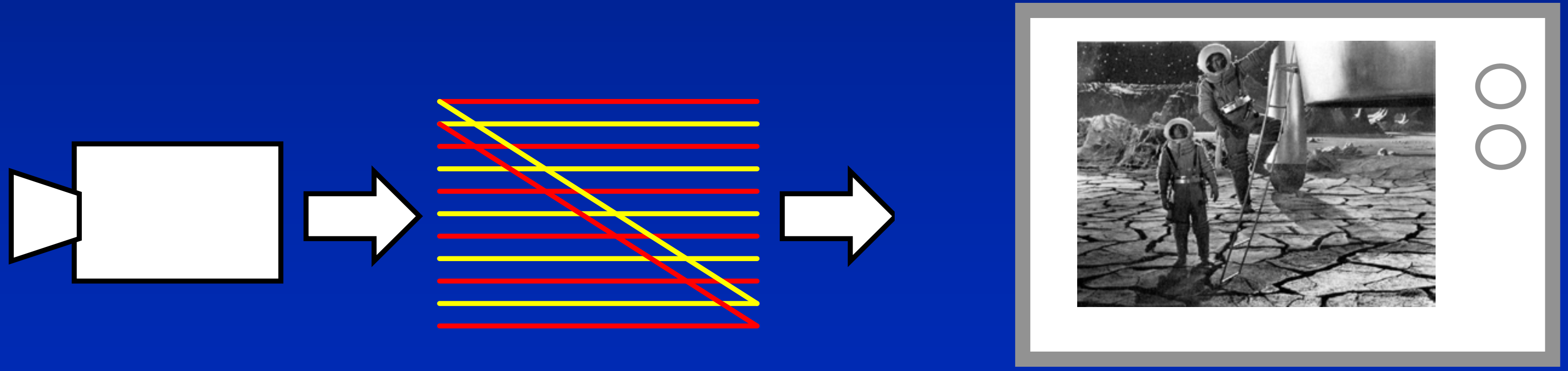


- low refresh rate -> flicker
- high refresh rate -> too much bandwidth
- solution: interlacing
- provides 60 Hz refresh rate with only 30 Hz update rate

Update Rate vs. Refresh Rate



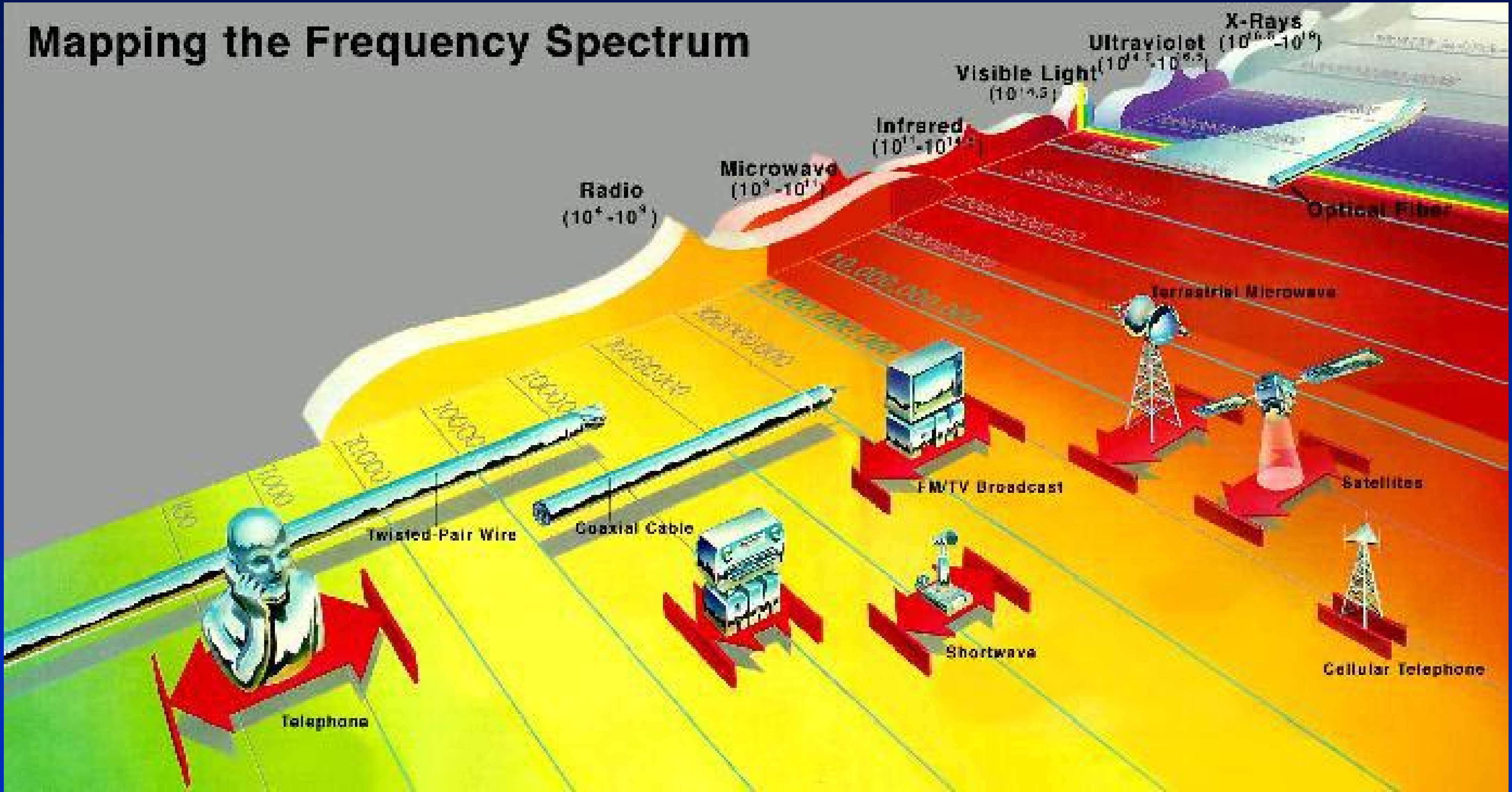
Film: 24fps update rate, 3 blade shutter, 72Hz refresh rate



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

- interlacing: matches flicker limits of vision, minimizes bandwidth

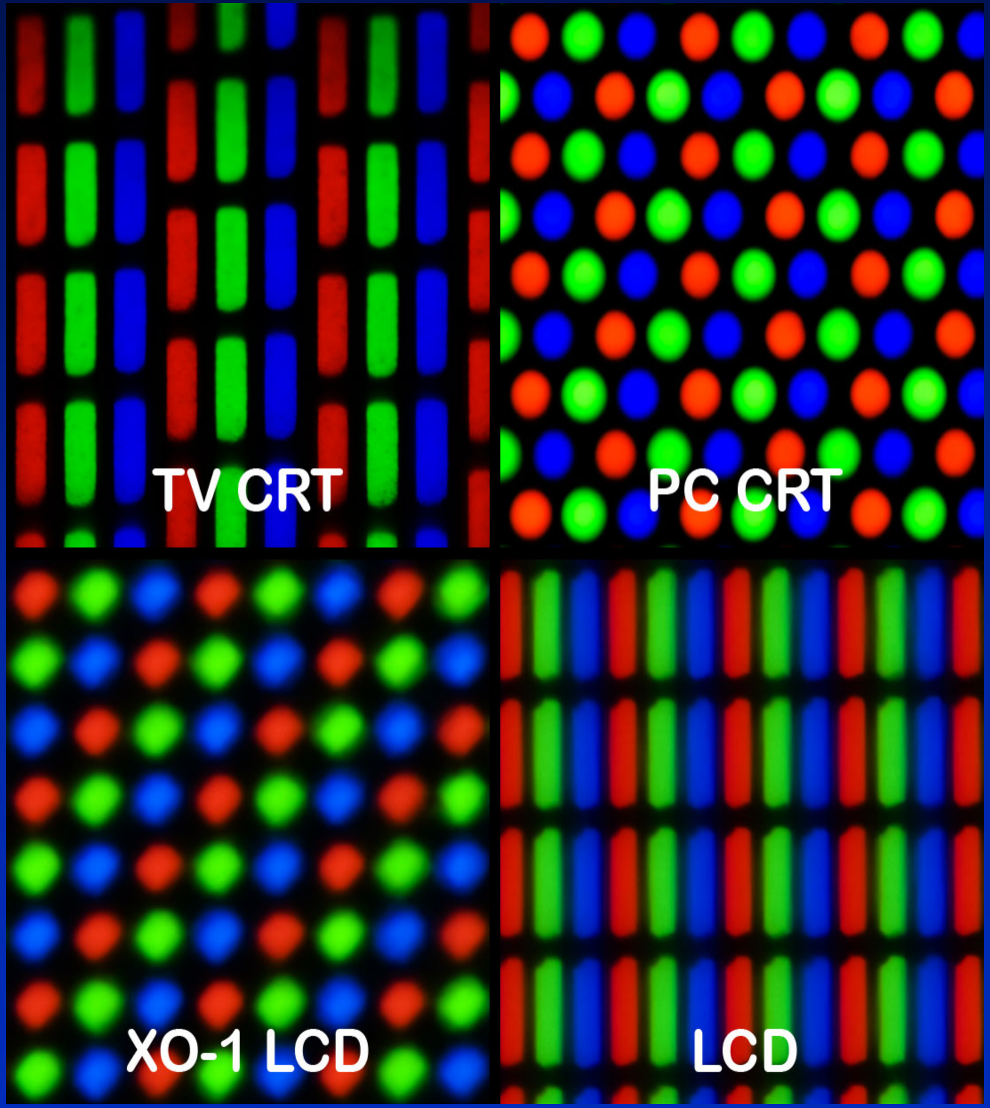
Mapping the Frequency Spectrum



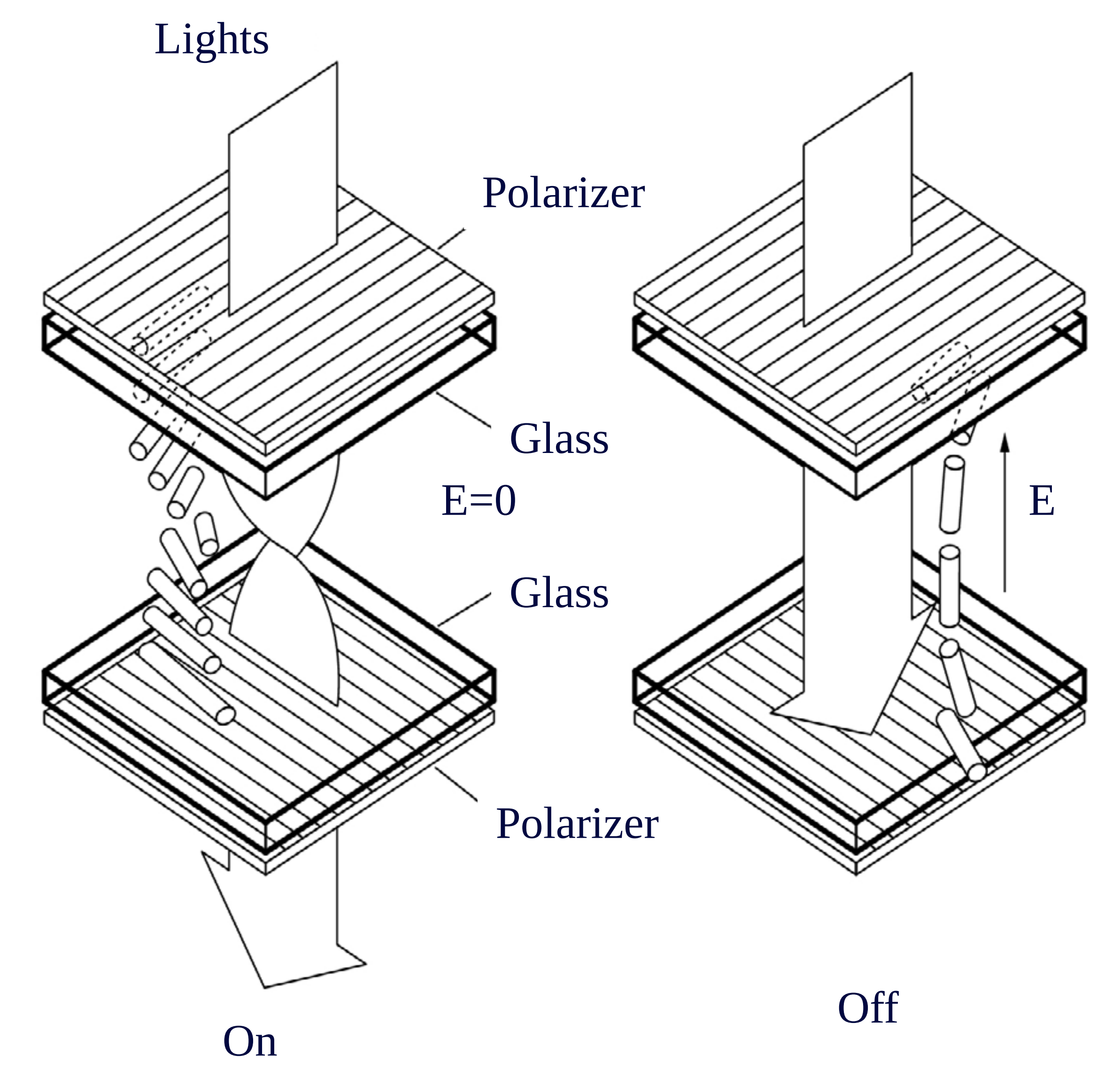
Important Properties of Liquid Crystals

- 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

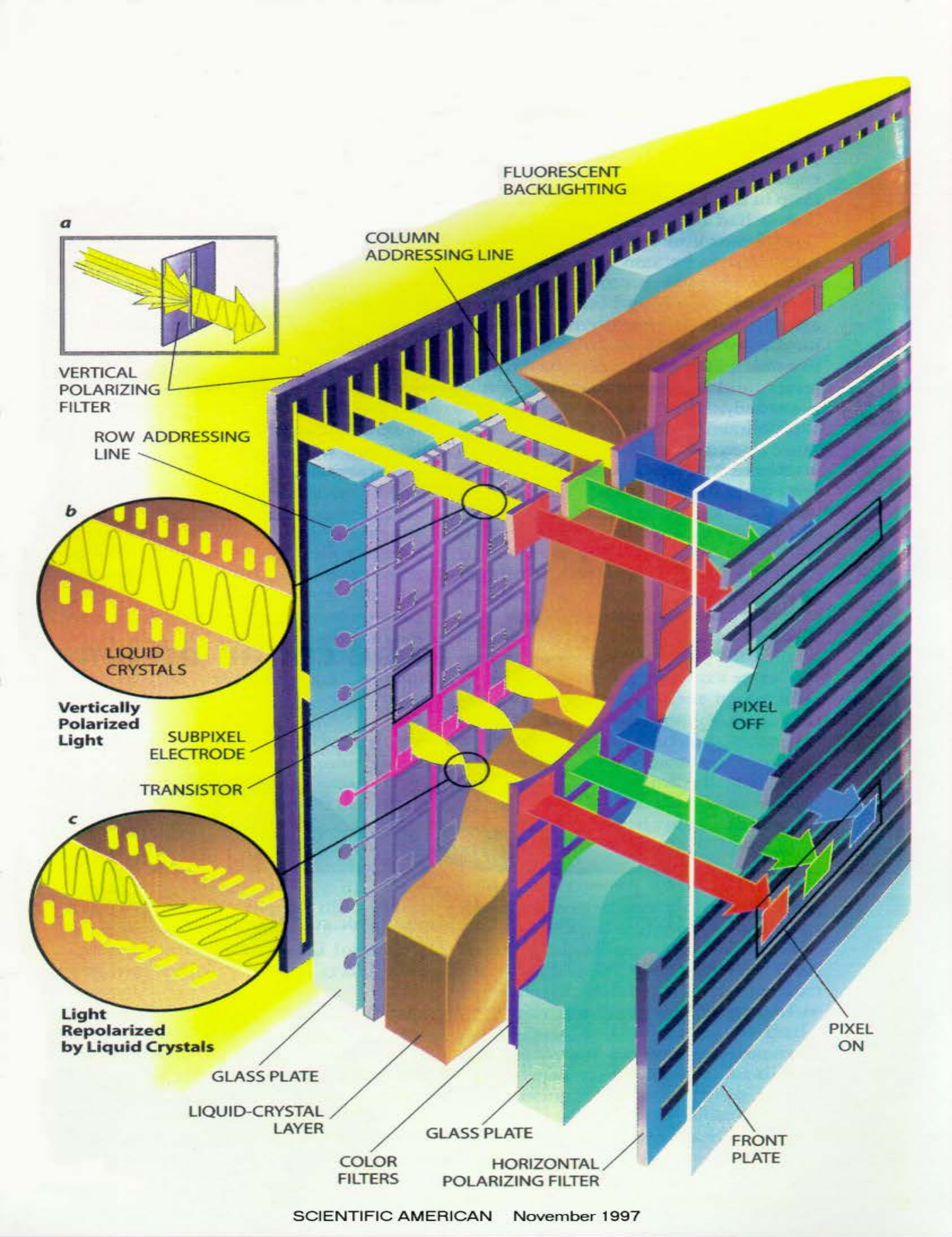


Polarization of Liquid Crystal



Scientific American, November 1997

Liquid Crystal Color Display

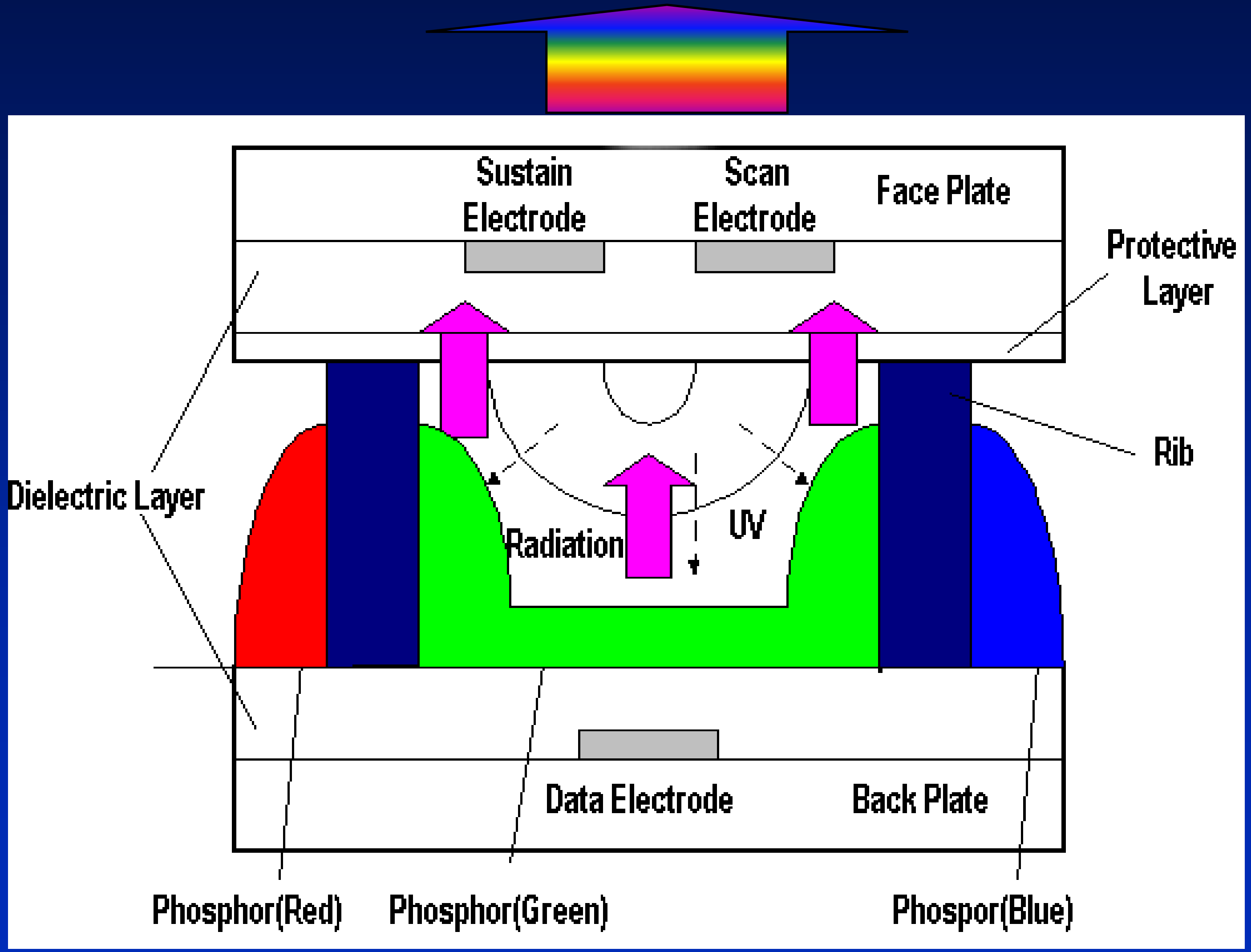


Scientific American, November 1997

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

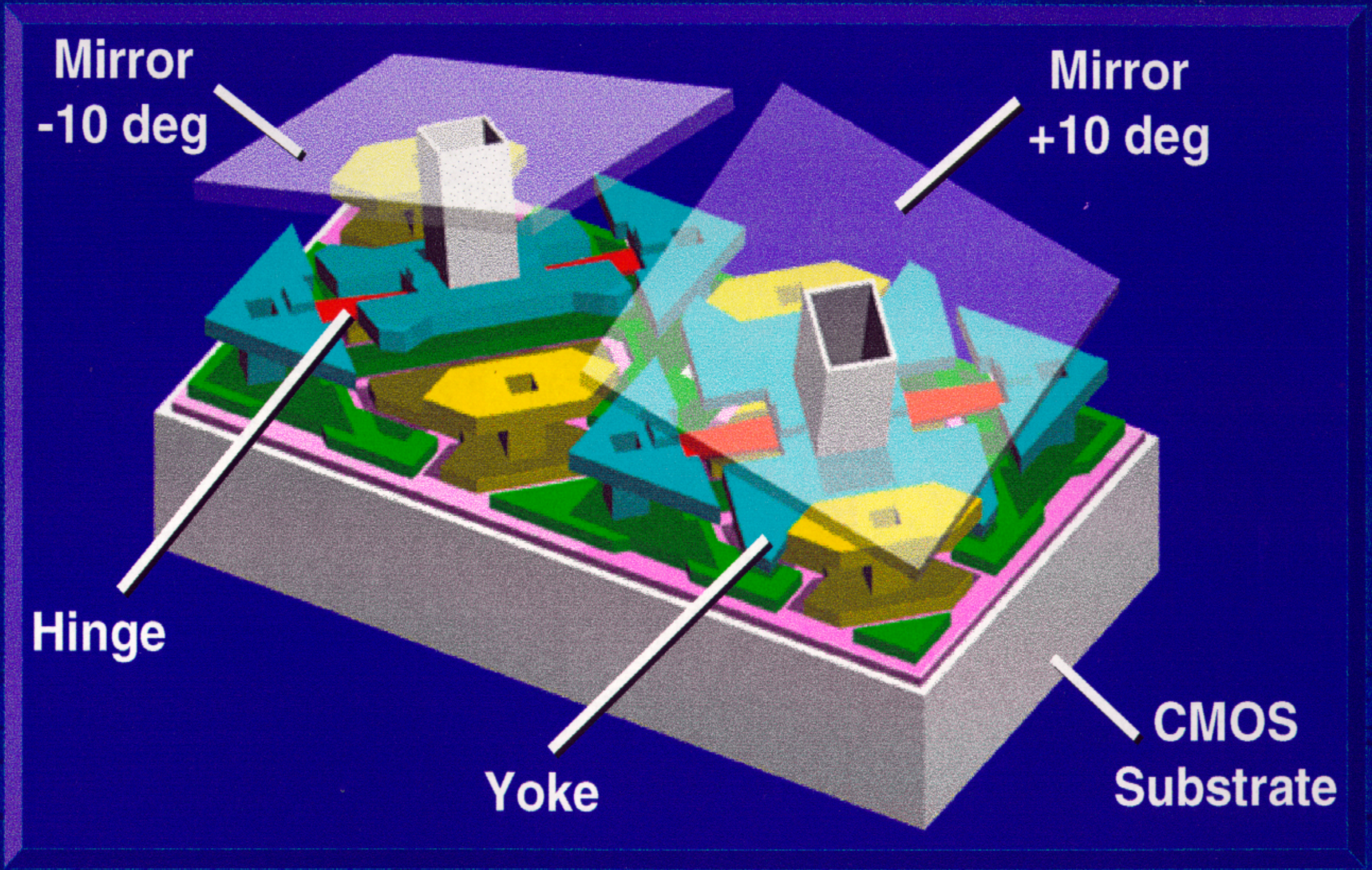
- The advantage is that they can have high brightness (at the expense of watts). Thus can be used in brightly lit areas.

- 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)

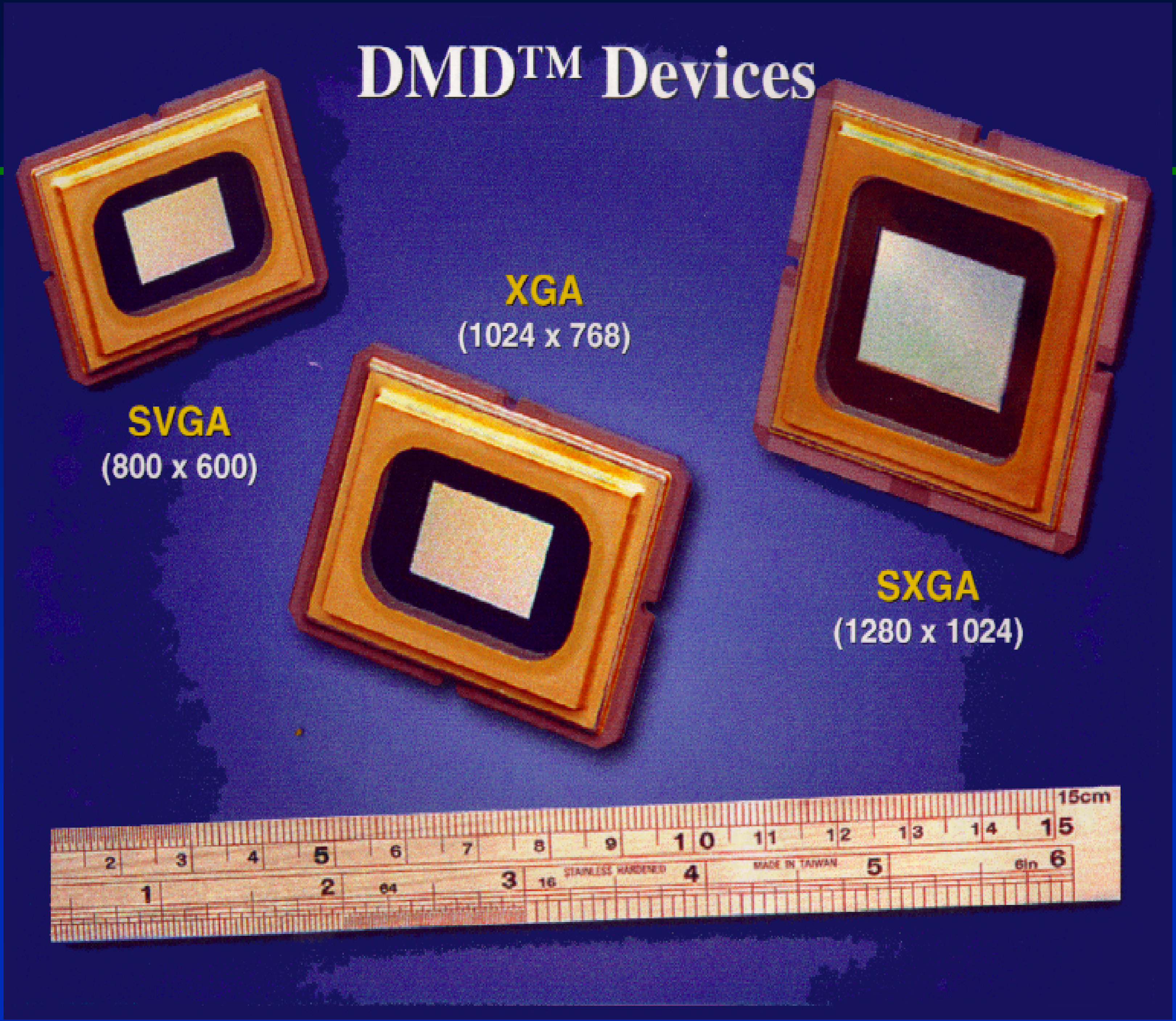
- Pioneered by Texas Instruments. The research on these micromechanical (MEMs) devices started in 1977.
- The first digital light valve projection systems (DLPs) had mirrors measuring 17 microns per side. At 1280 x 1028 resolution (HDTV) this resulted in a rather large chip in 1996.

DMD Structure

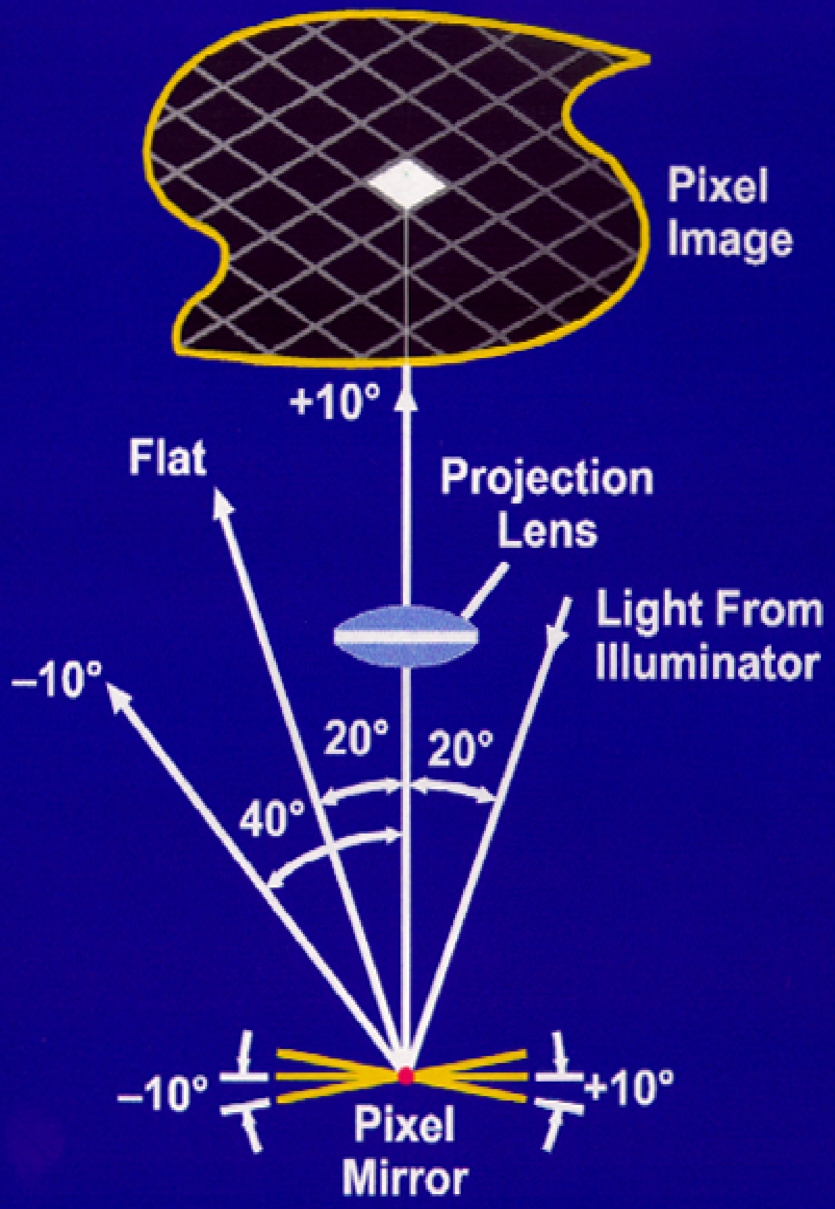


Digital Micromirror Device (DMD™)

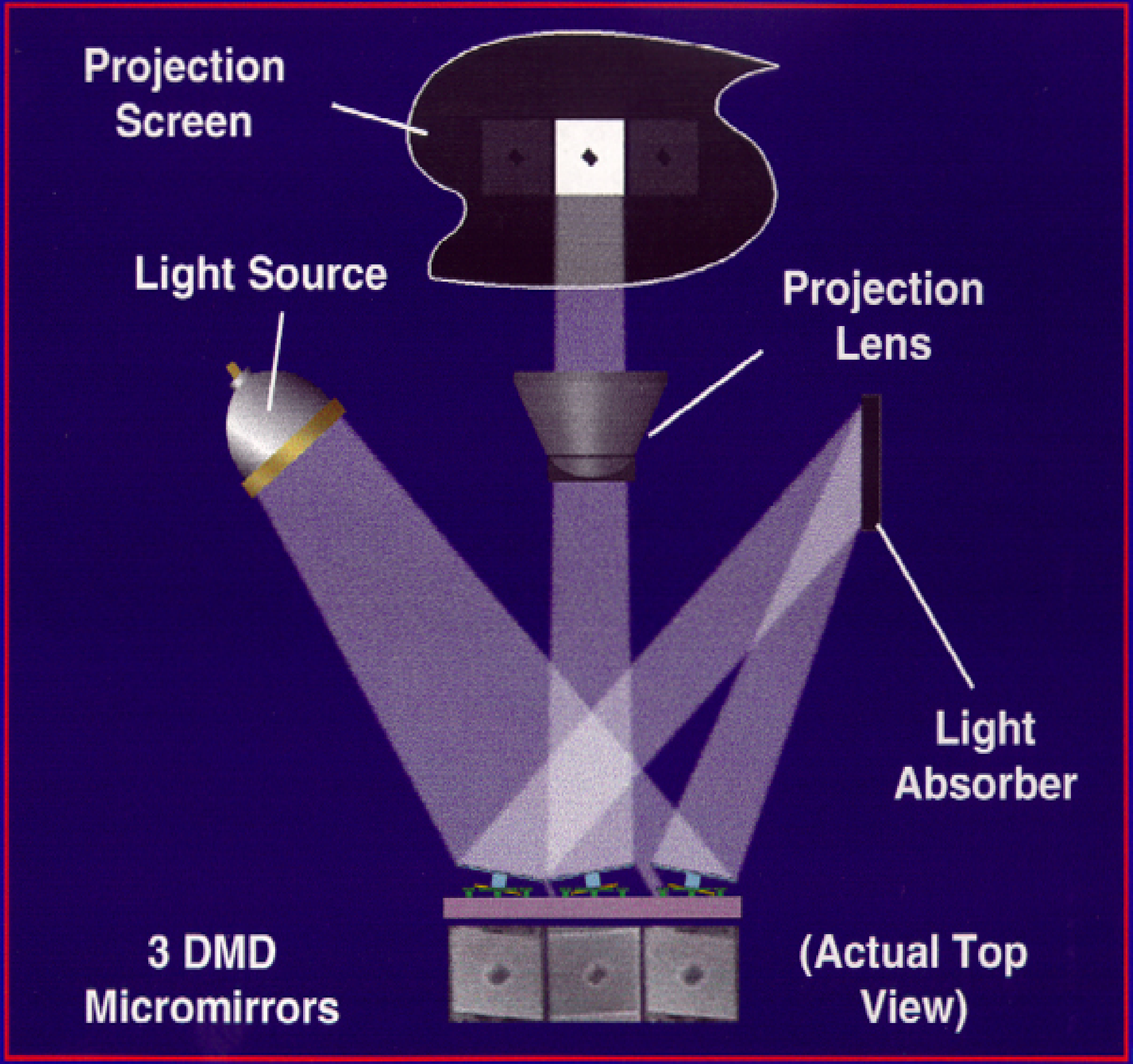
A True Microelectromechanical System


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

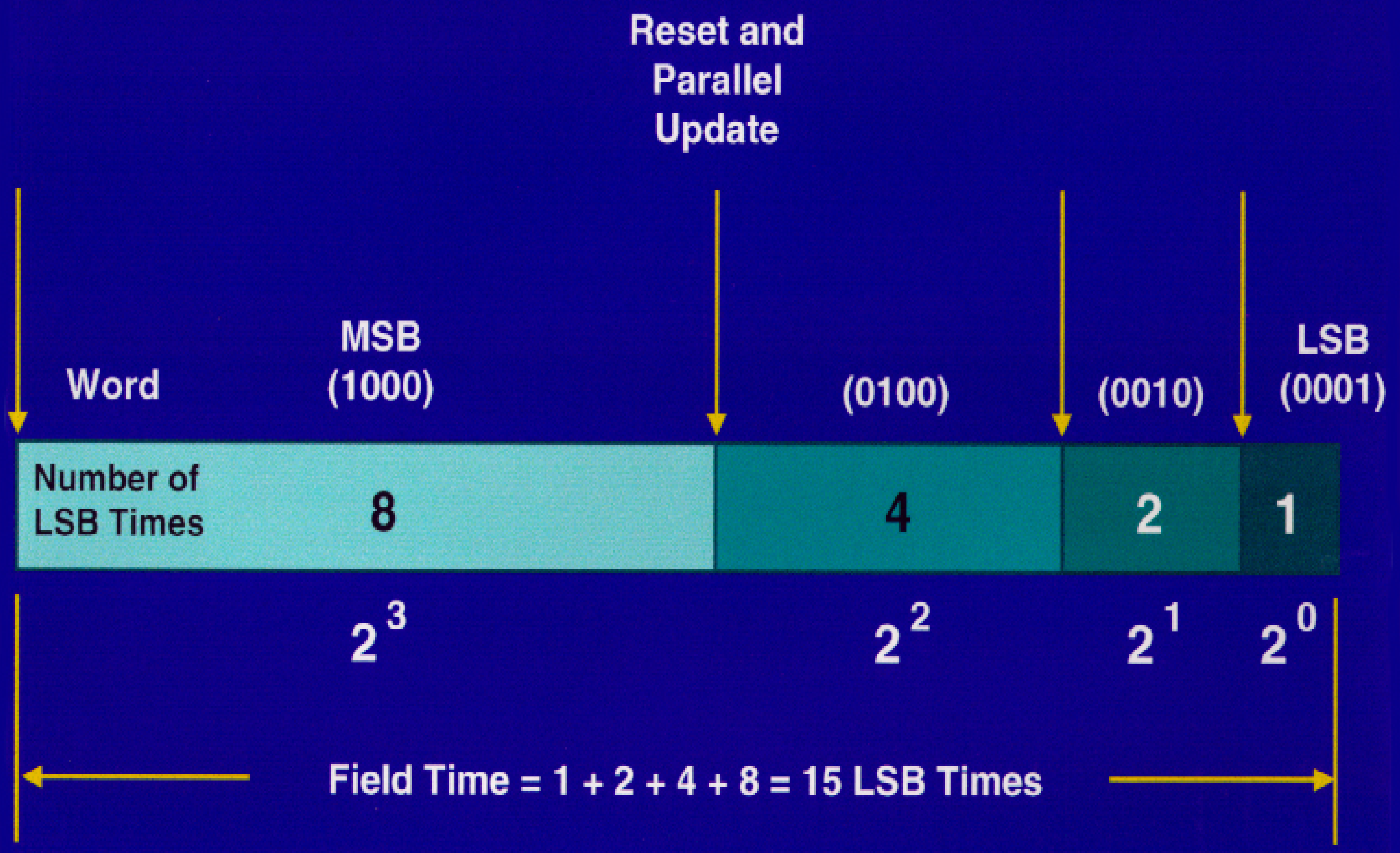


DMD™ Switching Example (1 On)



DMD™ Grayscale Projection

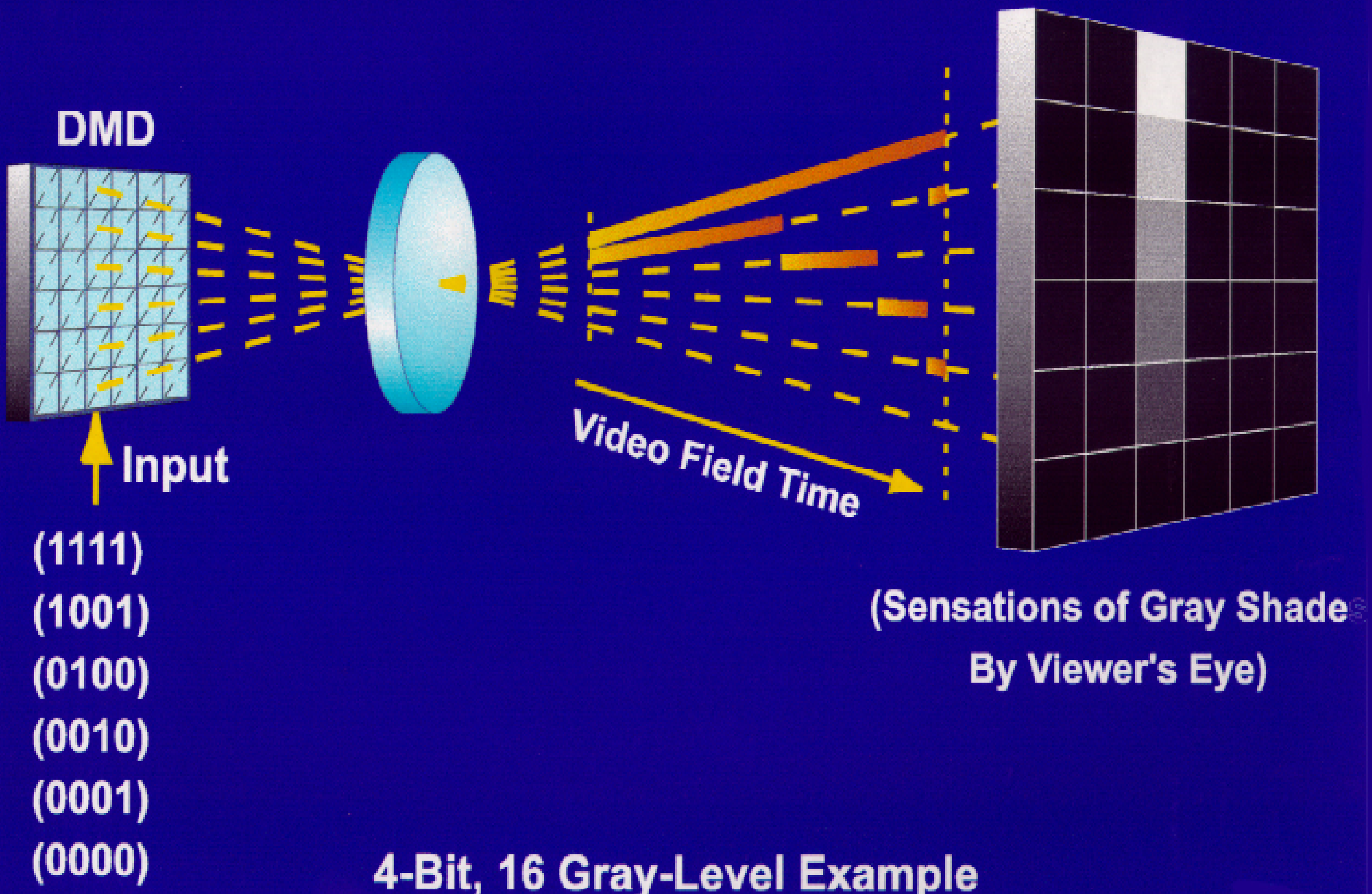
Pulsewidth Modulation



(4-Bit, 16 Gray-Level Example)

How Grayscale is Created

DMD™ Binary Pulsewidth Modulation



4-Bit, 16 Gray-Level Example

Example: Lenna Original

1000

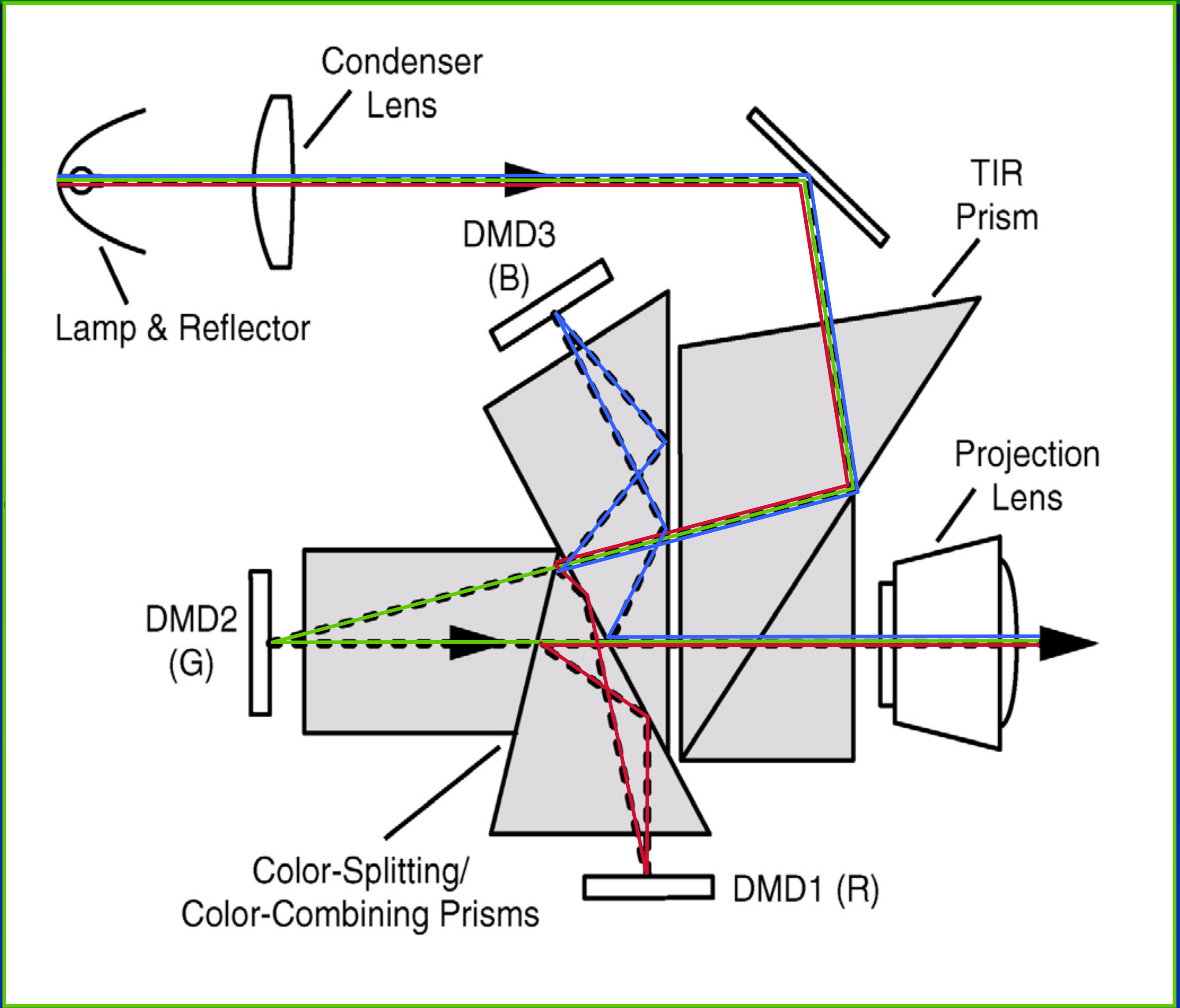
1100

1110

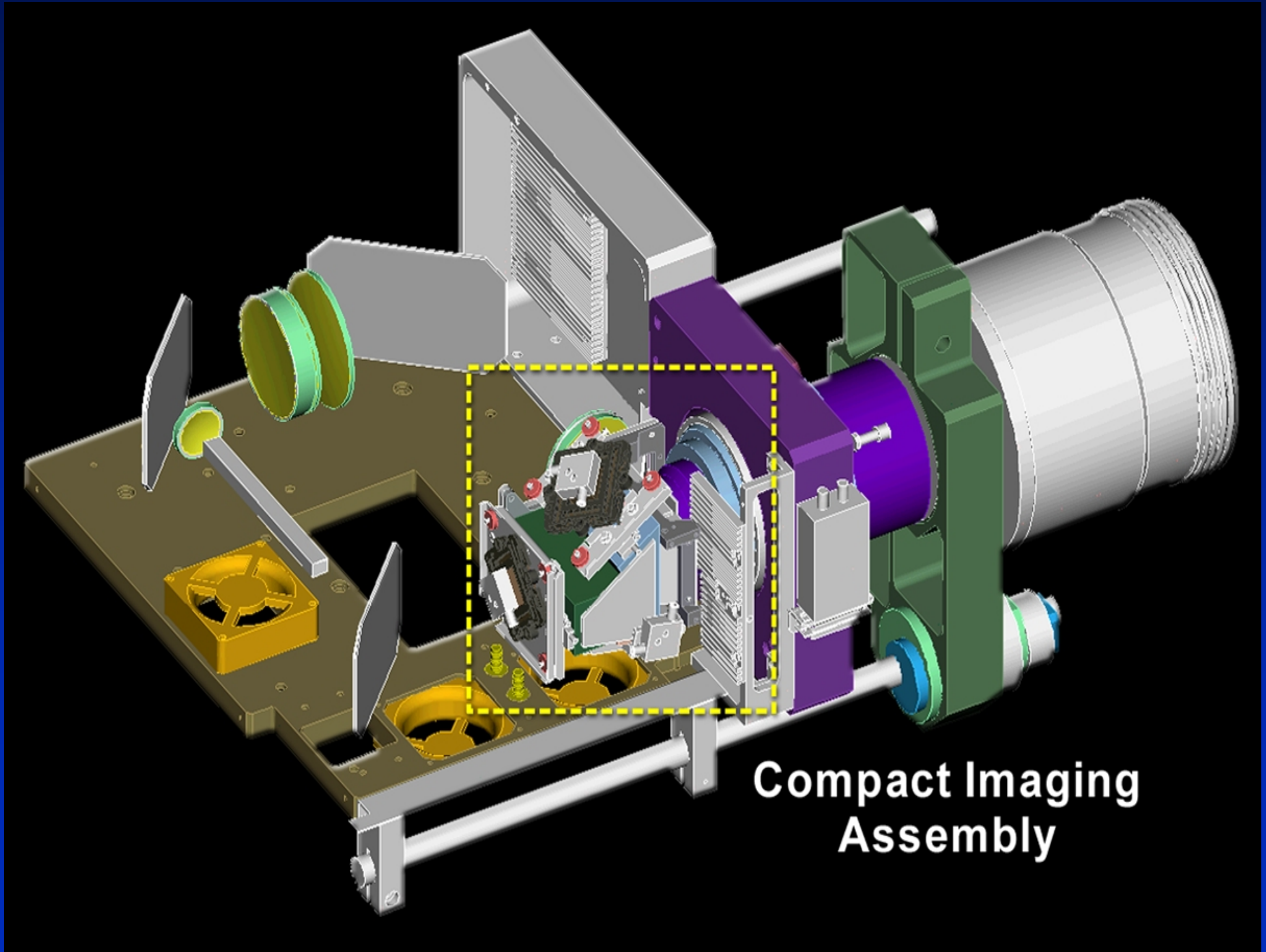
1111

11111111

3-Chip DLP Optical System



DLP Projection System



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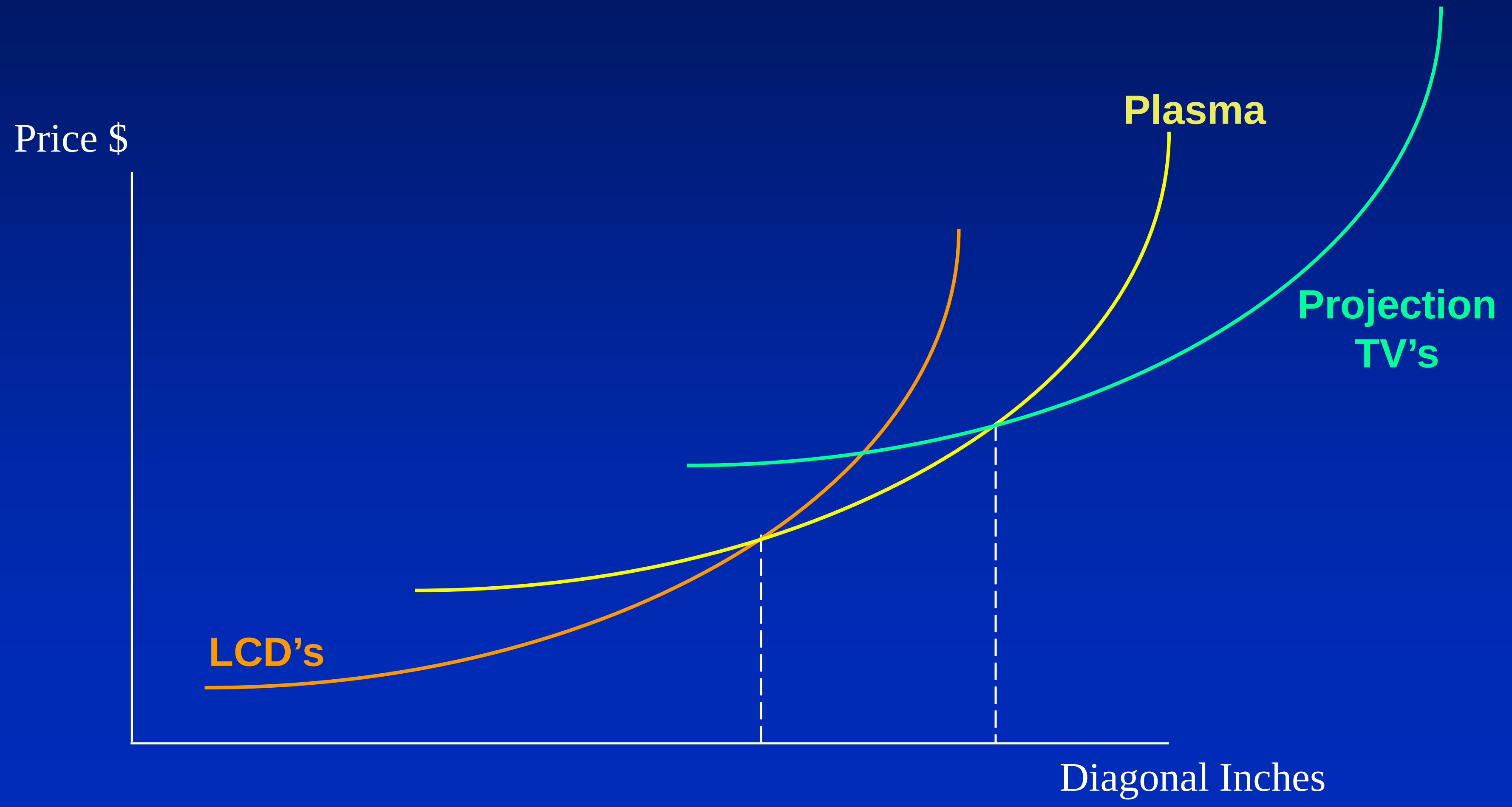
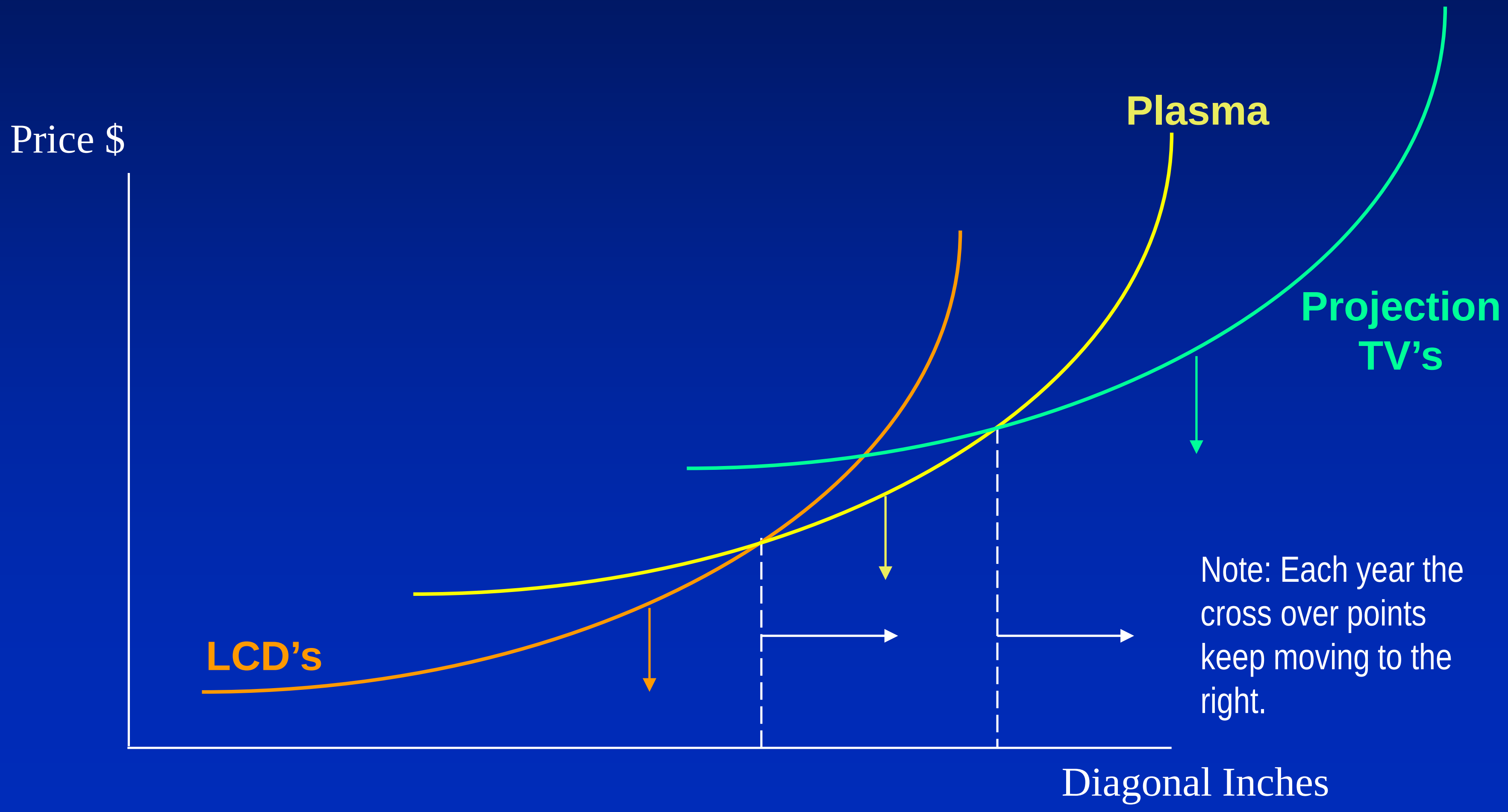
- The first digital light valve projection systems (DLPs) had mirrors measuring 17 microns per side. At 1280 x 1028 resolution (HDTV) this resulted in a rather large chip in 1996.
- Today this technology is used in almost all digital theaters and some home televisions.
- Most theaters now use DLP with 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

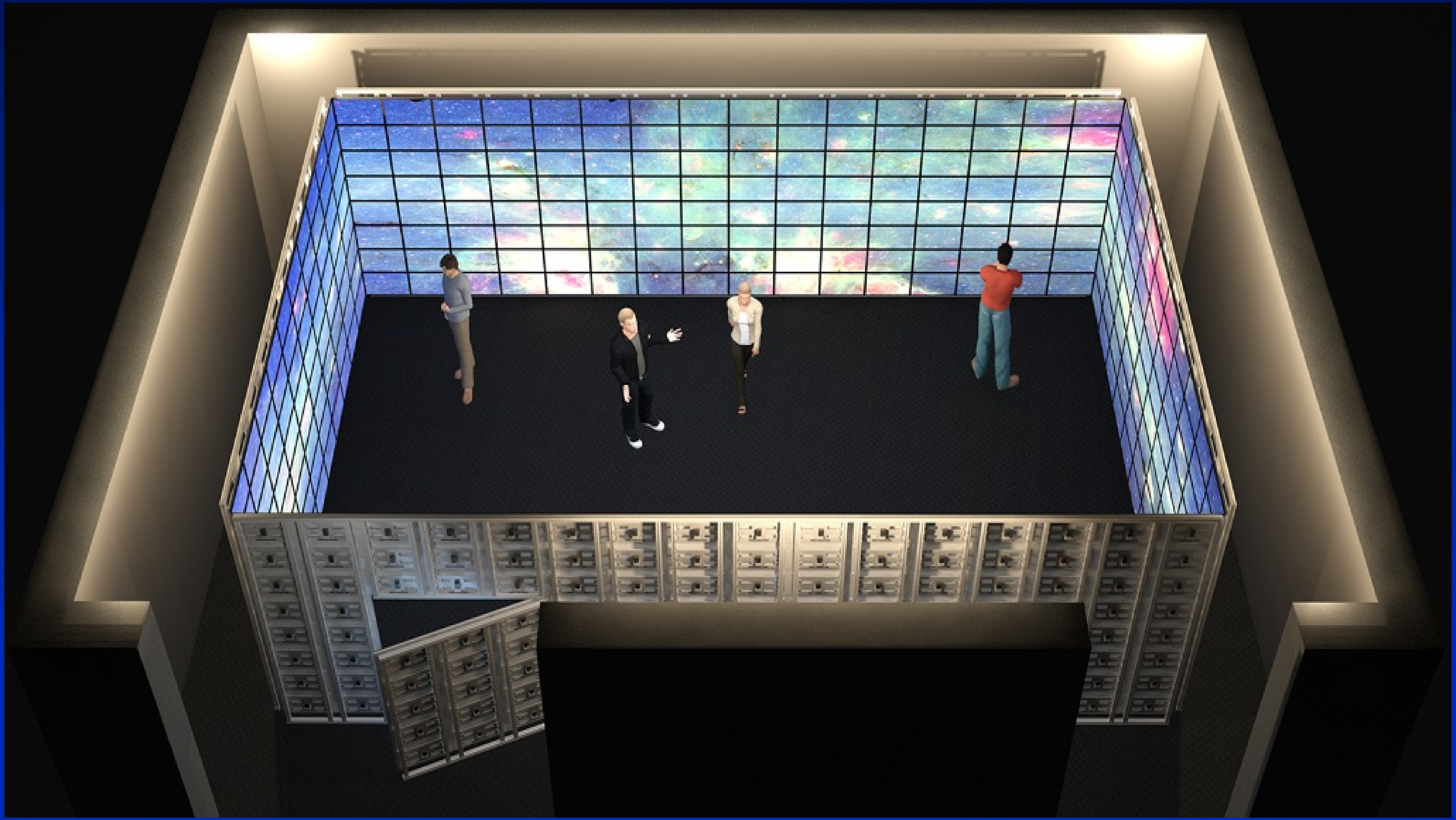
- The quest for size
- The quest for brightness
- The quest for reduced energy
- The quest for mobility
- The quest for resolution

Cornell Panoramic Projection System

NASA Ames Control Room

FutureFlight Center at NASA-Ames

Stonybrook's Reality Deck

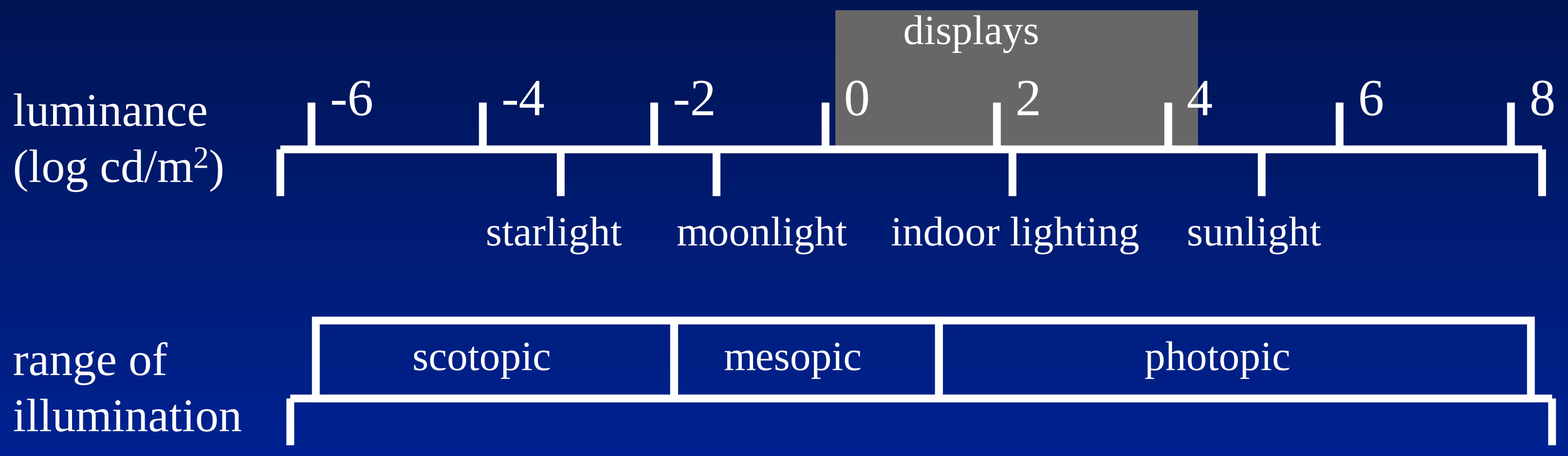


Samsung 110-inch 4K UHD TV 2014

Christie CP4230 Digital Cinema Projector 2018

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

Visual Adaptation



- poor contrast
- no color
- low acuity

- good contrast
- good color
- high acuity

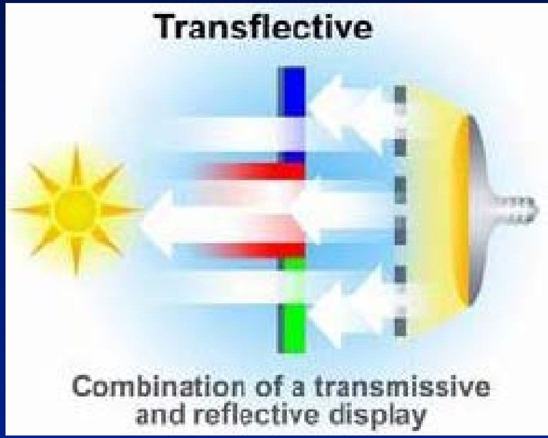
Sunnybrook Display Technology

High resolution
colour LCD

High Dynamic Range
Display

Low resolution
Individually Modulated
LED array

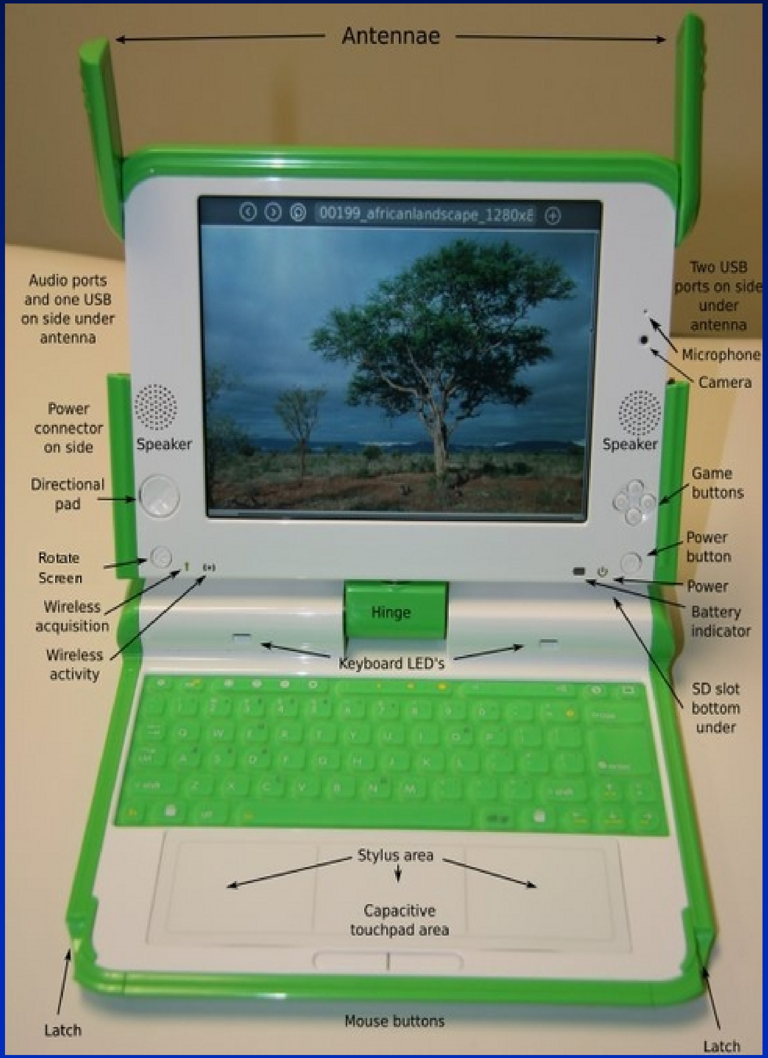
The XO and One Laptop Per Child



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.

OLPC XO-4 Touch August 2013



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

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
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)

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.

Sony OLED

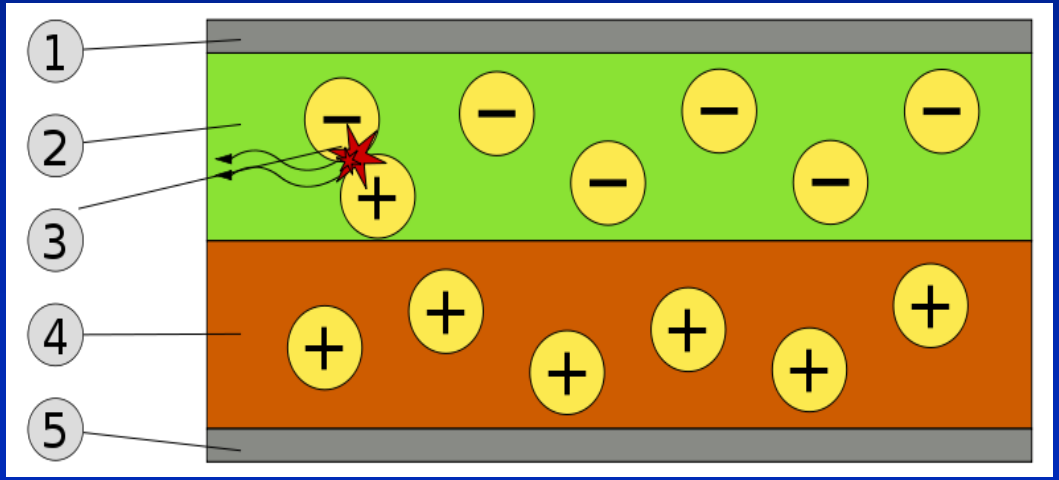
Sony's 2.5-inch, 160-by-120-pixel OLED prototype can be bent into a semicircle while playing full-motion video

May 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).

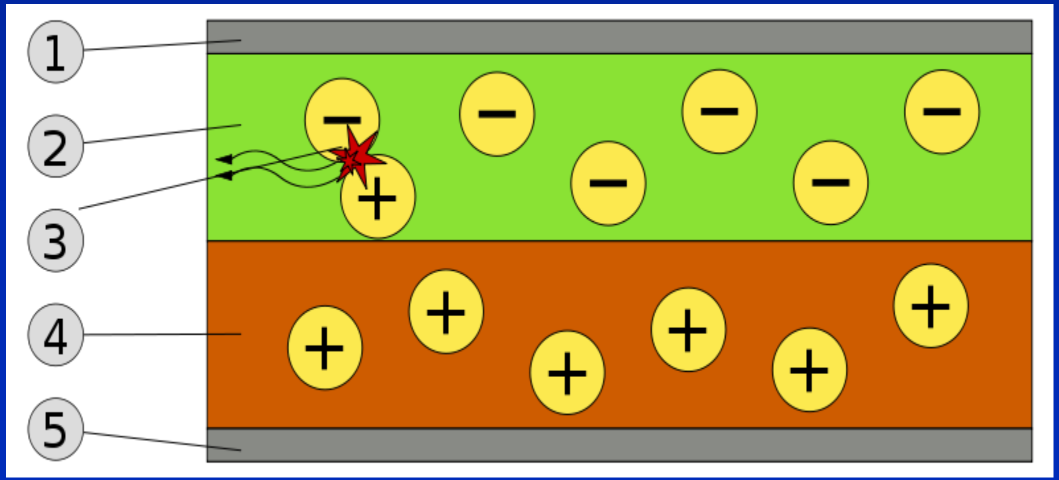


OLED Explanation

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.



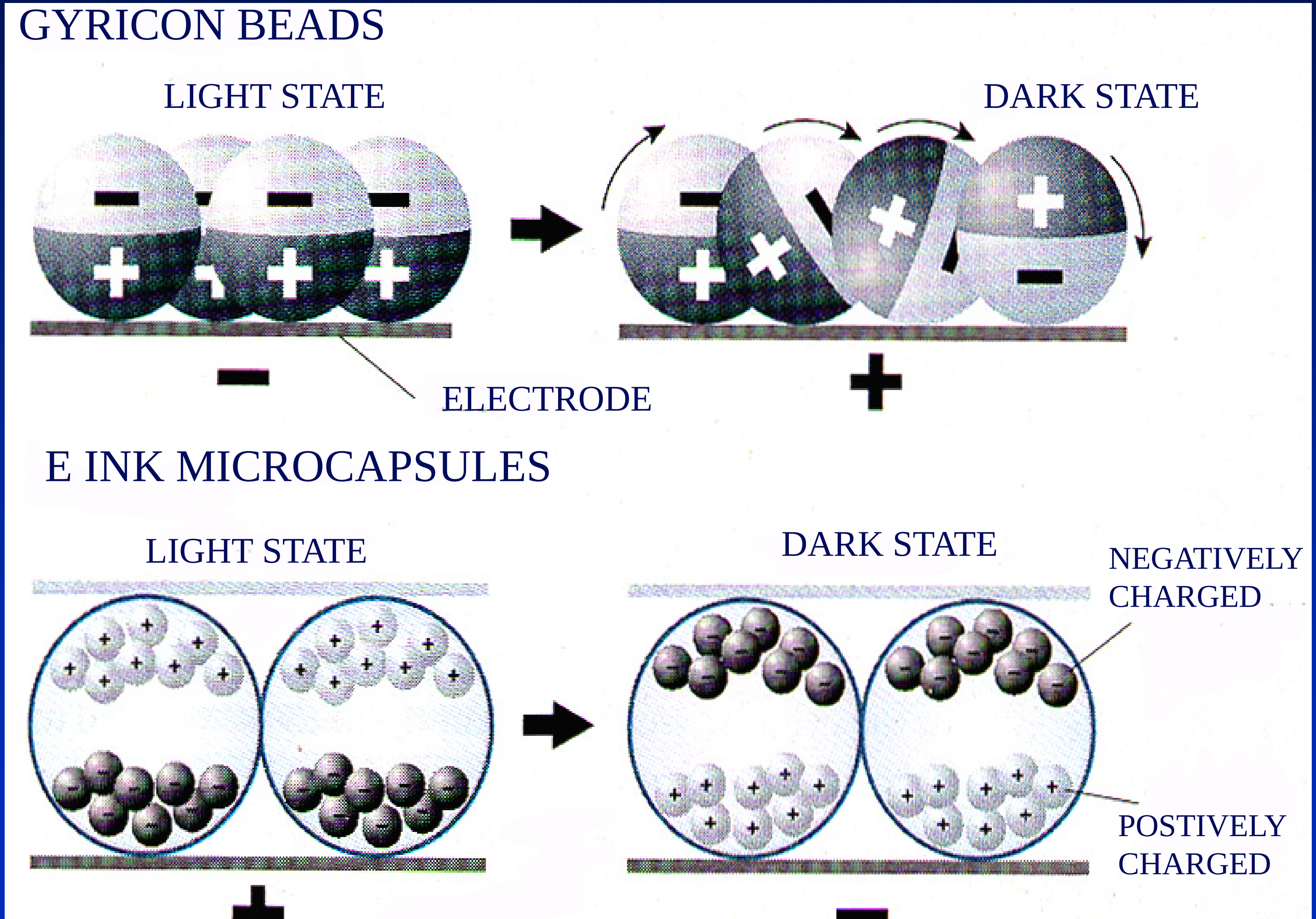
Sony 27-inch OLED Panel 2007

SAMSUNG's 55" OLED Display 2012

Samsung Curved OLED TV

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

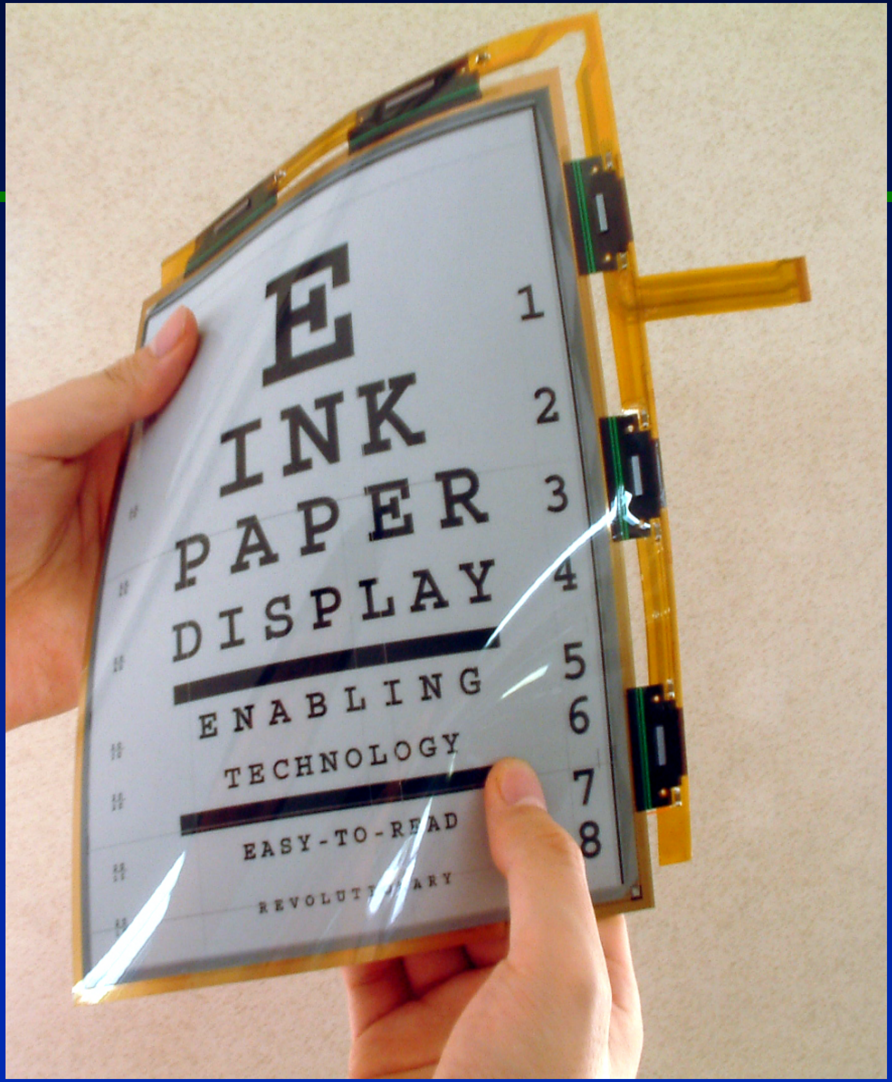
How E-Paper Works



Scientific American, 11/2001, p. 54.

Nick Sheridon, Xerox PARC inventor of electronic reusable paper, and Fereshteh Lesani show off the first roll produced by 3M partners.

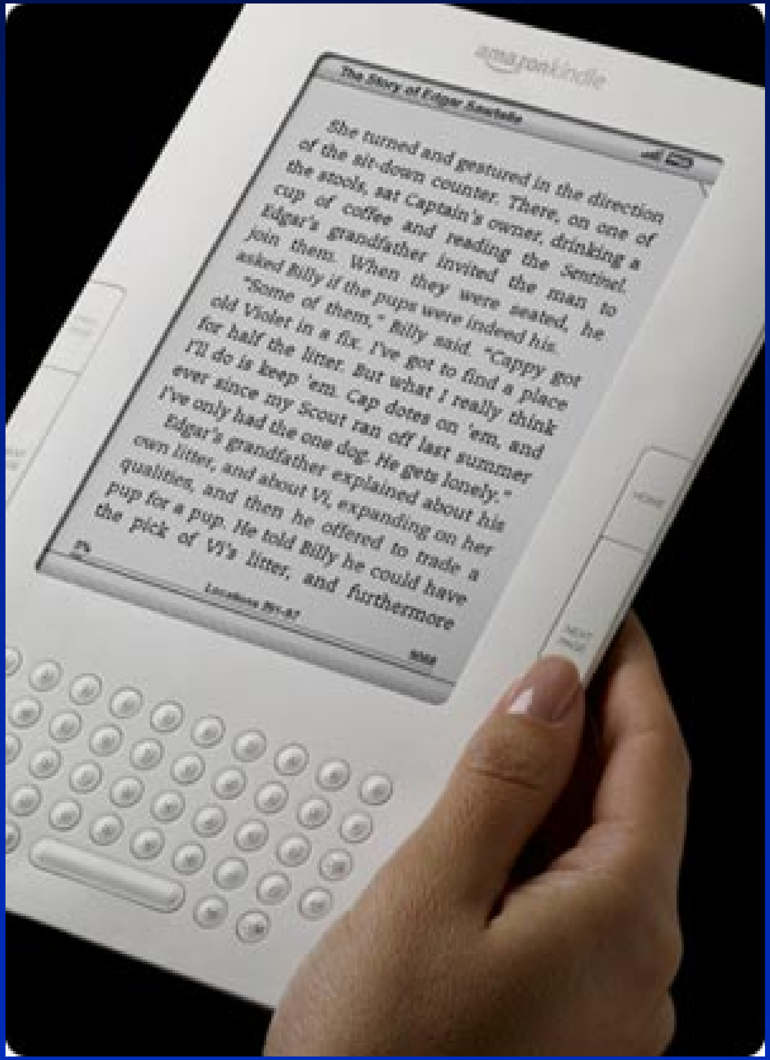
http://www2.parc.com/hsl/projects/gyricon/

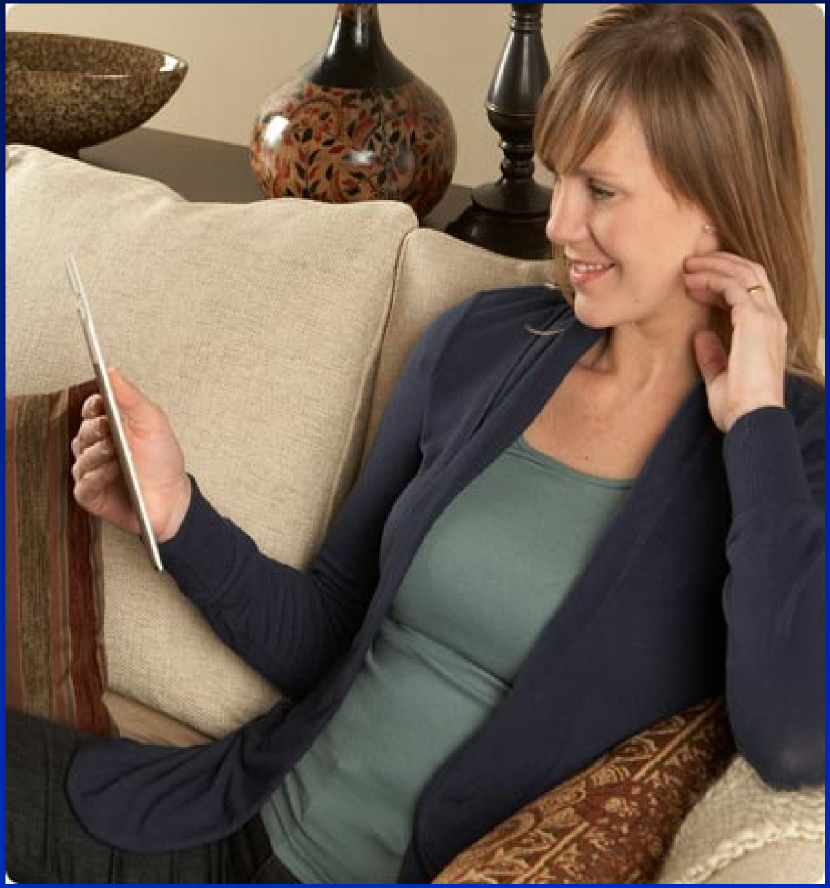


Flexible Tablet-Sized Display From L.G. Philips LCD and E Ink Corporation

http://www.eink.com/

Kindle 2

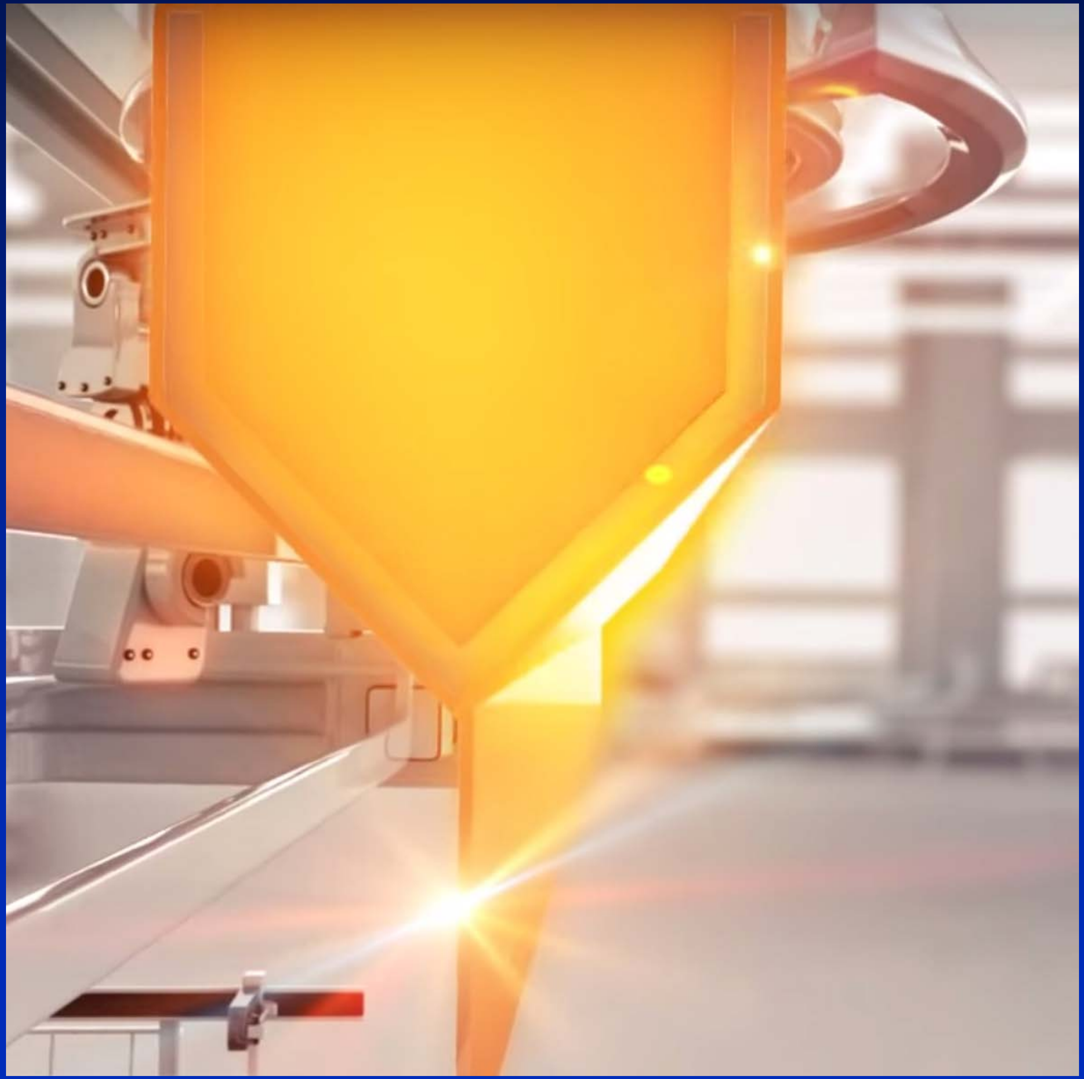




http://www.amazon.com/Kindle-Amazons-Wireless-Reading-Generation/dp/B00154JDAI

Corning

Corning Fusion Process



Modifications to Existing Technology

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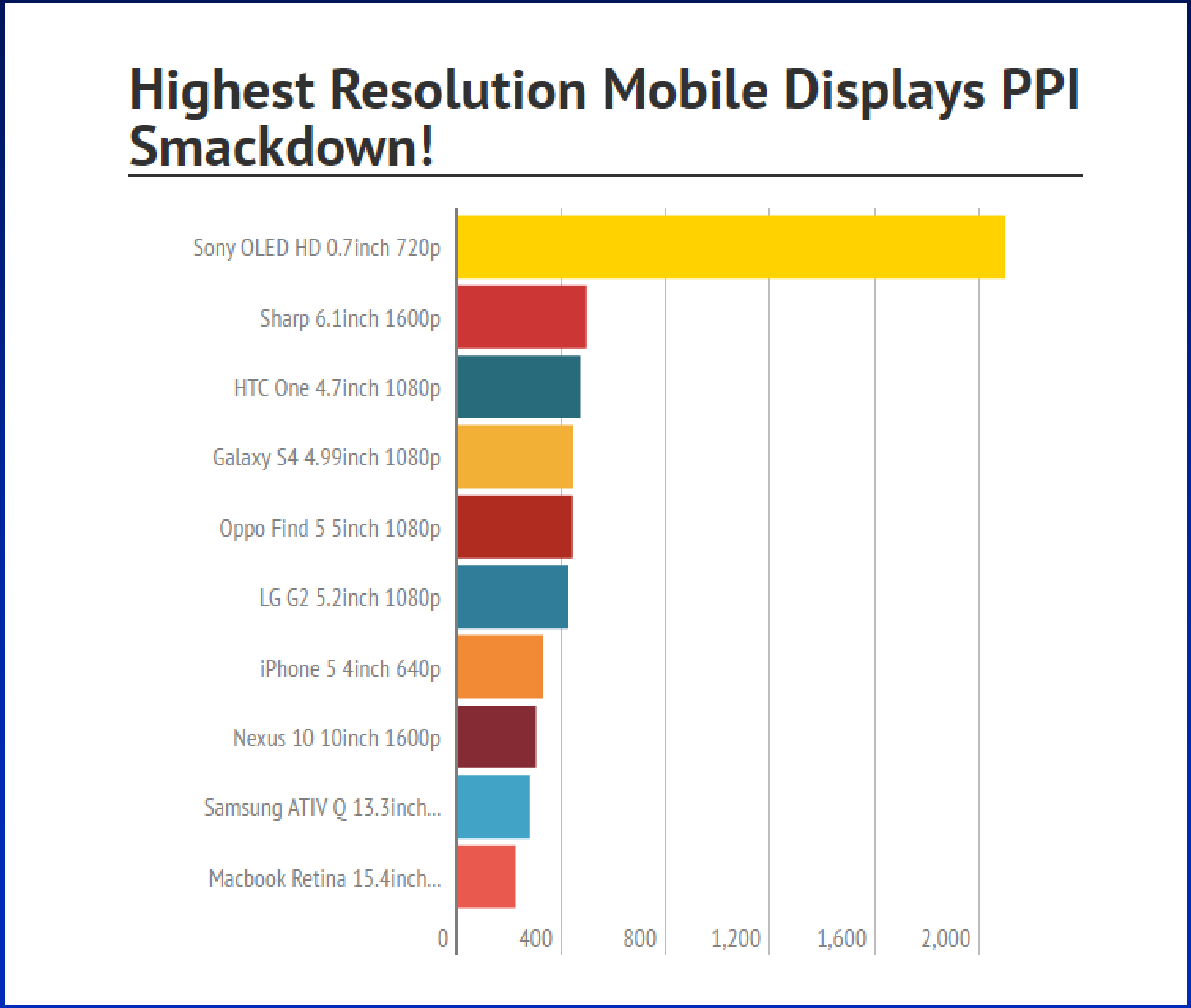
- The quest for mobility
- The quest for resolution

Dell’s UltraSharp Display 2017

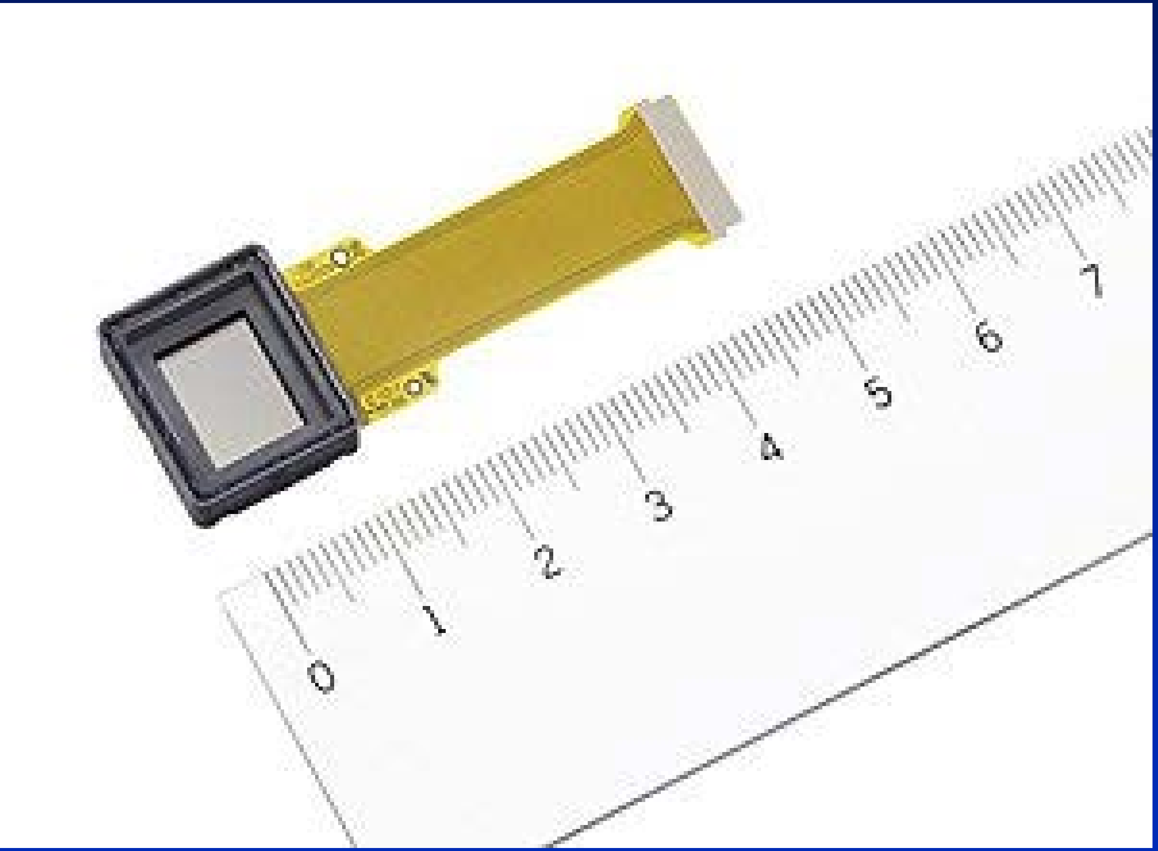
$3,699.99
7,680 x 4,320 resolution

LG 88-inch 8K Display 2018

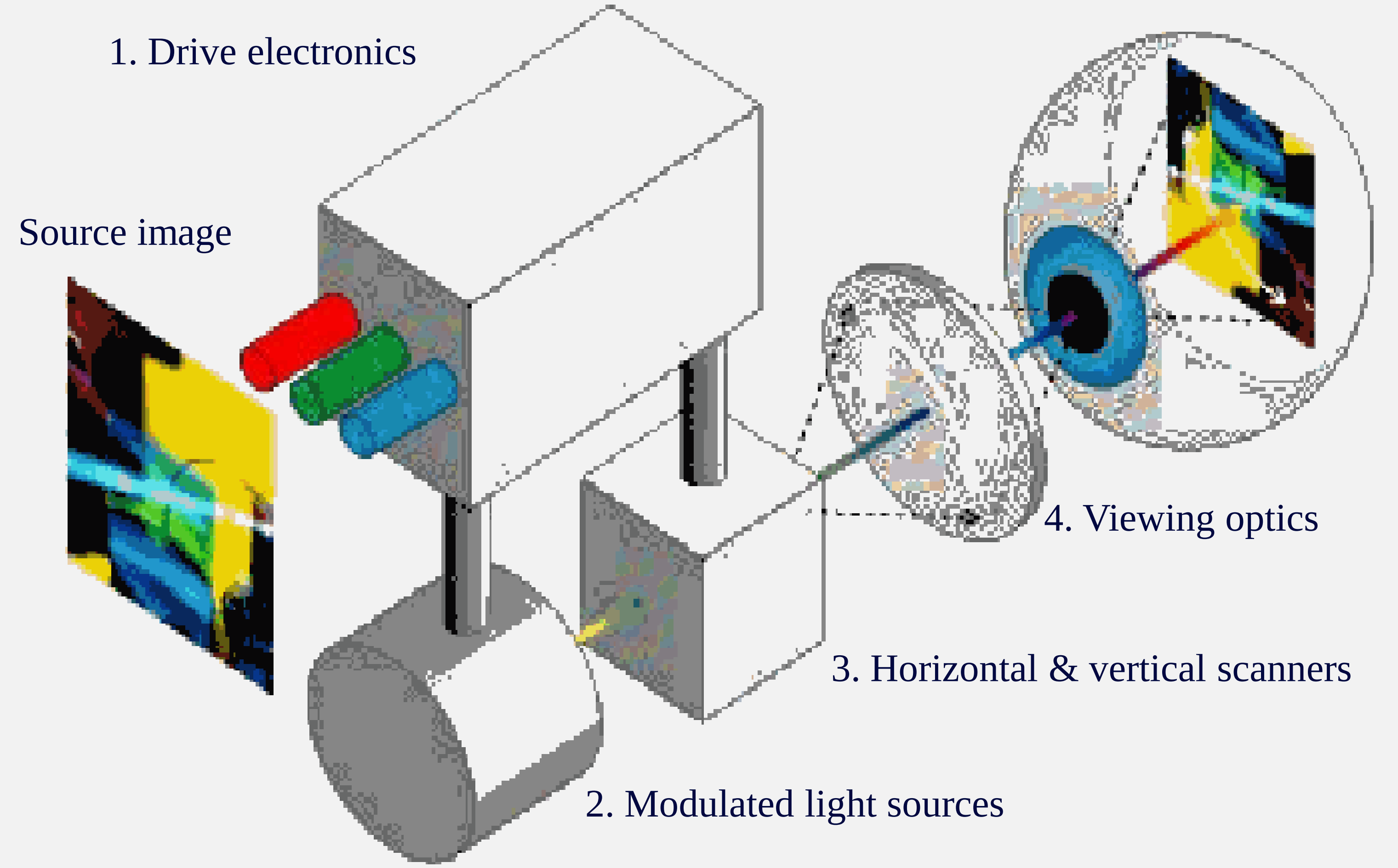
Sony's 2098 ppi 9/29/2016



Sony 2016

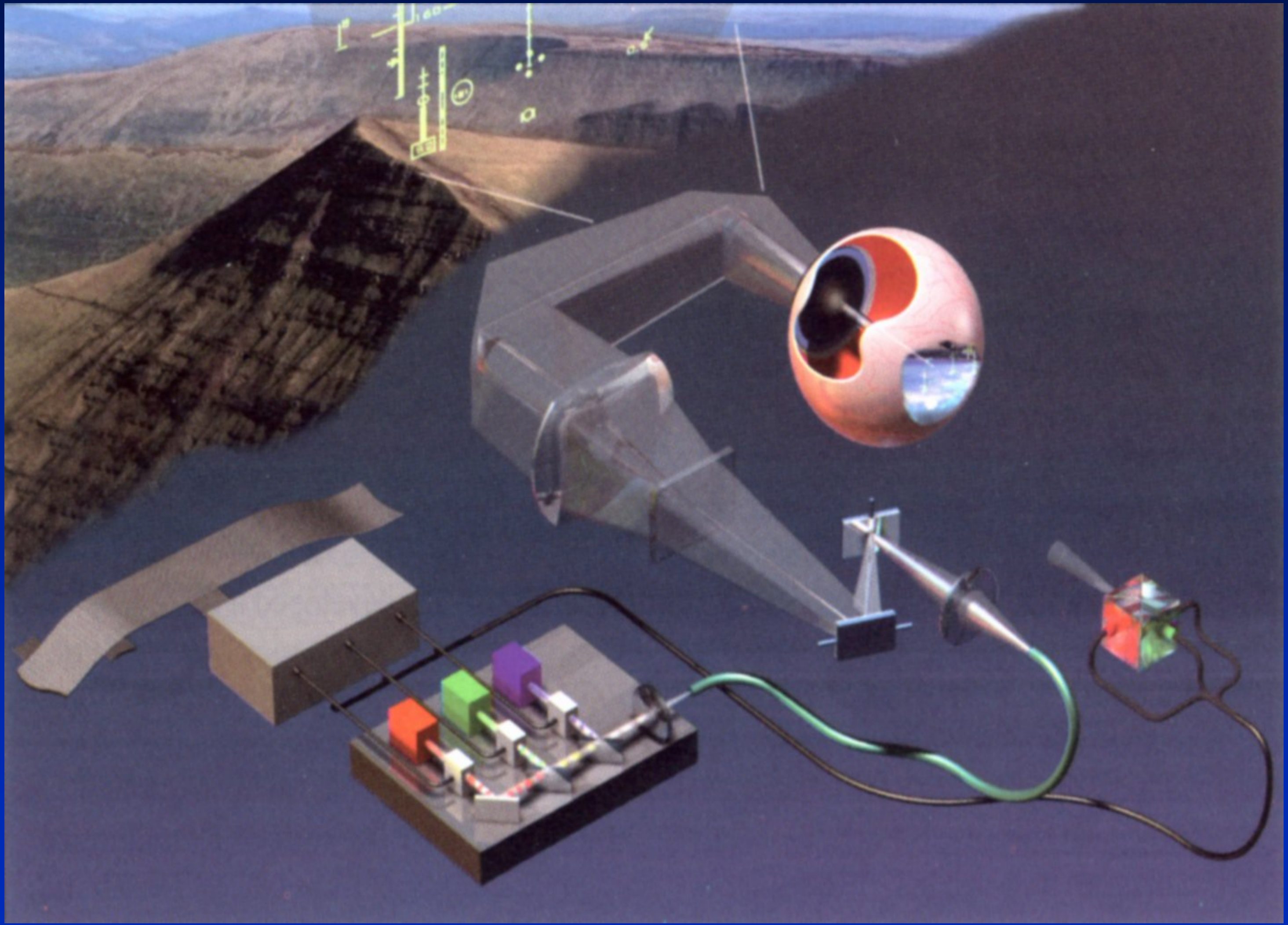


Retinal Displays



Virtual Retinal Display primary components.

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

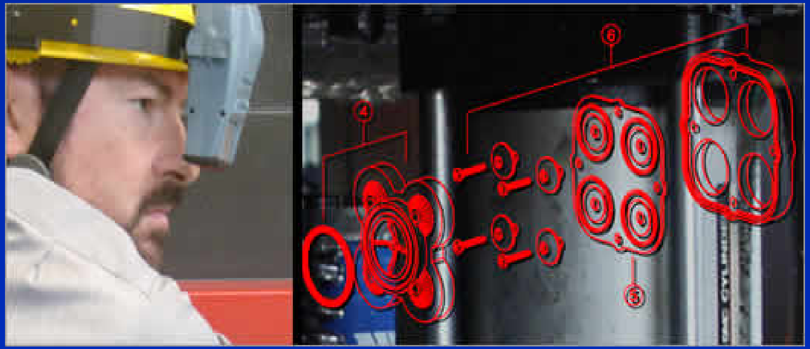


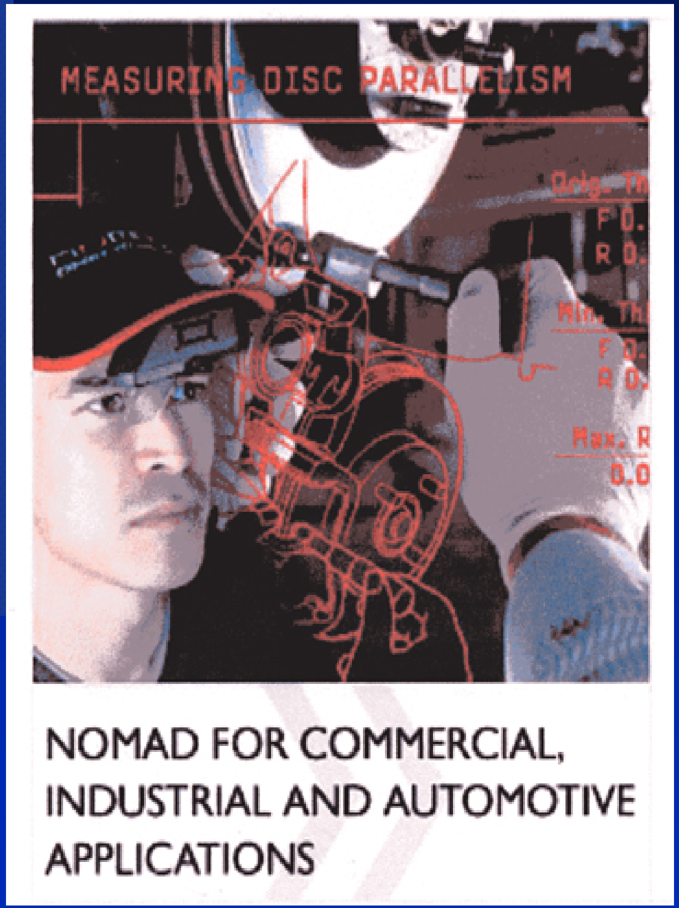
Information Display, “A Helmet-Mounted Laser Display,” January 2000, vol. 16, no. 1, p. 13.

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

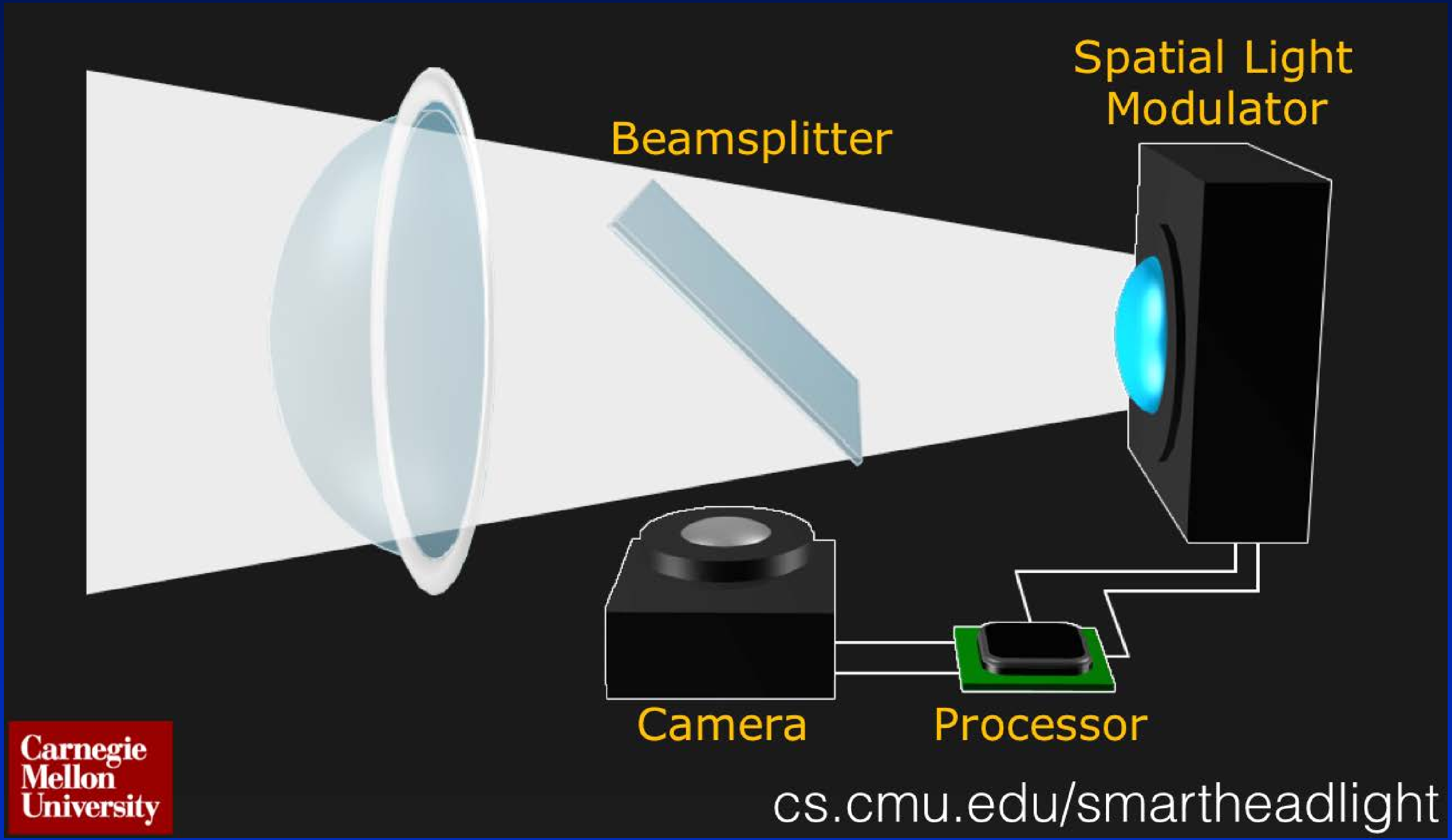




http://www.microvision.com/nomad/

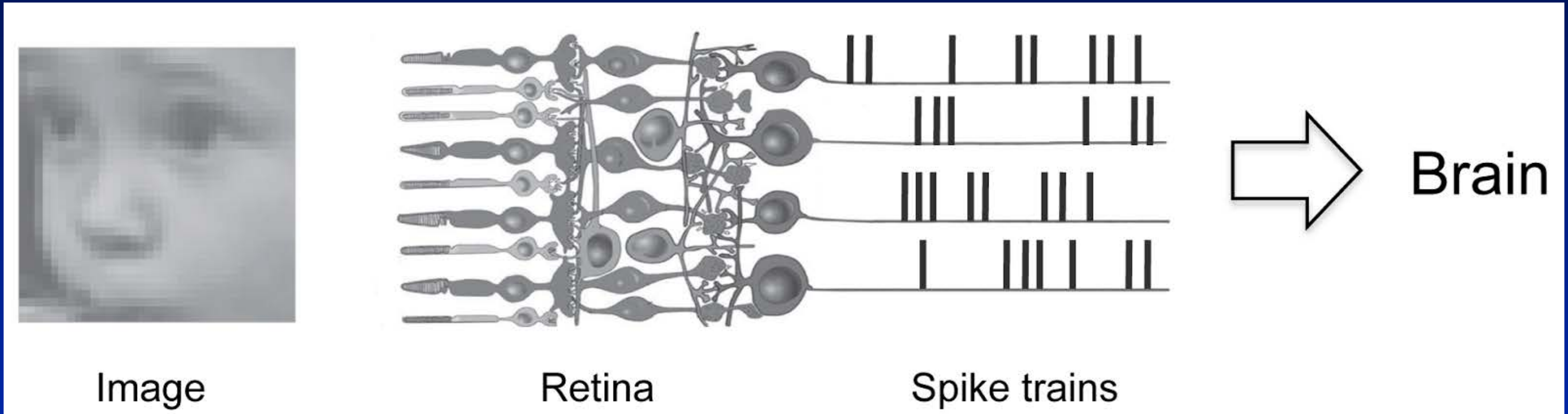
Headlights- Carnegie Mellon

Smart Headlight

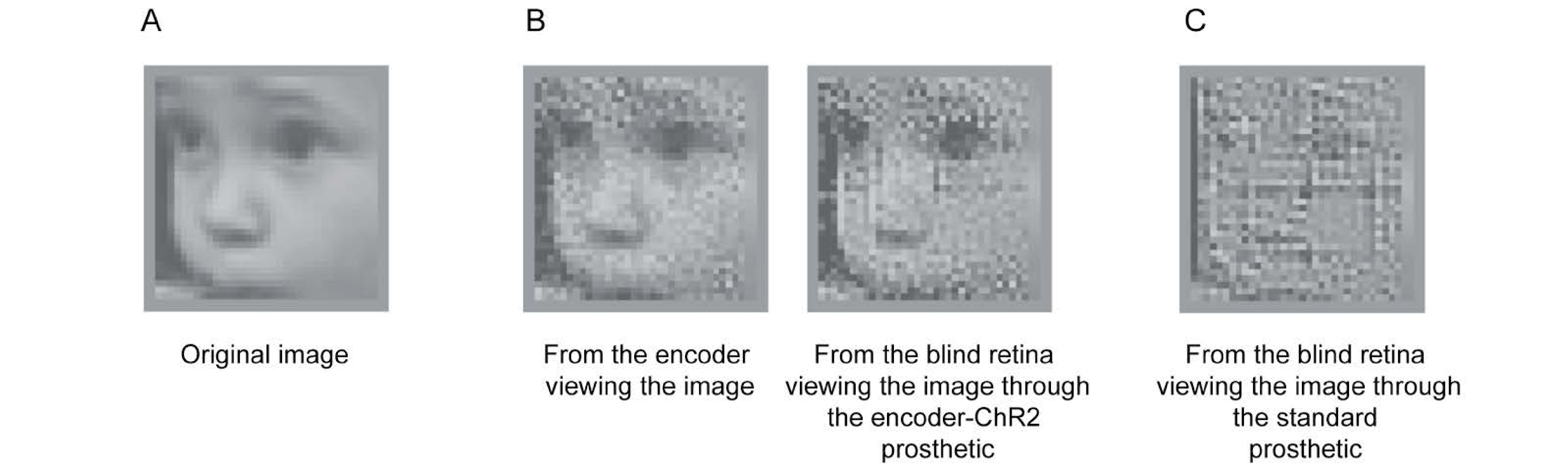


Smart Headlights

Retinal Prosthetics Arons 2013



Retinal Prosthetics Arons 2013



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