신소재 화학
Organic & Nano- Materials

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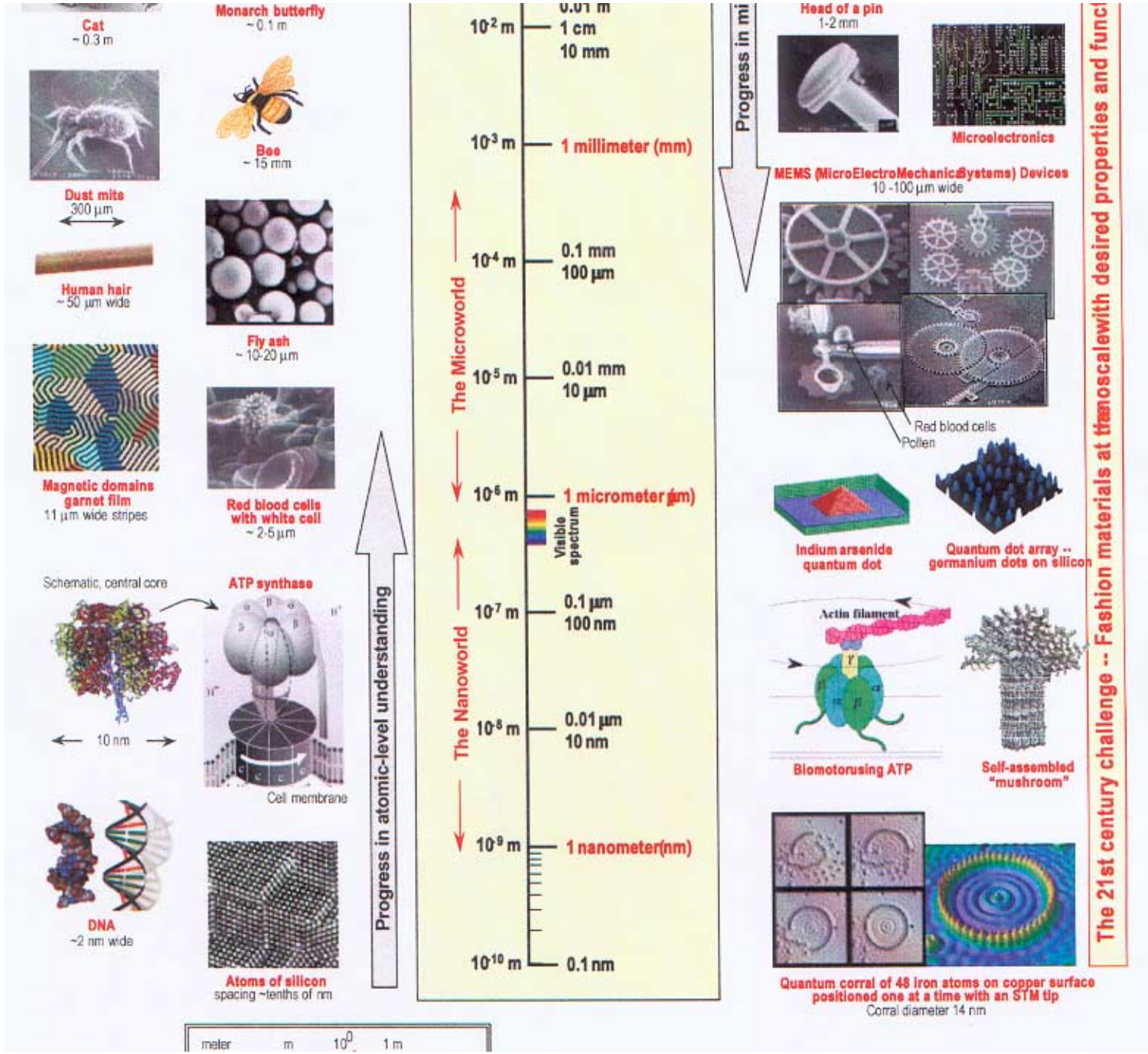
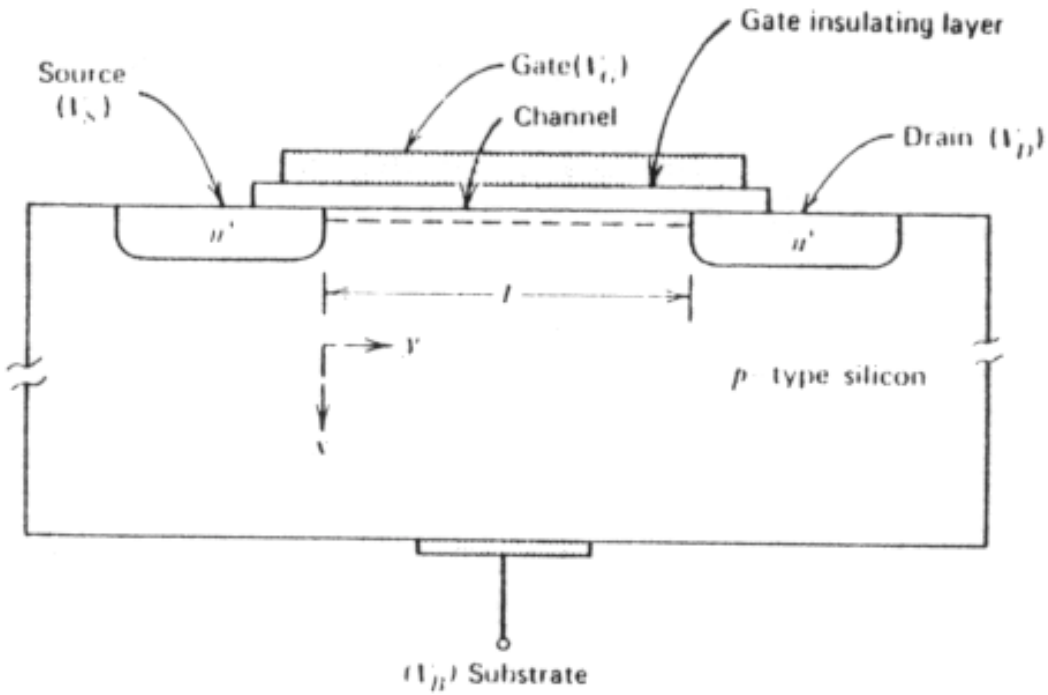

Cat
~ 0.3 m
Monarch butterfly
~ 0.1 m
Bee
~ 15 mm
Dust mite
300 µm
Human hair
~ 50 µm wide
Fly ash
~ 10-20 µm
Magnetic domains
garnet film
11 µm wide stripes
Red blood cells
with white cell
~ 2-5 µm
Schematic, central core
ATP synthase
10 nm
Cell membrane
DNA
~2 nm wide
Atoms of silicon
spacing ~tenths of nm
Progress in atomic-level understanding
10^{-2} m
1 cm
10 mm
10^{-3} m
1 millimeter (mm)
10^{-4} m
0.1 mm
100 µm
10^{-5} m
0.01 mm
10 µm
10^{-6} m
1 micrometer (µm)
Visible spectrum
10^{-7} m
0.1 µm
100 nm
10^{-8} m
0.01 µm
10 nm
10^{-9} m
1 nanometer(nm)
10^{-10} m
0.1 nm
The Microworld
The Nanoworld
Progress in mi
Head of a pin
1-2 mm
Microelectronics
MEMS (MicroElectroMechanicalSystems) Devices
10 -100 µm wide
Red blood cells
Pollen
Indium arsenide
quantum dot
Quantum dot array --
germanium dots on silicon
Actin filament
Biomotorusing ATP
Self-assembled
"mushroom"
Quantum corral of 48 iron atoms on copper surface
positioned one at a time with an STM tip
Corral diameter 14 nm
The 21st century challenge -- Fashion materials at thenoscalewith desired properties and funct
meter
m
10^{0}
1 m

Efforts to reduce the size



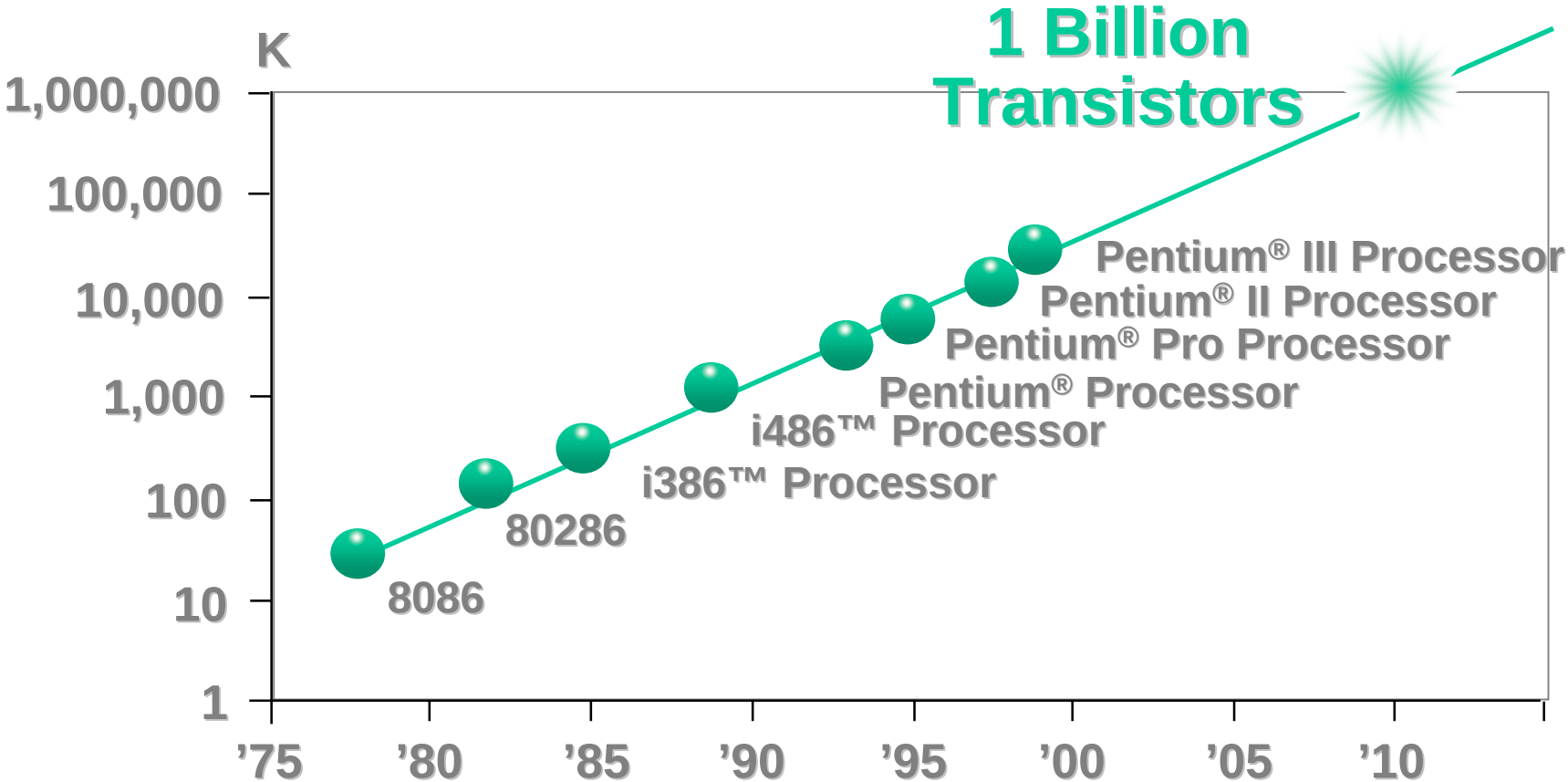
Limitations to silicon MOSFET circuits.
New devices: Single electron transistors, resonant tunneling diodes.

Benefits of scaling

- Reducing the size of the transistors makes them faster and keeps the power consumption reasonable.
- Putting more transistors in a circuit enables more computation.
- Integrating several chips into one improves reliability.
- Cost per transistor goes down.

How long will Moore's Law continue?

Billions of dollars will be spent to make sure that improvement of silicon chips stay on the curve predicted by Moore, but there are some serious obstacles that must be overcome.



Source: Intel

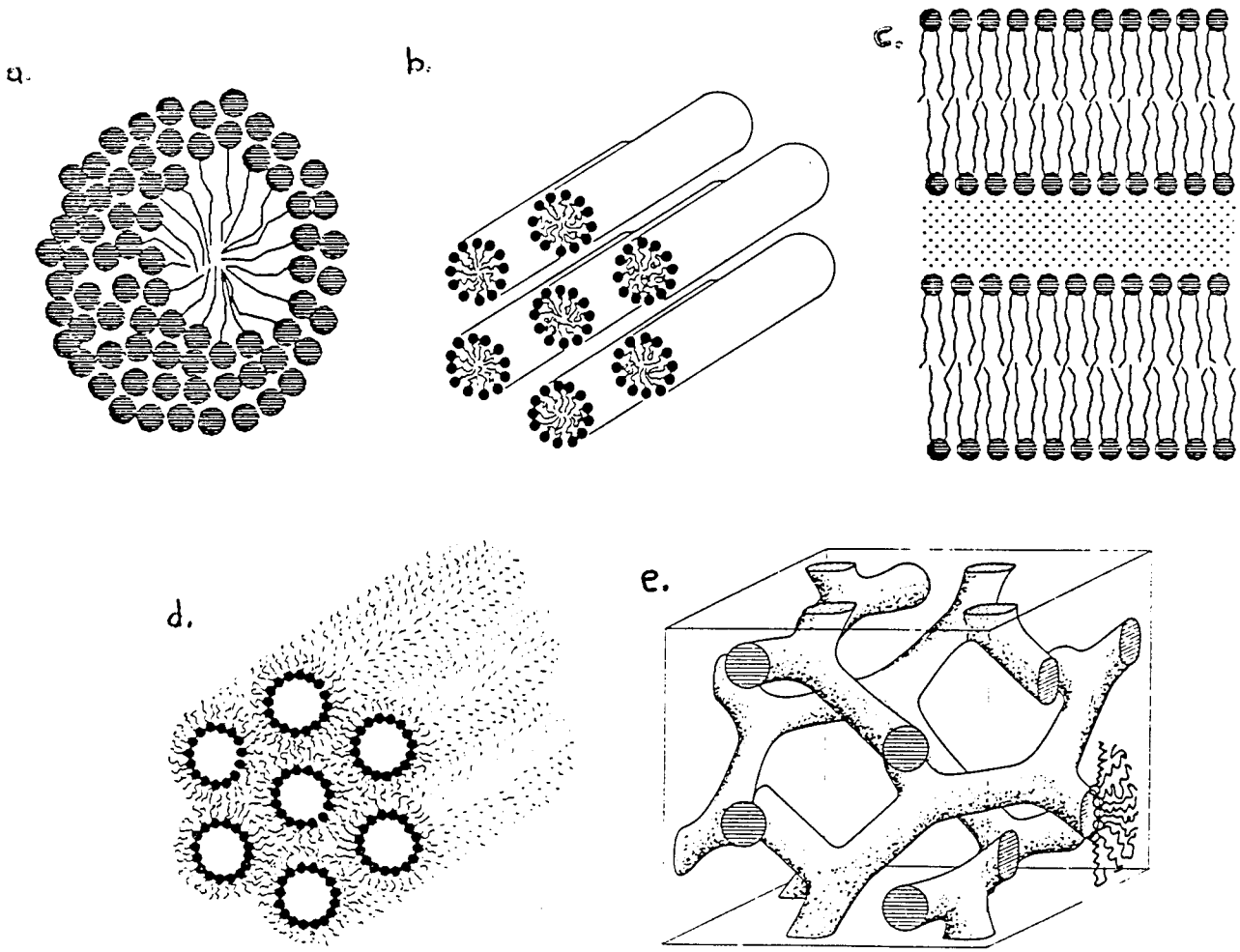
Other obstacles

- The resolution of lithography must go far below 100 nm.
- Heat must be dissipated.
- Fabrication plants are costing billions of dollars.

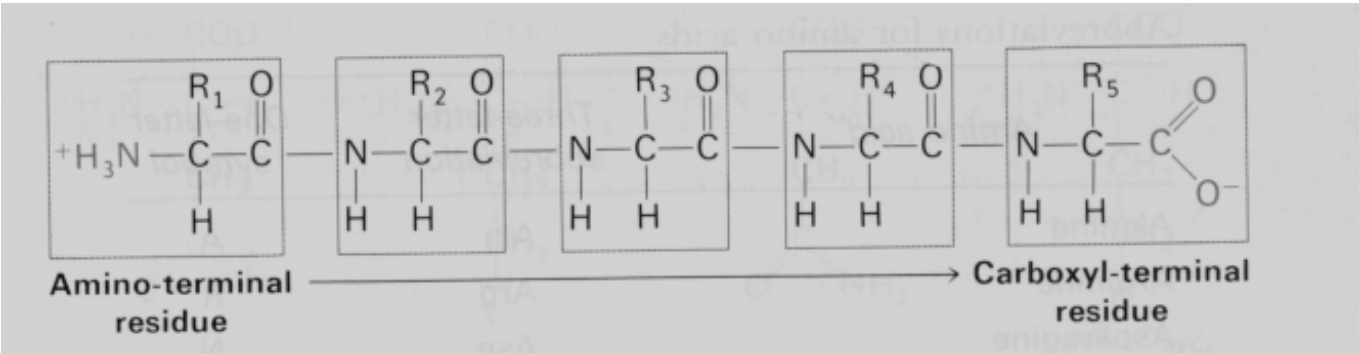
As daunting as the problems are, it is expected that the silicon industry will find ways to solve them for at least 5 more years and maybe much longer.

After ~2010: not how to push silicon (or germanium) technology forward, but how to make new devices with non-traditional fabrication techniques.

Organic materials can self-assemble on the nanometer length scale to make highly advanced materials

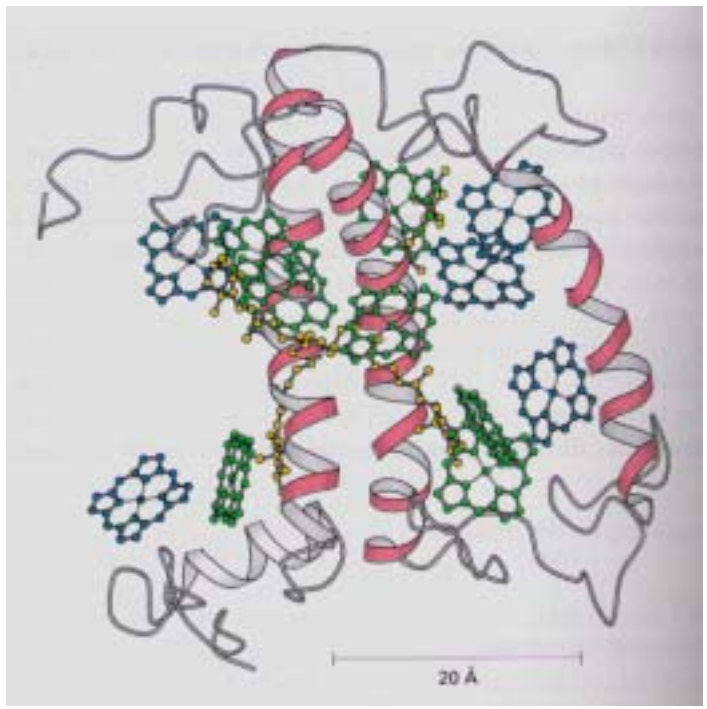


Proteins

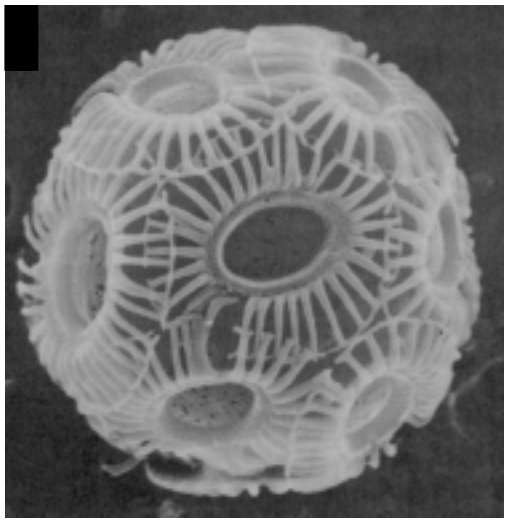


- Proteins are natural polymers made up from a collection of 20 different amino acids.

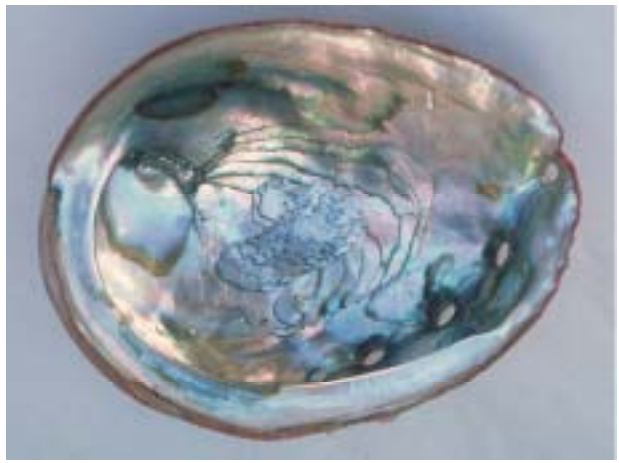
- They self-assemble into complex 3D shapes that can have a variety of advanced functions.

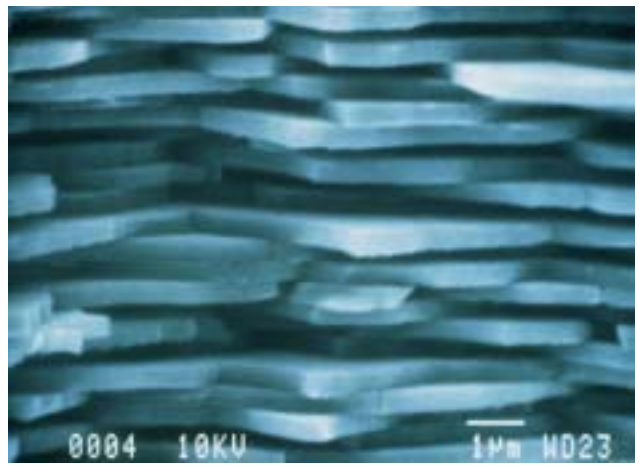


Biomimetics

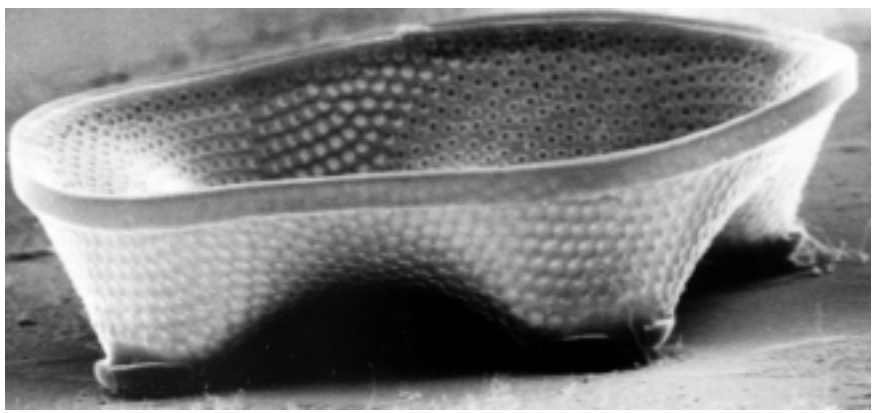


Coccosphere ($CaCO_3$)

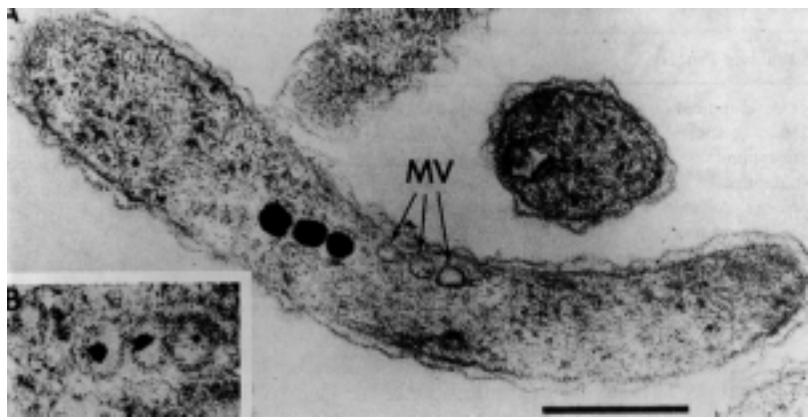




Abalone shell ($CaCO_3$)

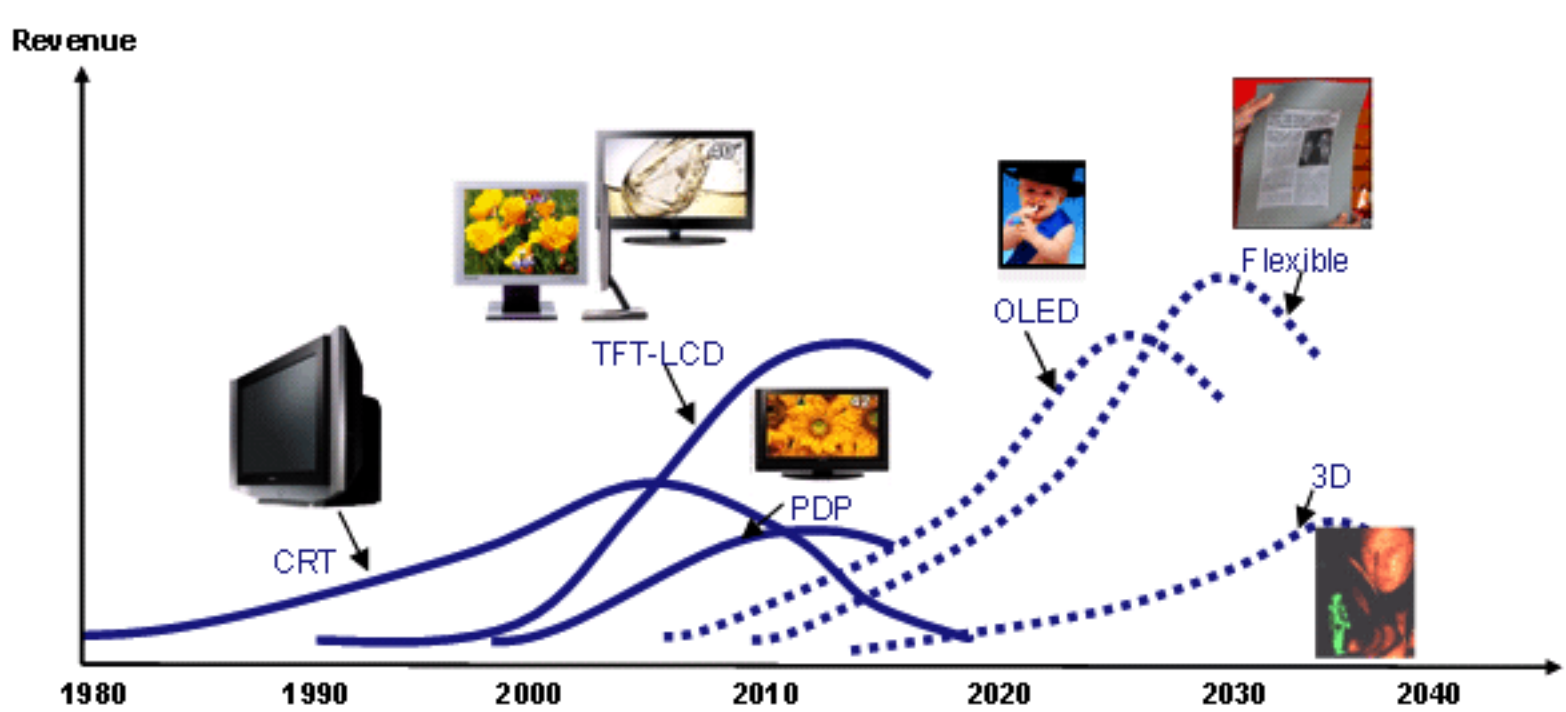


Diatom (SiO_2)

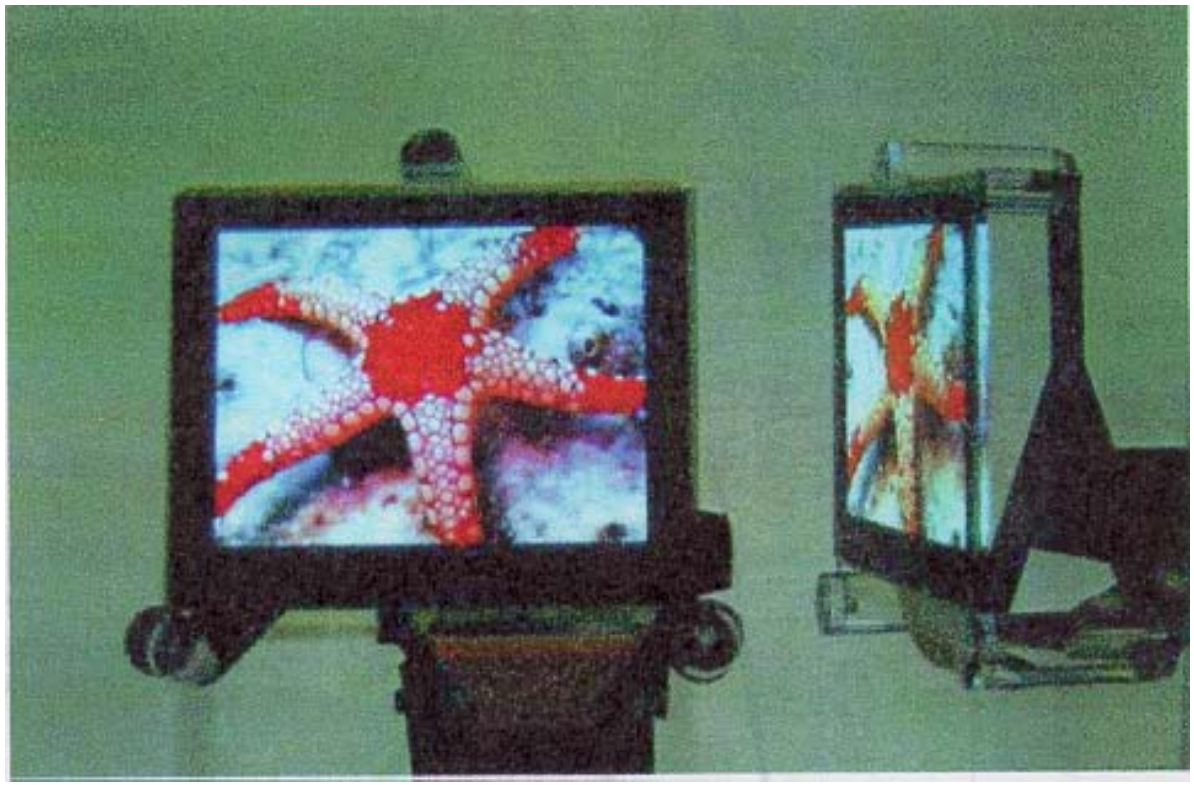


Magnetotatic bacterium (Fe_3O_4)

Organic semiconductors are emerging as very important materials for electronics and photonics

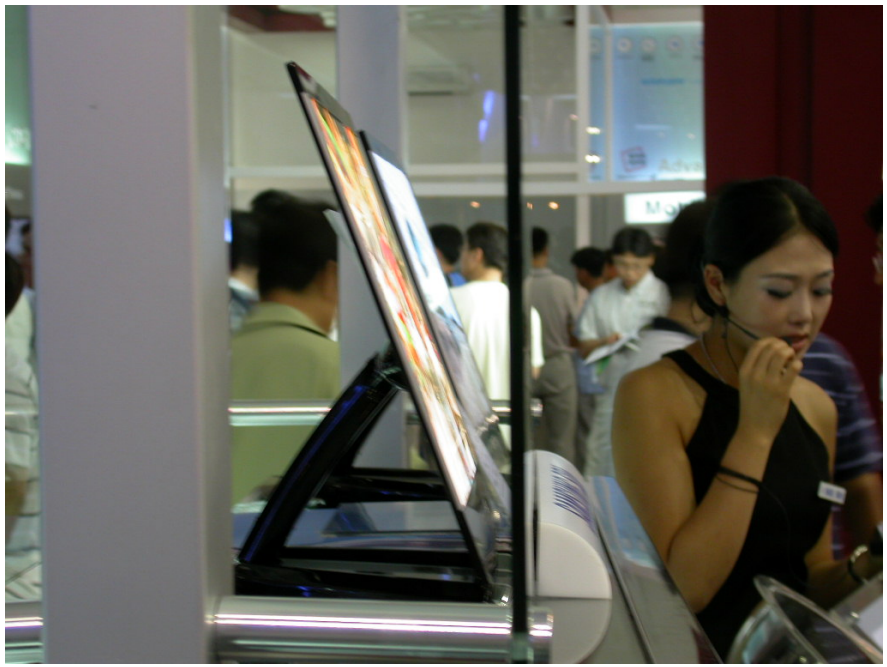

Revenue
CRT
TFT-LCD
PDP
OLED
Flexible
3D
1980
1990
2000
2010
2020
2030
2040

Full-color OLED display



Kodak-Sanyo

OLED 패널



SDI 17”패널 (2004년)

OLED 패널 시장동향

MP3

JVC XA-F112/F52

LGE MFFM20

JVC XA-C109/C59

SEC YP-K5

Mobile phone

Kyocera W44K

SEC SGH-E870

Toshiba W45T

Nokia 6215i (Dual PMOLED)

* OLEDNet prime report

OLED 패널 시장동향

Car Audio

Alpine CDA-9857Ji

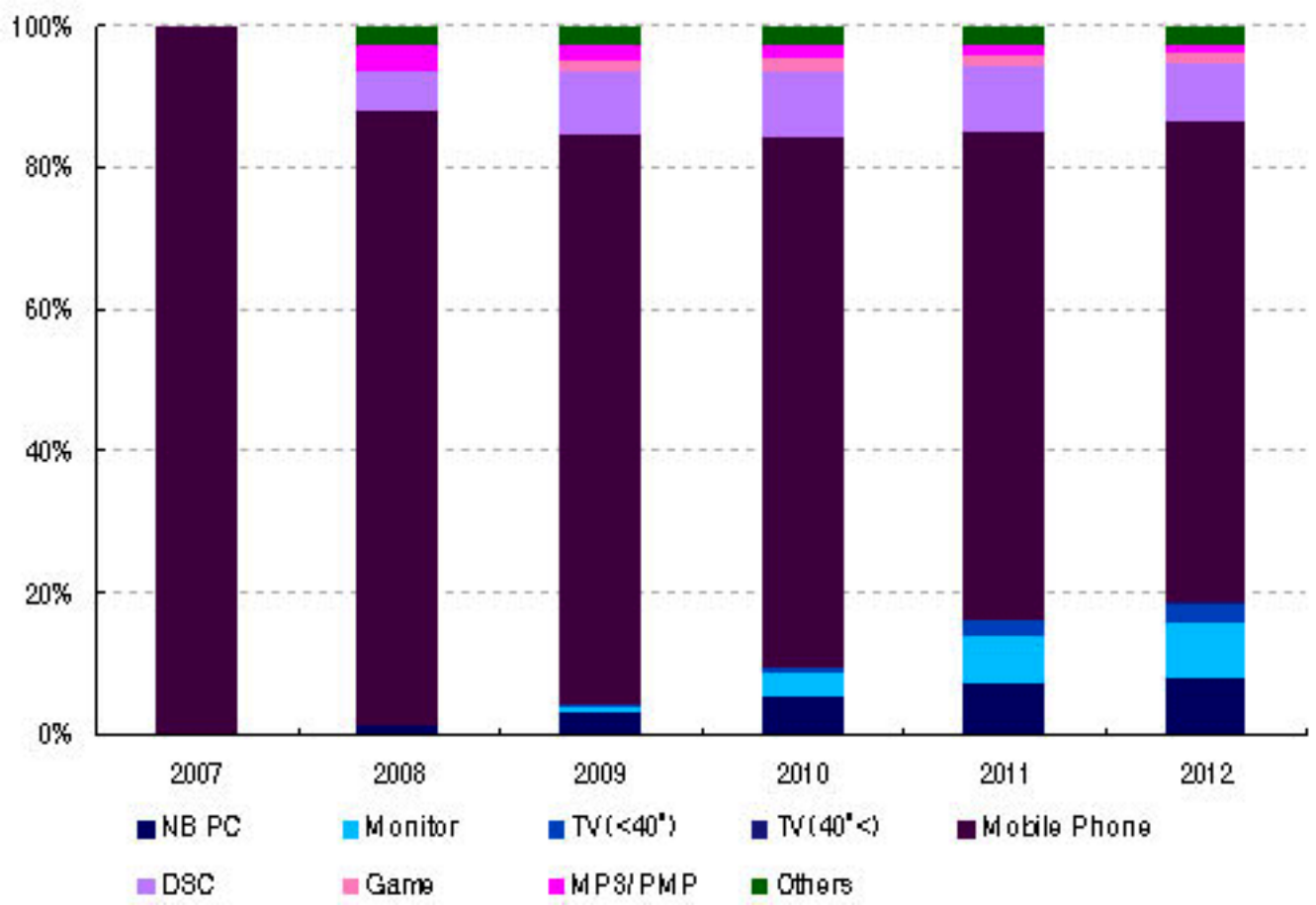
Pioneer DEH-P7800MP

기타

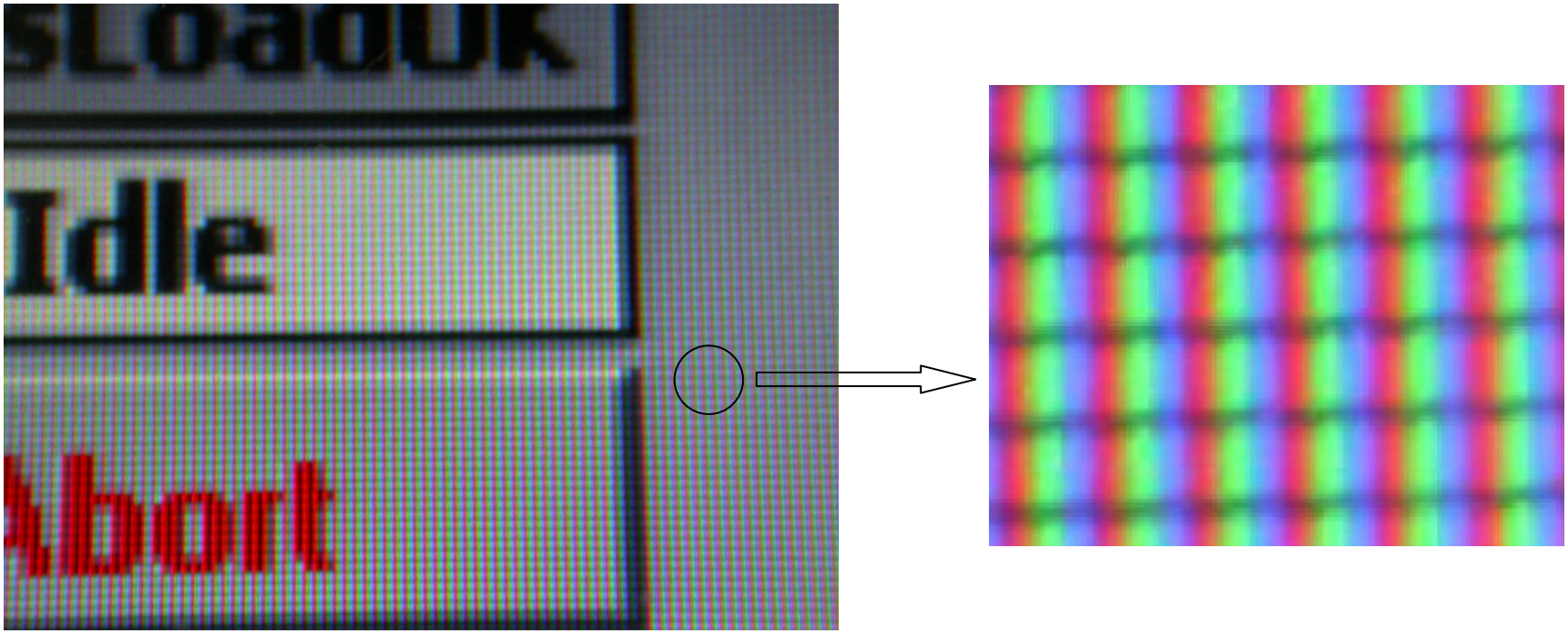
China Aigo F029

대양이엔씨 X1(MC²)

* OLEDNet prime report


100%
80%
60%
40%
20%
0%
2007
2008
2009
2010
2011
2012
NB PC
Monitor
TV(<40")
TV(40"<)
Mobile Phone
DSC
Game
MPS/PMP
Others

Pixel

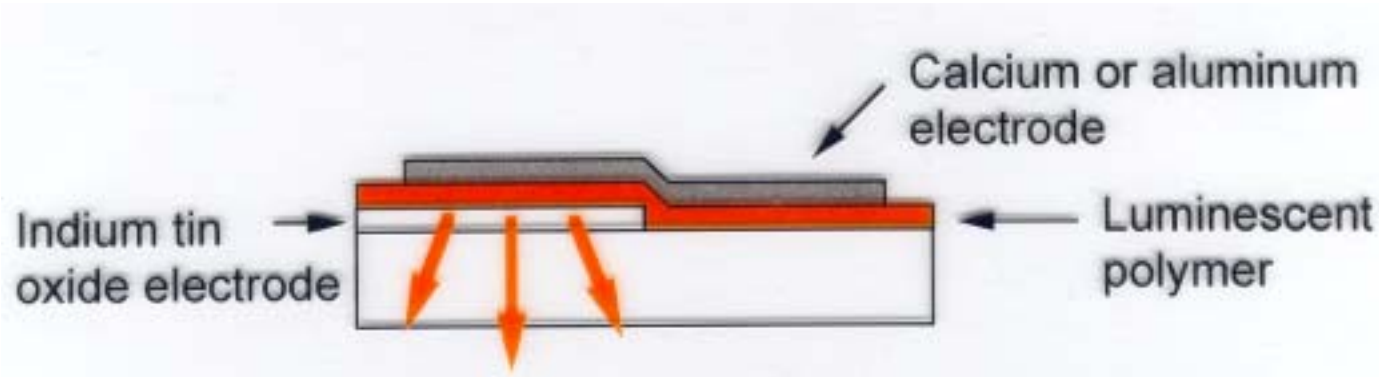


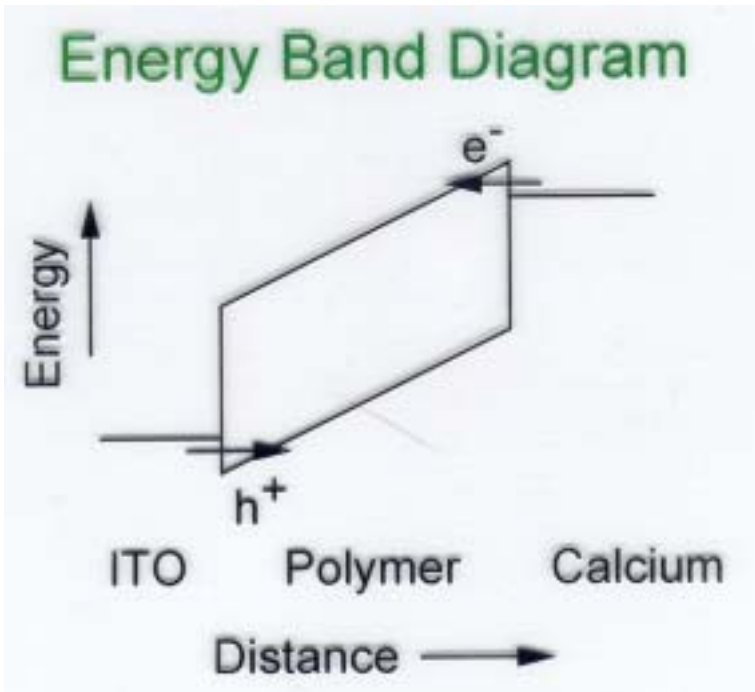
빛의 삼원색 : 빨강, 초록, 파랑

*색의 삼원색 : 빨강, 노랑, 파랑 (칼라프린터 잉크)

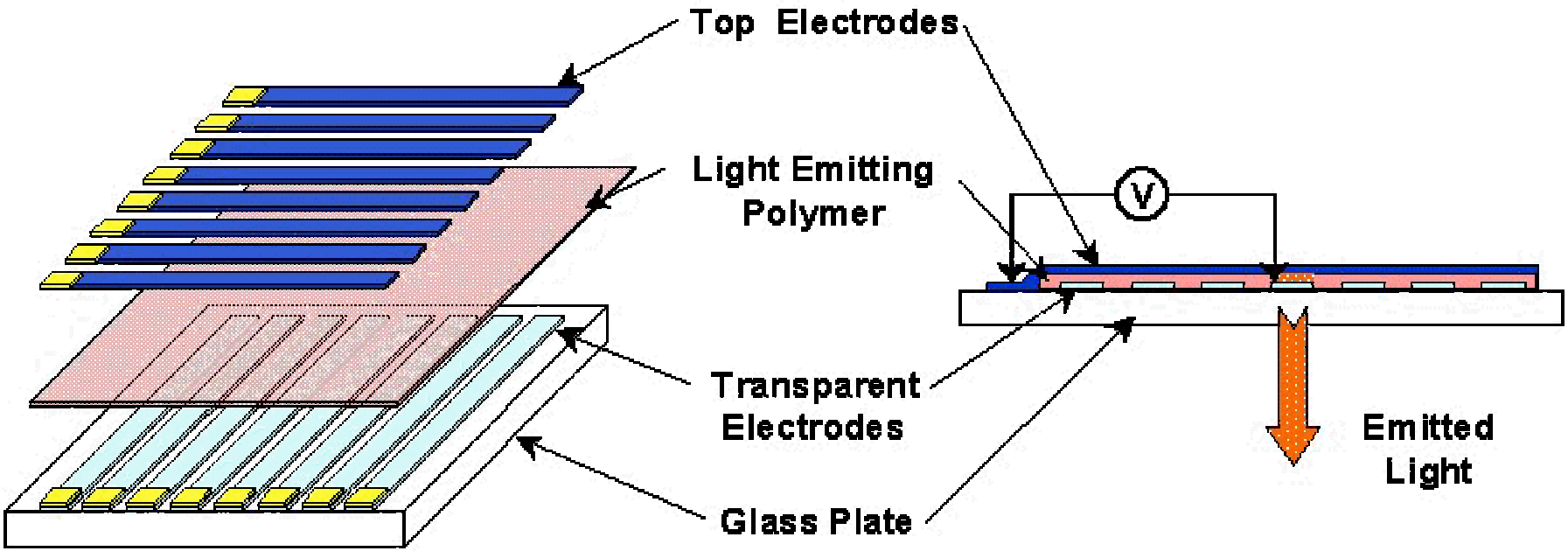
GRACEL

Polymer Light-Emitting Diodes





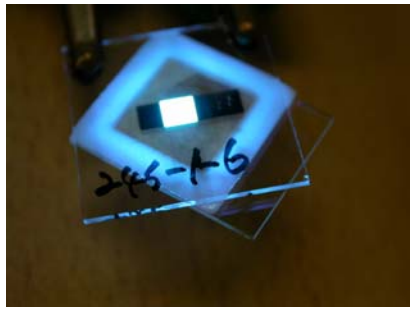
Fabrication of polymer displays

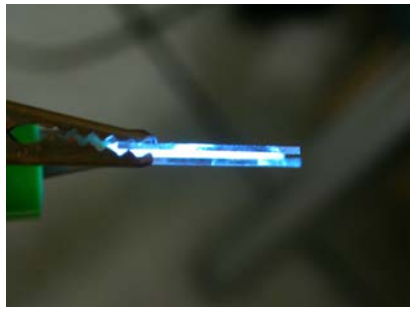


소자 제작 공정

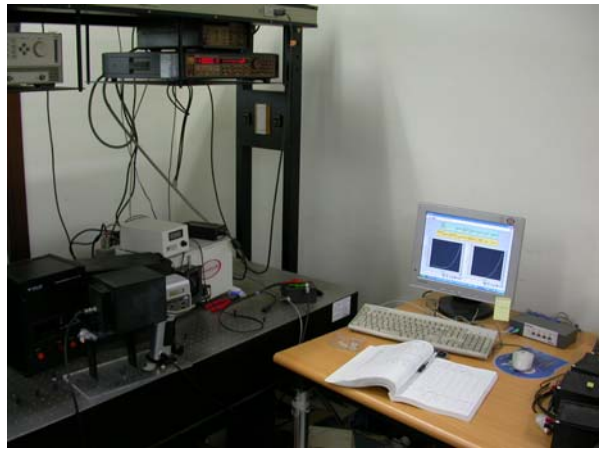
Glove Box

소자

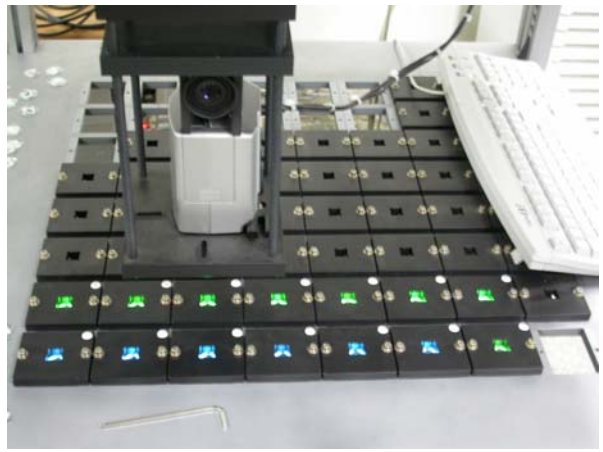




발광사진

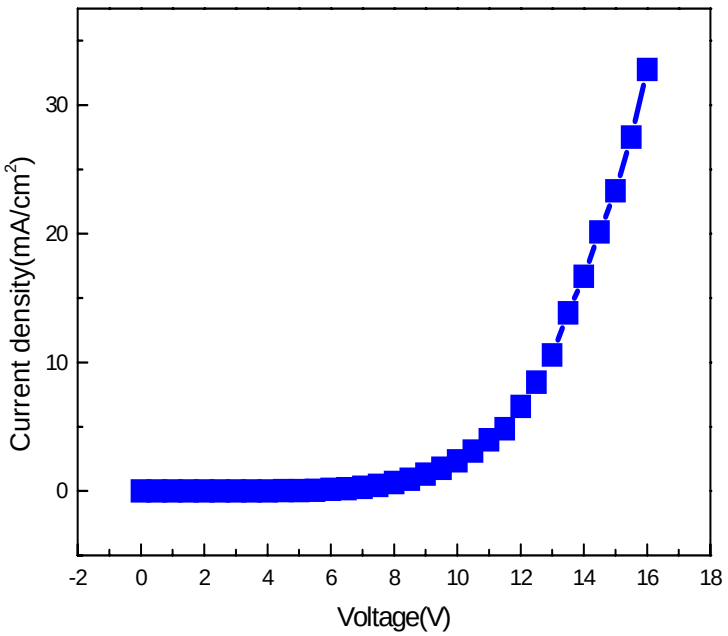


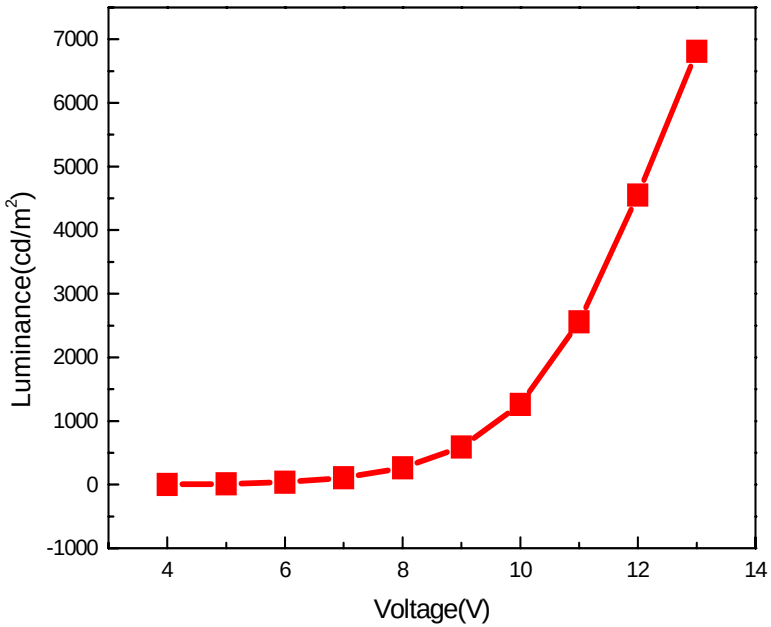
J-V-L



lifetime

소자 평가 DATA





- Current density (J) = current/device area, mA/cm^2
- Luminance (L) : 광원의 단위면적, solid angle당 나오는, 인간 눈의 민감도를 고려한 빛의 초당 에너지 (human scale light power), cd/m^2

*형광등 : 5000-15,000cd/m2, 보름달 : 2500cd/m2

GRACEL

Flexible integrated circuits

These inexpensive circuits will be probably be used for smart cards and active matrix displays.

C.J. Drury et al., *Appl. Phys. Lett.* 73 (1998) p. 108.