나노 기술의 이해
(Understanding Nanotechnology)

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Lecture 13.
Nanotechnology applications (3)

Display & Data storage

Display

Flat Panel Display (FPD)

The market shares of the Flat Panel Displays is increasing:

- **World market of $100 billion in 2005**

Two needs:

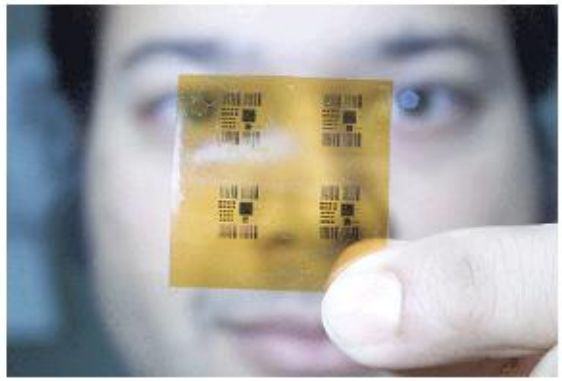
- **Large displays with low resolution**
- **Microdisplays with large resolution (portable systems):**
  - Laptop, mobile phones, PDA, e-book, GPS, watches, smart card

Today, LCDs dominate the FPD market :

- **89 % of the FPD market in 2000 (laptop, PDA, mobile phones)**

Competitive technologies

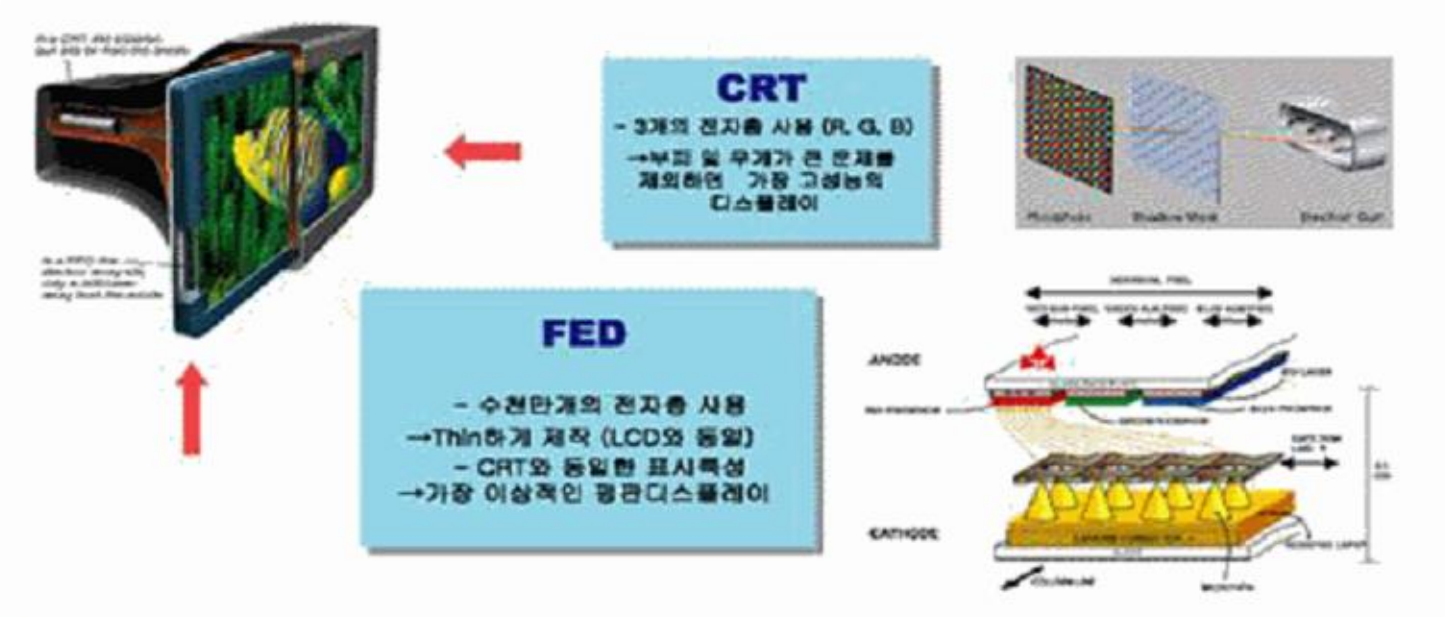
- **Field Emission Dispalys (FED)**
- **OLED**
- **Micro-mirror arrays (MMAs)**
- **Plasma Displays Panels**



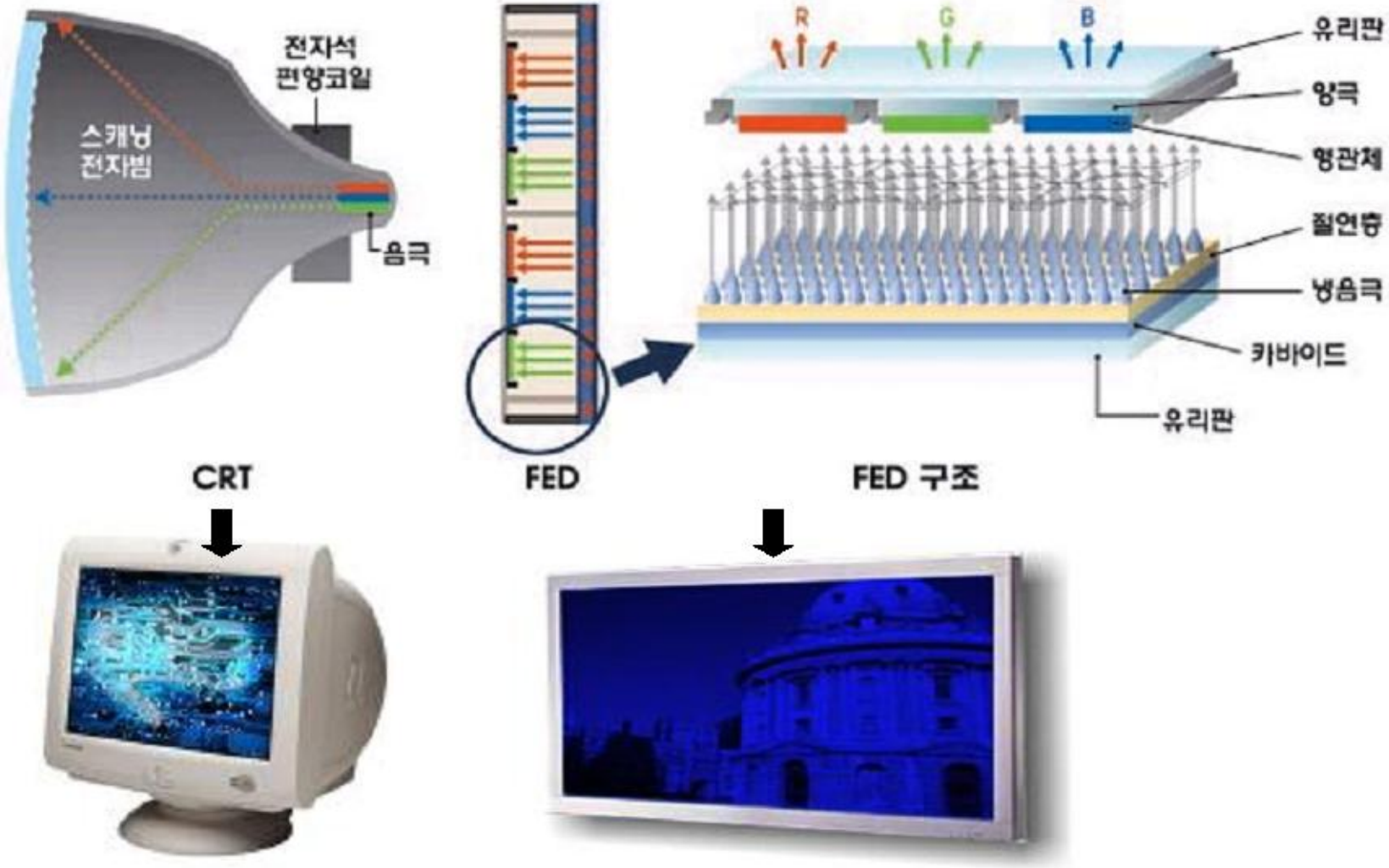
Field Emission Display (FED)

- **FED(전계방출 디스플레이)는 금속 또는 반도체로 만들어진 극미세 구조의 전계방출 캐소드에 전기장을 인가하여 진공 속으로 방출되는 전자를 형광체에 충돌시켜 화상을 표시.**

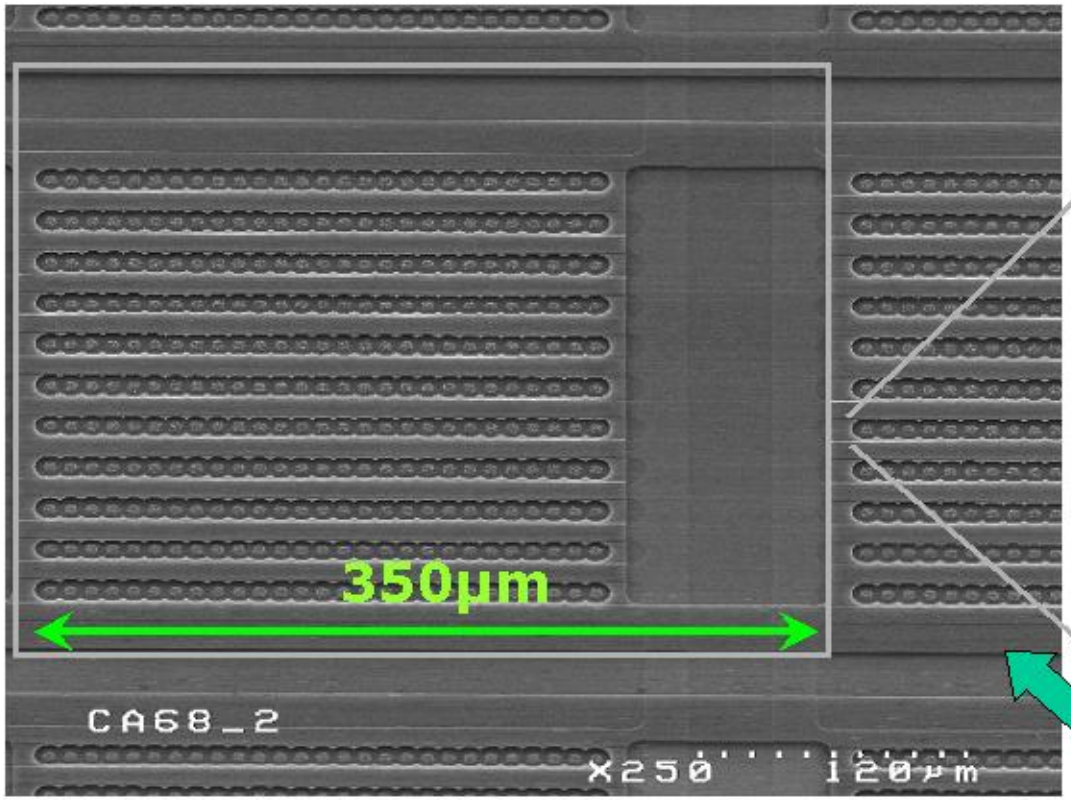
- **CRT(브라운관)의 우수한 표시특성을 그대로 살리면서 경량, 박형화가 가능한 차세대 평판 디스플레이("Thin CRT" 라고도 부름)로서, 광시야각, 저 소비전력, 빠른 응답속도, 고해상도, 고화질, 넓은 사용온도 범위 등의 장점을 가짐.**

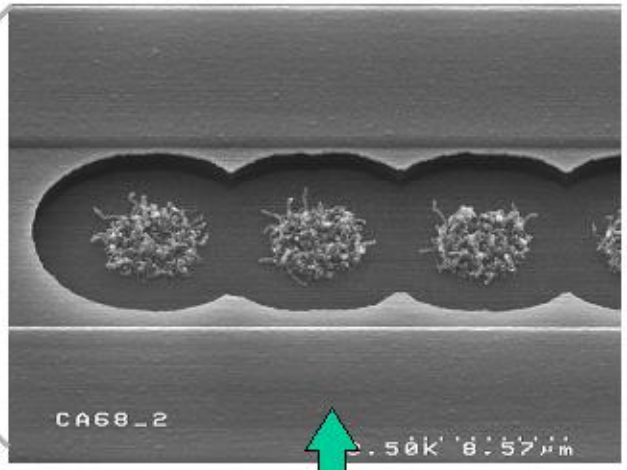


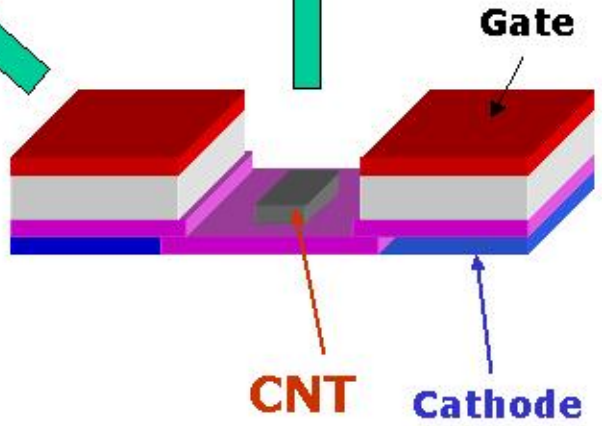
Field Emission Display (FED)



Carbon Nano tubes as emitters in FED





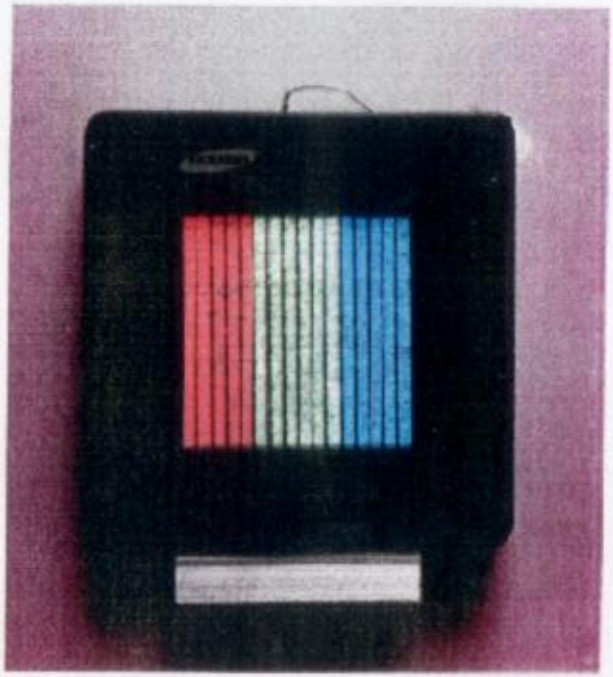


<Pixel Structure>

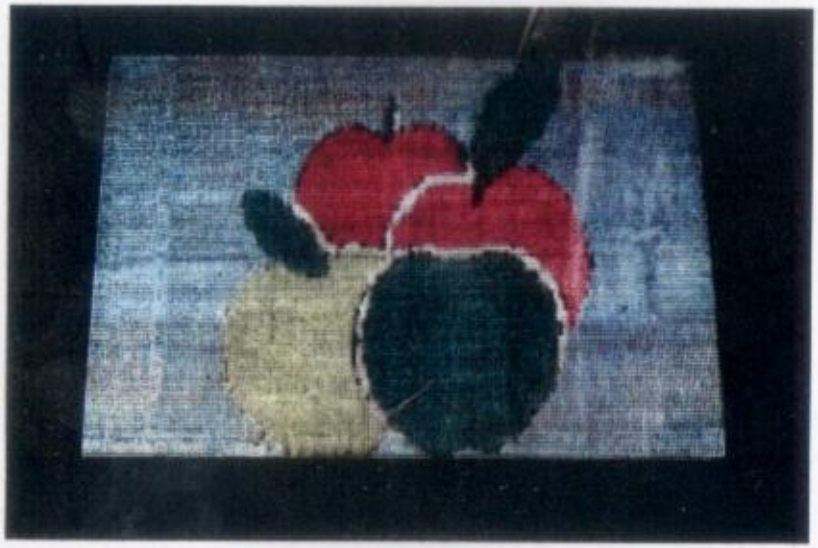
- No critical photolithographic step
- Only 3 masks

Carbon Nano tubes as emitters in FED

Carbon Nanotube Full-color Display



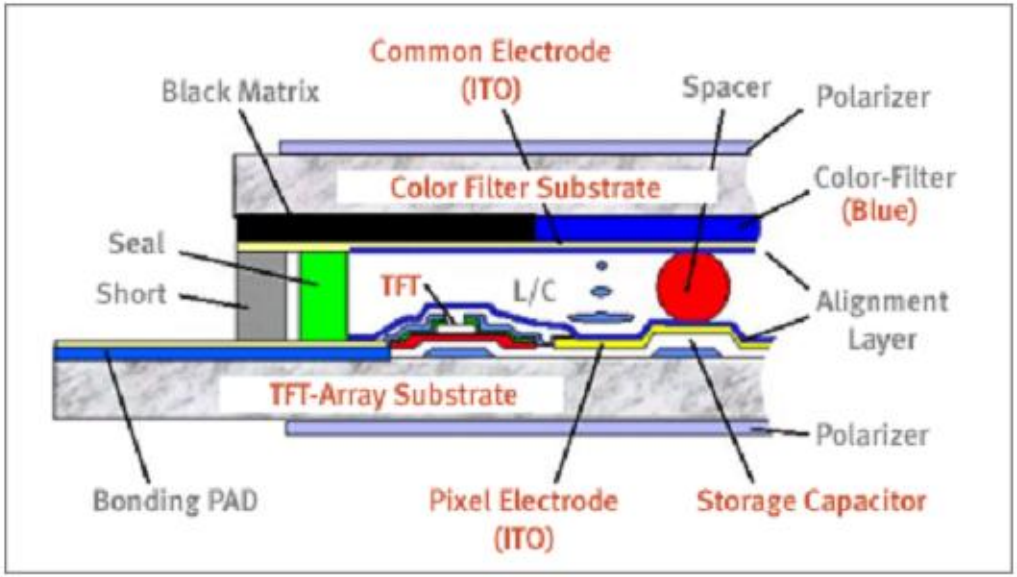
4.5 inch

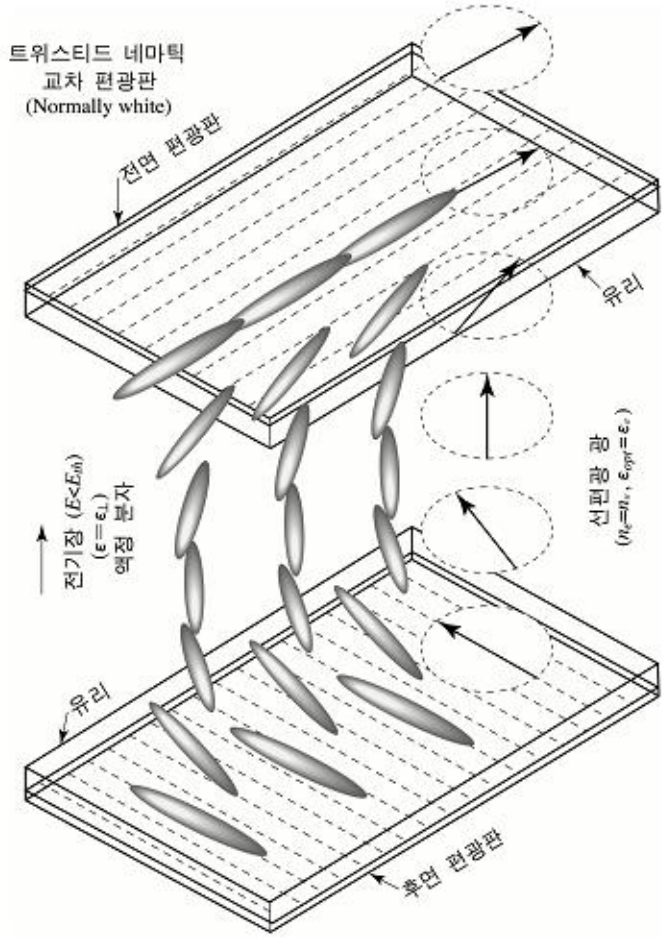


Manufactured by Samsung Electronics

Liquid Crystal Display (LCD)

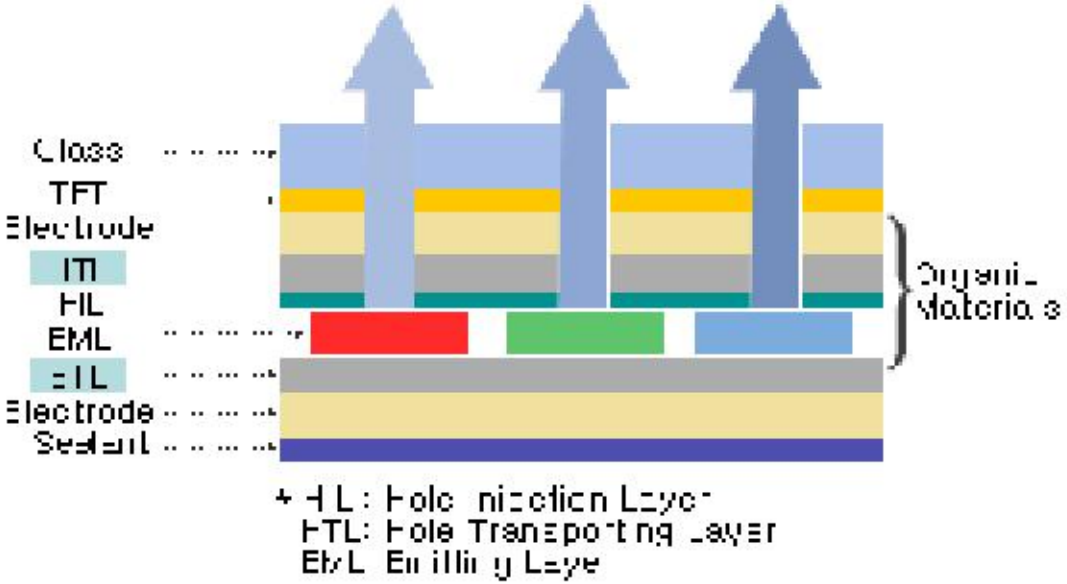
❖ **LCD는 Back light unit (BLU)에서 나오는 백색광을 액정을 통해 선택적으로 통과시켜 화상을 표시한다. 이때 액정의 정렬은 a-silicon thin film transistor (TFT)로 구동 시킨다.**





Organic Light Emitting Diodes (OLED)

OLED (organic light emitting diodes) dis plays are made from ultra thin films of o rganic materials patterned into pixels th at function similarly to standard LED tec hnology.



Advantages of OLEDs over LCDs

<LCD>

Advantage

1. Easy to carry
2. Pleasant to read
3. Cheap to buy

Limitation

1. Low brightness and contrast
2. Limited view angle
3. Low energy efficiency
4. Limited temperature range

<OLED>

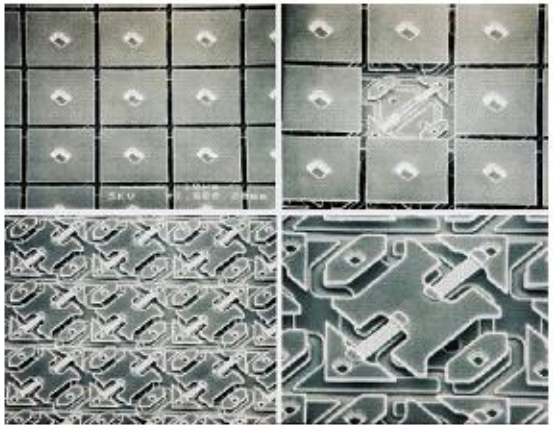
- Self-luminous
- Less limited viewing angle
- Higher contrast ratio
- Cheaper
- Easier to make
- Less power

Application of OLED

Flexible Displays
: "Roll-to-Roll" Manufacturing

Products

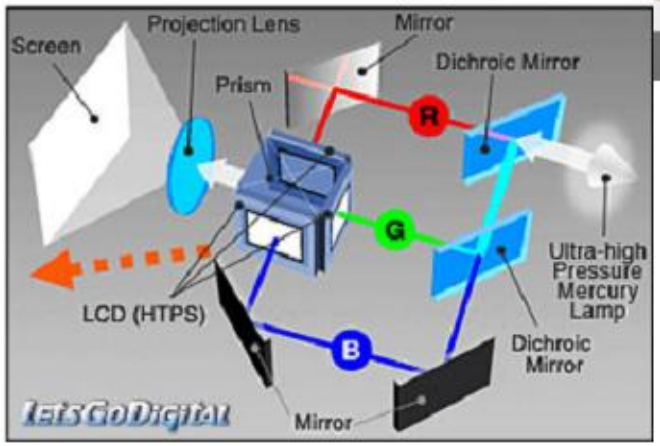
Micro-mirror arrays (MMAs)



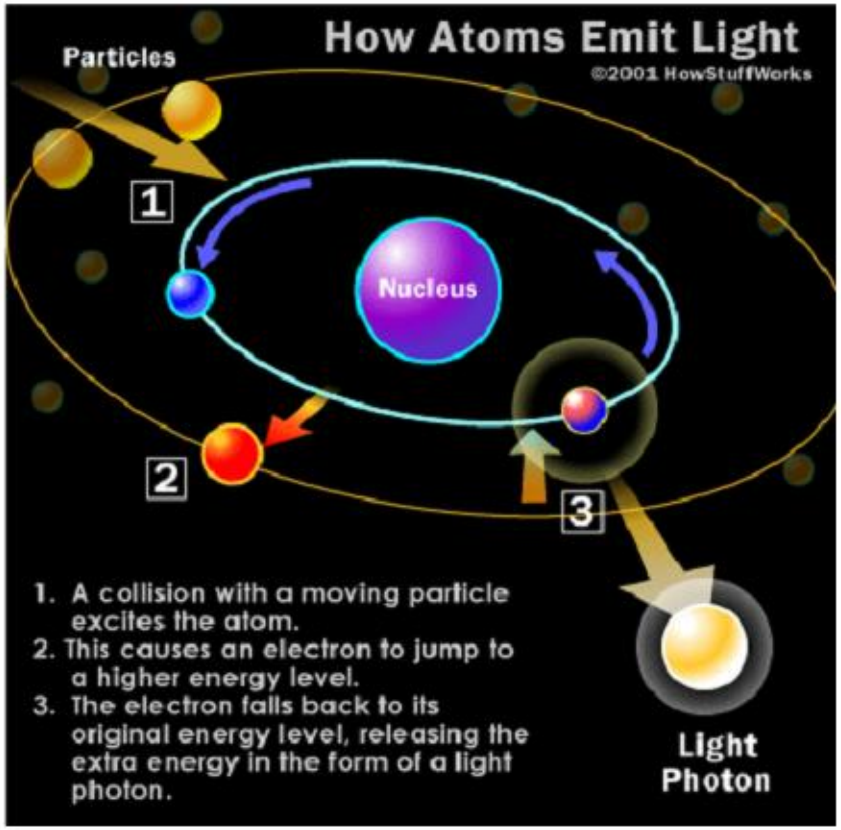
A pixel is bright or dark on the projection screen according to the mirror tilt

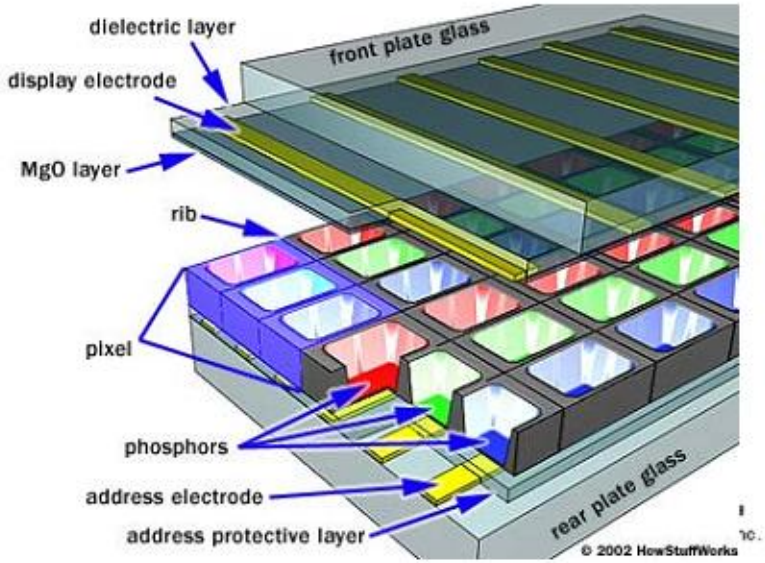
- Si array of Al μmirrors which can be rotated
- Integrated MST devices **over a CMOS circuit**
- First in the market for portable projection systems (Texas Instruments)
- High switching speed
- **New applications**: front projection systems for cinemas, movie

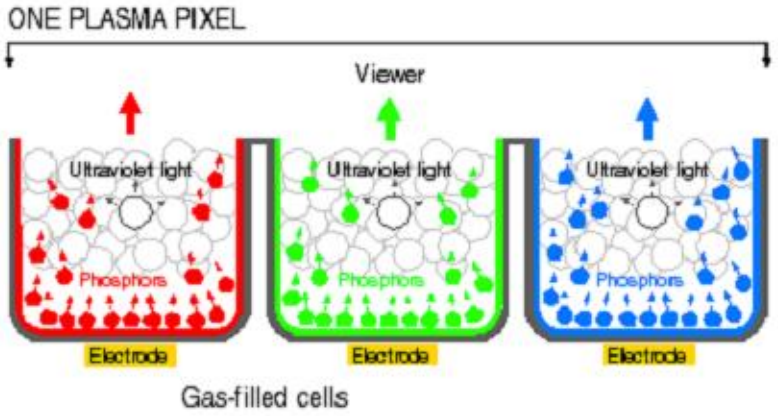
- Electrostatic-actuated array of ribbons
- **Surface** micromachining
- **Each element** can reflect or diffract light
- Silicon Light Machines' proprietary technology



Plasma Displays Panels





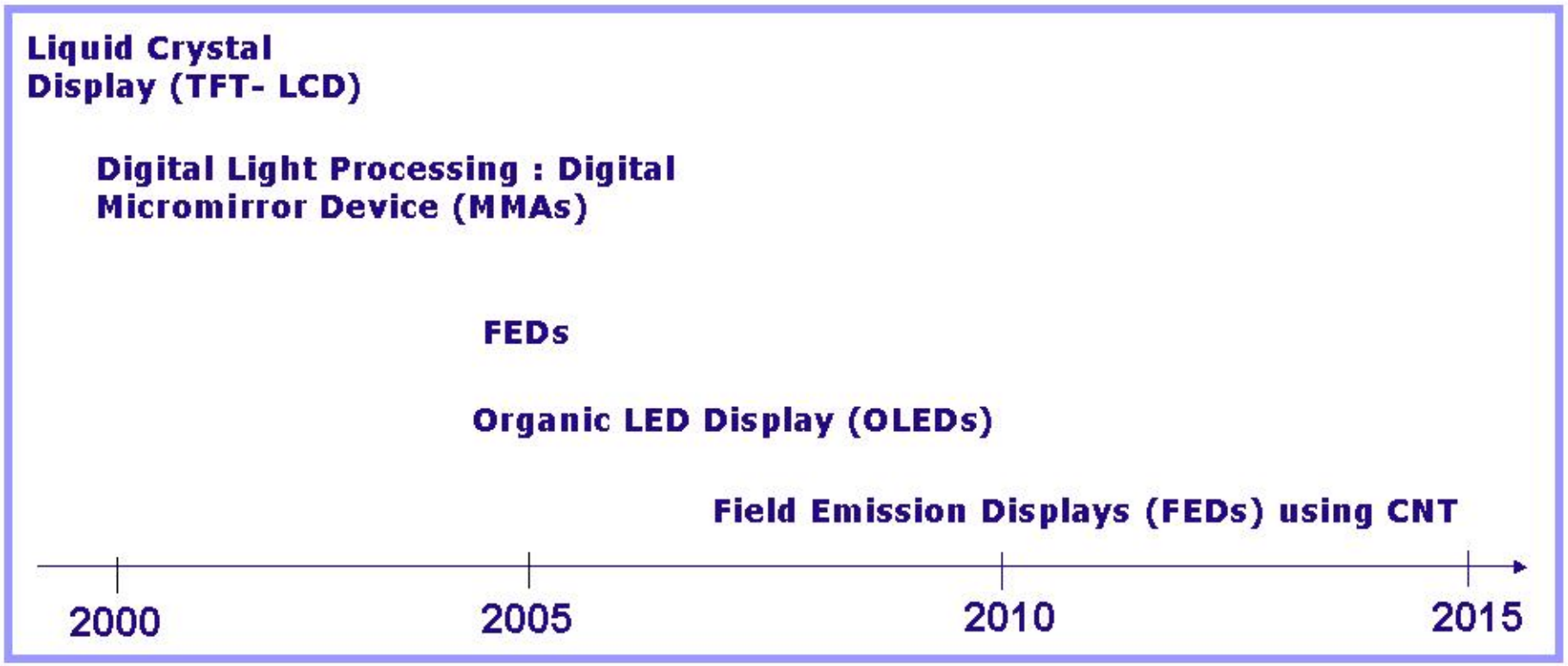


FPDs' characteristics

	LCD	OLED	FED	Plasma Displays Panels
Brightness	200 cd/m^2	200 cd/m^2	70 cd/m^2	600 cd/m^2
Contrast	350 : 1	1000 : 1	200 : 1	1000 : 1
Consumption	3 W (10")	2 W (5.5", Sanyo-Kodak)	2 W (10")	1000 W (61")
Pixellisation	1 600x1 024 (22 inches) 1 100 p/cm^2	eMagin : 12x9 mm 47 000 p/cm^2	640x480 (10 inches) 950 p/cm^2	843x480 (42 inches) 80 p/cm^2

Technical roadmap

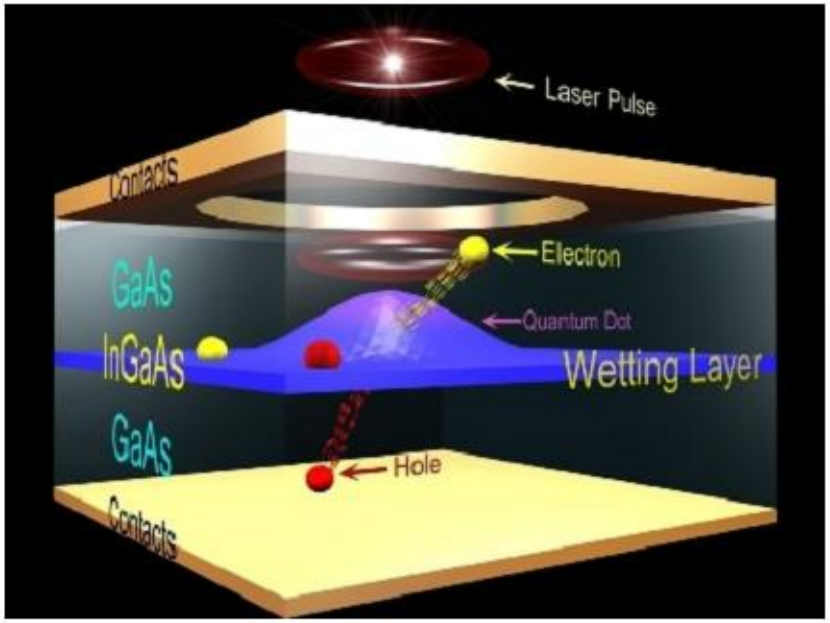
- According to Nexus, the microdisplays market will grow from $ 150 million in 2 000 to $ 2 700 million by 2005
- Depending on the technologies, applications will be direct view, front projection, rear view or near eye

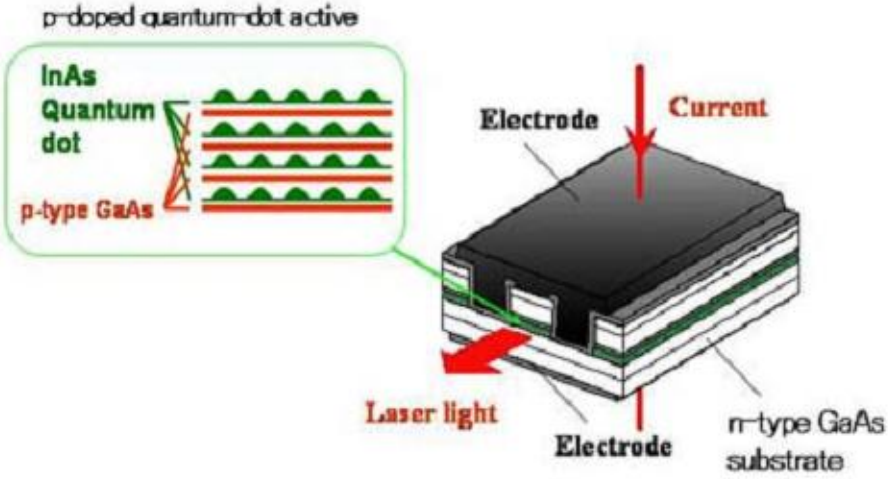


Quantum dot laser display

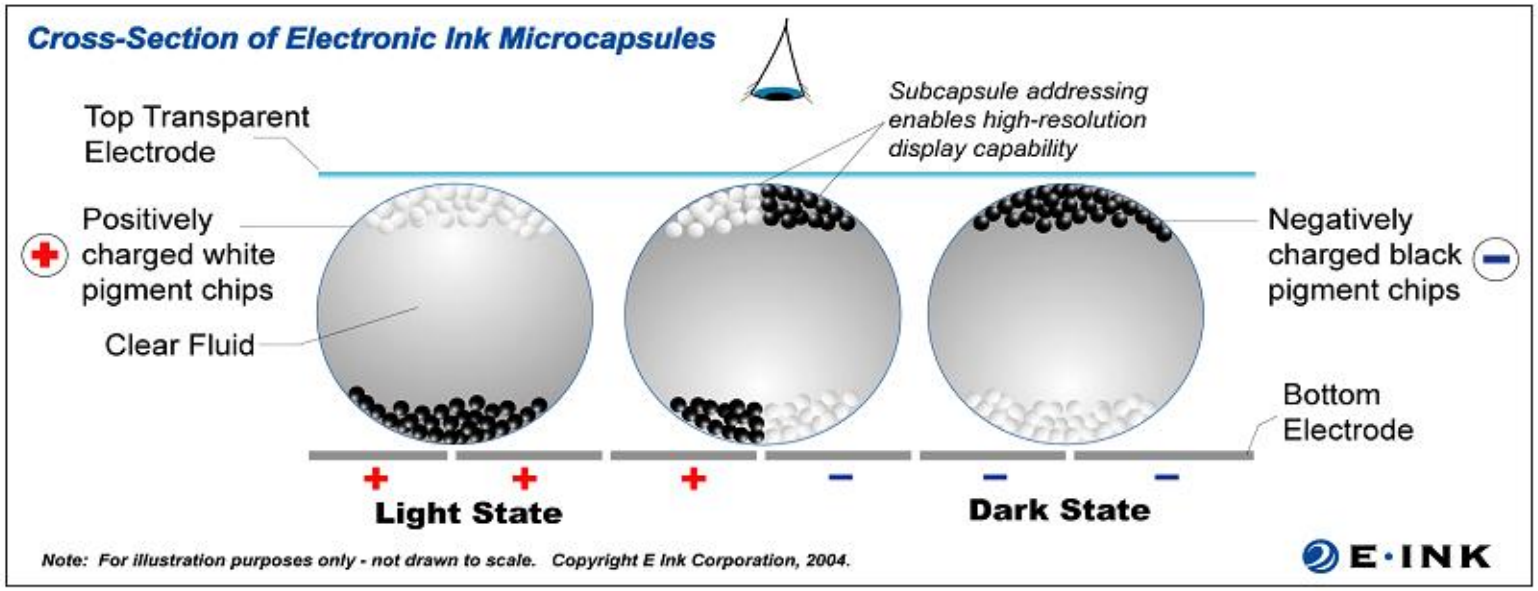
- A quantum dot laser succeeds in minimizing temperature-sensitive output fluctuations, something not possible with previous semiconductor lasers.

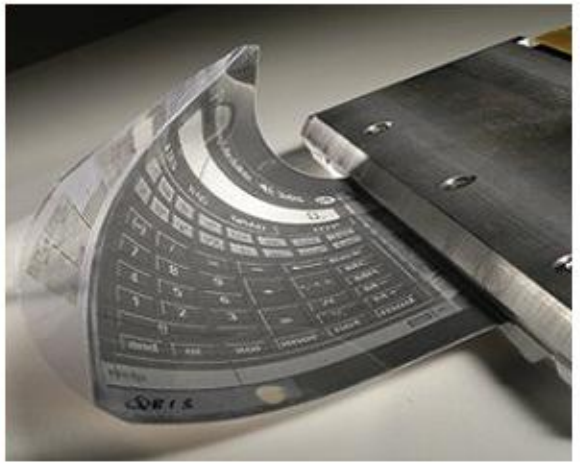
- A quantum dot laser includes a laser host material; a plurality of quantum dots disposed in the host material; and a pumping source for exciting and inducing a population inversion in the quantum dots.





E-paper


Cross-Section of Electronic Ink Microcapsules
Top Transparent Electrode
Subcapsule addressing enables high-resolution display capability
Positively charged white pigment chips
Clear Fluid
Negatively charged black pigment chips
Bottom Electrode
Light State
Dark State
Note: For illustration purposes only - not drawn to scale. Copyright E Ink Corporation, 2004.
E·INK



Data Storage

Demand for information storage & Downsizing of hard Disk Drives

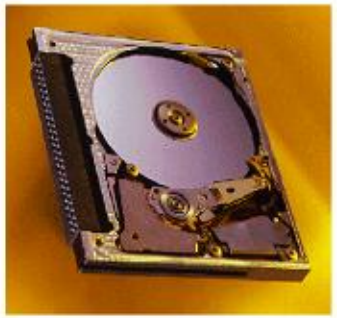
- **New applications and services lead to data storage increase:**

  - ✓ E-Medicine, video on request, interactive 3D video, genome database, biometric data base (finger prints) …

- **Demanding Large capacity & Small size & High data-rate w/random access**

3.5" HDD

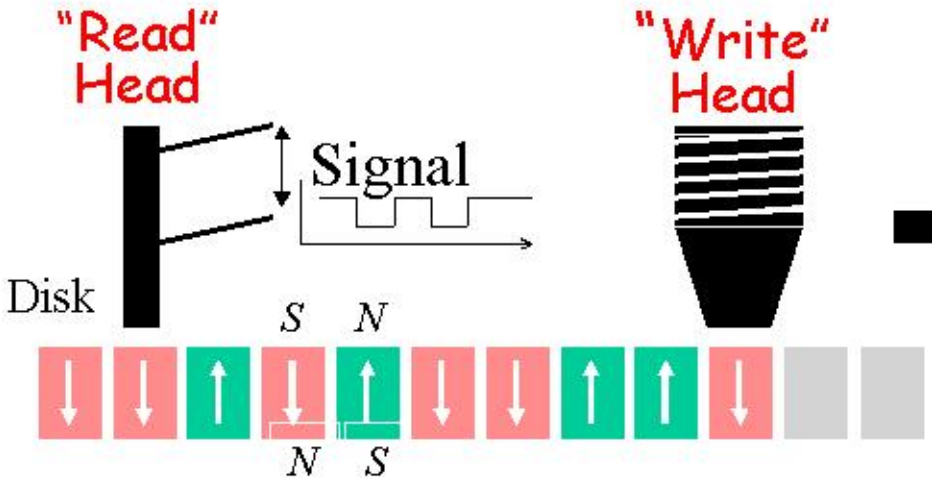
2.5" HDD



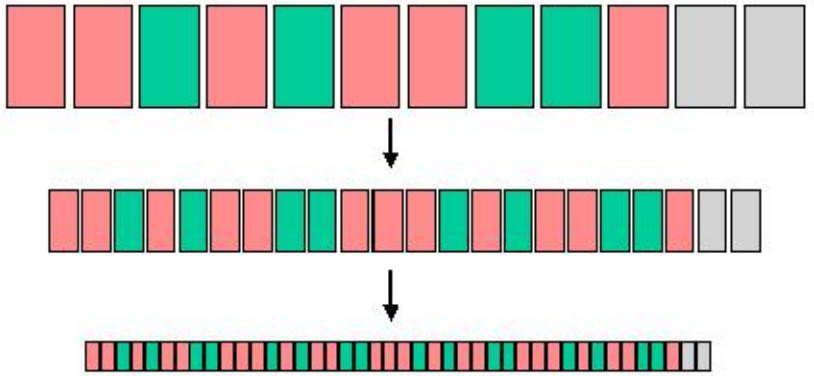
1" HDD

Nanotechnology meets data storage

A computer hard drive stores your data magnetically



Scaling Down to the Nanoscale



Increases the amount of data stored on a fixed amount of "real estate" !

Now ~ 50 billion bits/in², future target more than 1 trillion bits/in²

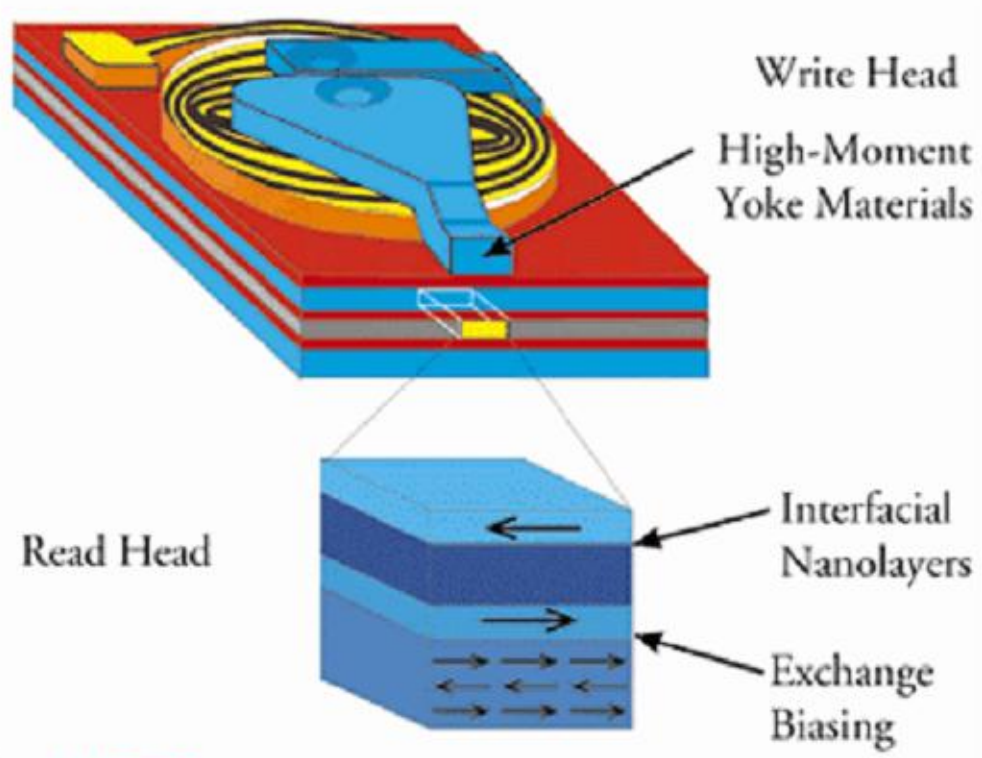
25 DVDs on a disk the size of a quarter, or all Library of Congress books on a 1 sq ft tile!

Nanotechnology meets data storage

Nano-layered Disk Heads

- Special sensitivity of Disk head comes from "Giant Magneto-Resistive effect" or (GMR)

- IBM is (was) leader in this technology



Evolution of the needs in data storage

- Magnetic storage is the most used technology today and Thin Film Heads ha ve increasing performances

- **But superparamagnetic limit could be reached (60 – 70 Gb/in^2 is the limit)**

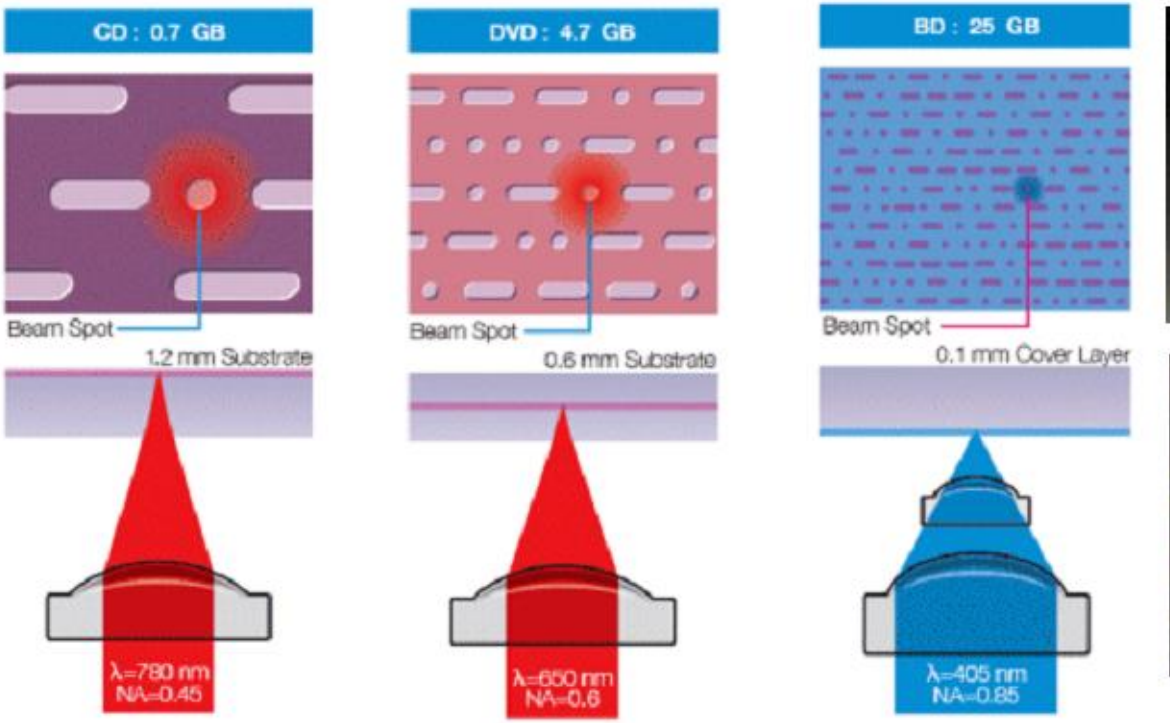
⬇

Other technologies are currently developed

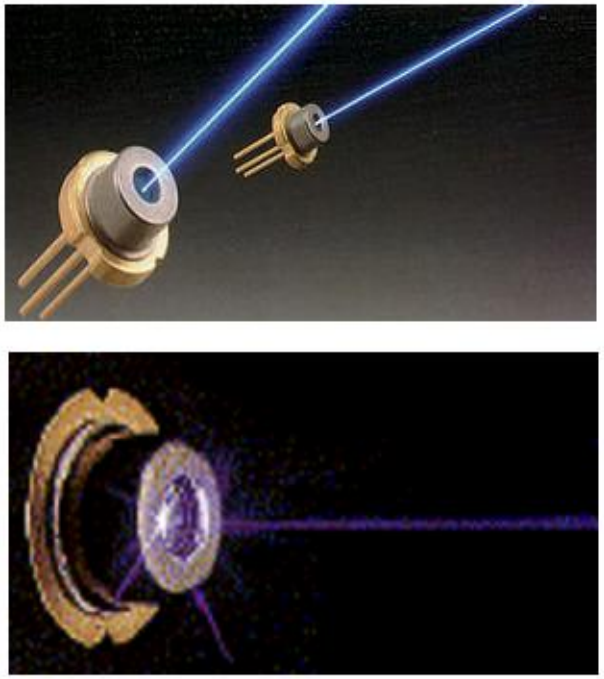
- **Optical technologies:**
  - ✓ **Holography**
  - ✓ **Blue laser**

- **Nanotechnologies:**
  - ✓ **Nanomechanical storage**
  - ✓ **Atomic resolution storage (the quantum level of an atom becomes the stor age media; HP + Darpa project; Objective: 1 Tb/in^2 in 2007)**

Blue ray disk - Blue laser diodes, state of art



<blue-violet laser>



<blue-violet laser diode>

- Today, only Nichia (J) is commercializing blue laser semiconductor based on GaN grown on sapphire. Its life-time is approximately 15,000 hours for 30 mW power, which is co mpatible with DVD applications.
- Prices remain very confidential and appears to be not compatible with high volume prod uction of appliances today

Blue ray disk

The next generation of optical disk:
« Blue-ray Disc » based on blue-violet laser diode

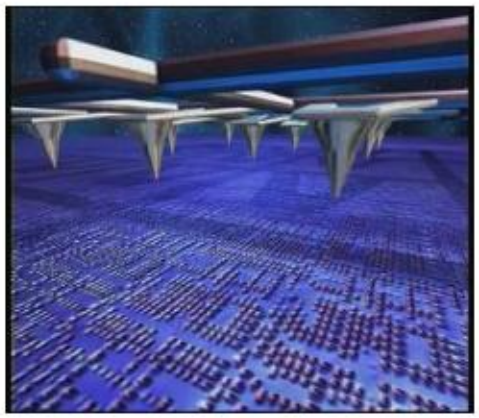
<blue-ray disk>

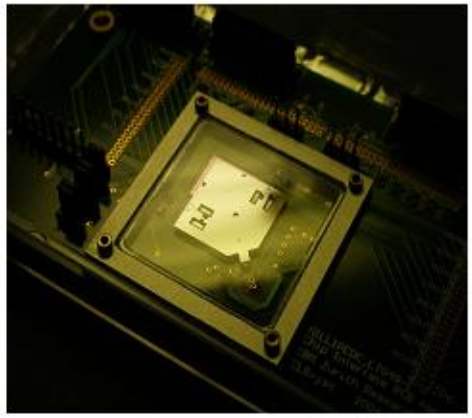
< 9 major players >

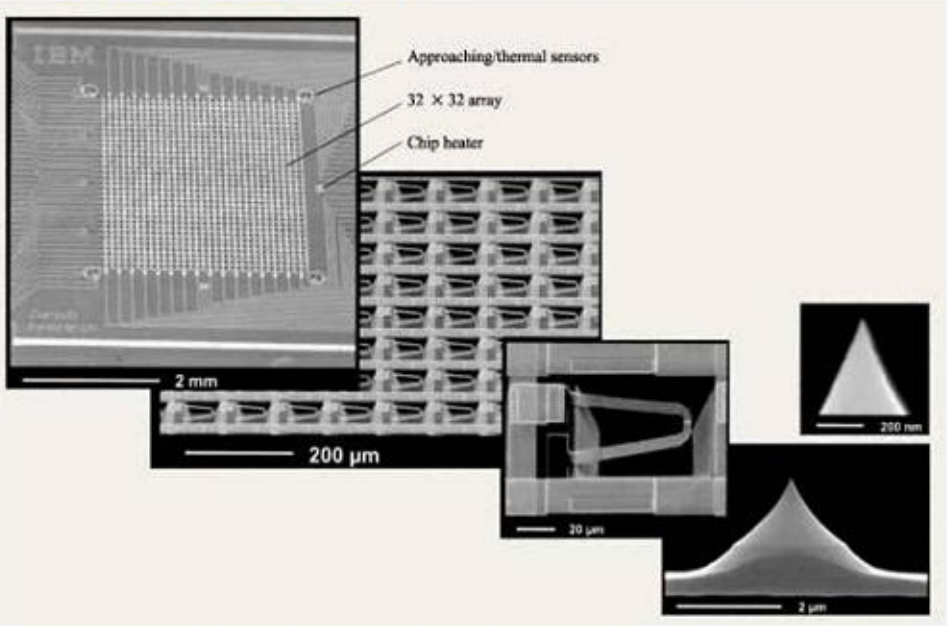
: Hitachi, LG, Matsushita, Pioneer, Philips, Samsung, Sharp, Sony, Thomson

Nanomechanical storage - The Millipede (IBM)

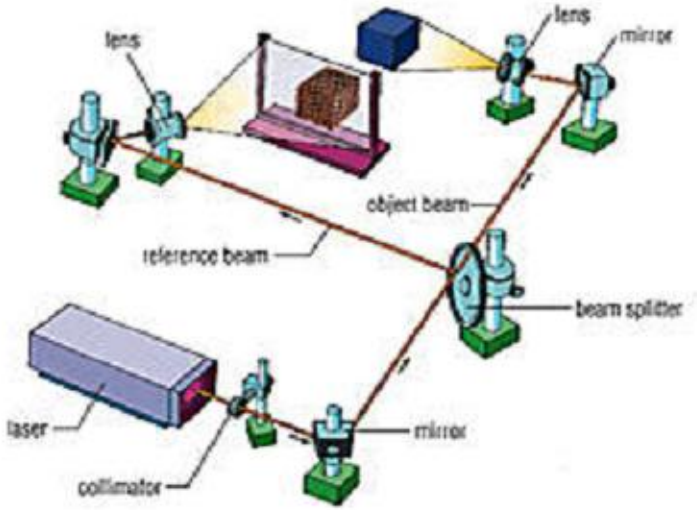
- **High-density data storage system based on AFM:**
  - ✓ Thermomechanical storage: Tiny depressions melted by an AFM tip into a polymer medium represent stored data bits that can then be read by the same tip
- **Densities in the hundreds of Gb/in² range**
- **The read/write head consists of an array of more than 1,000 thermomechanical probes, fabricated on a single silicon chip using VLSI microfabrication techniques**
- **Packaging issue**

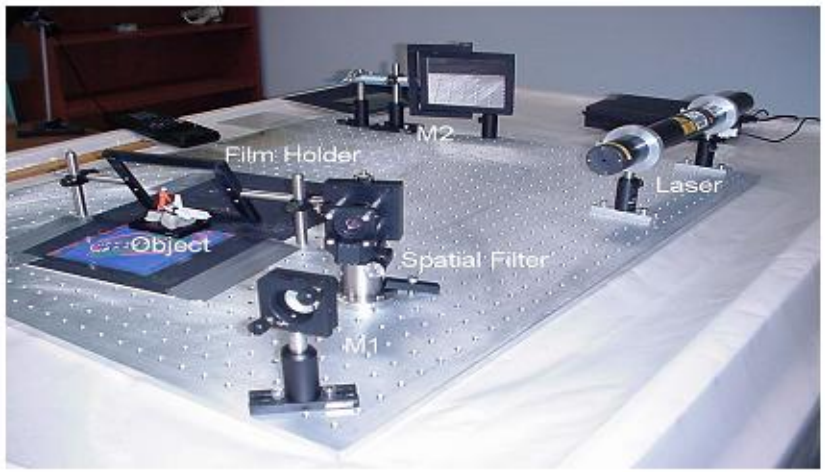






3D- Holography storage





Technical characteristics

	Holography	Blue laser	Nano-mechanical	Magnetic
Storage density	100 Gb/in²	20 Gb/in²	150 Gb/cm² 400 to 500 in the future	100 Gb/in² 300 in the future
Data transfer speed	20 to 40 Mo/s	33 Mb/s	60 kb/s	256 Mb/s
Applications	Data bank	HD DVD	Portable systems	Hard Disk
Some manufacturers	InPhase Technologies	Nichia, Hitachi, Matsuschita, Sony, Pioneer, Sharp	IBM Research	Fujitsu, IBM, Seagate
Technoloy maturity	?	Available 2004	Prototype	Mature technology

Technologies roadmap