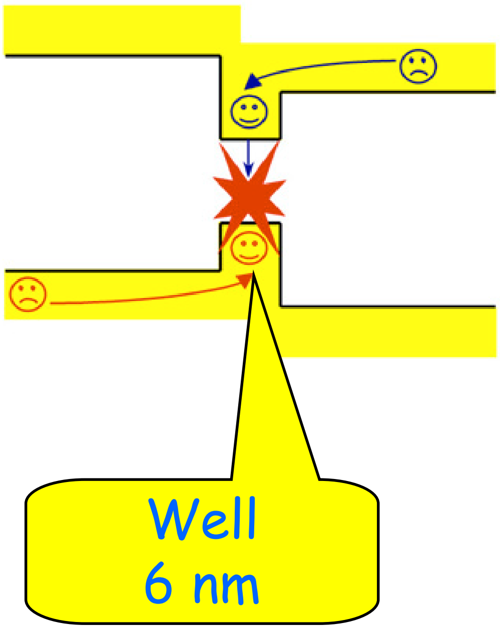
Nanotechnology in our Daily Life

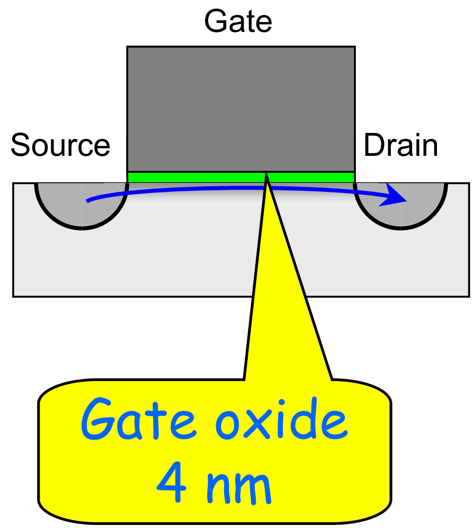
Iridescent car paint: Based on interference colors
(like a butterly, no bleaching after 5 years Miami)

Nanotechnology on our Desktops

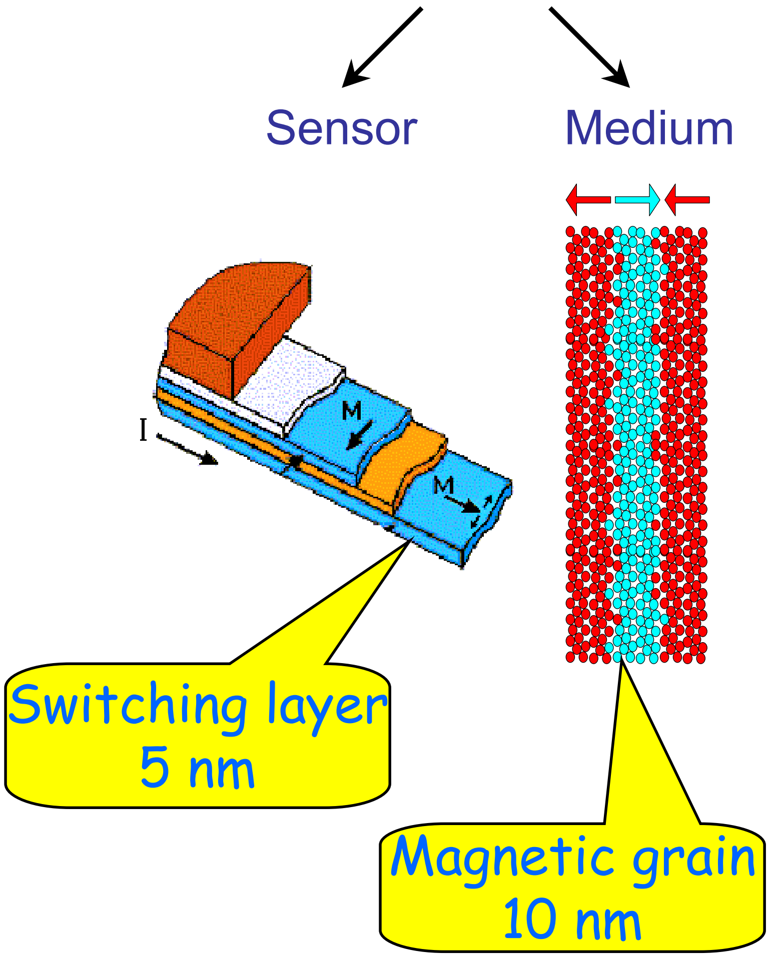
Quantum Well Laser



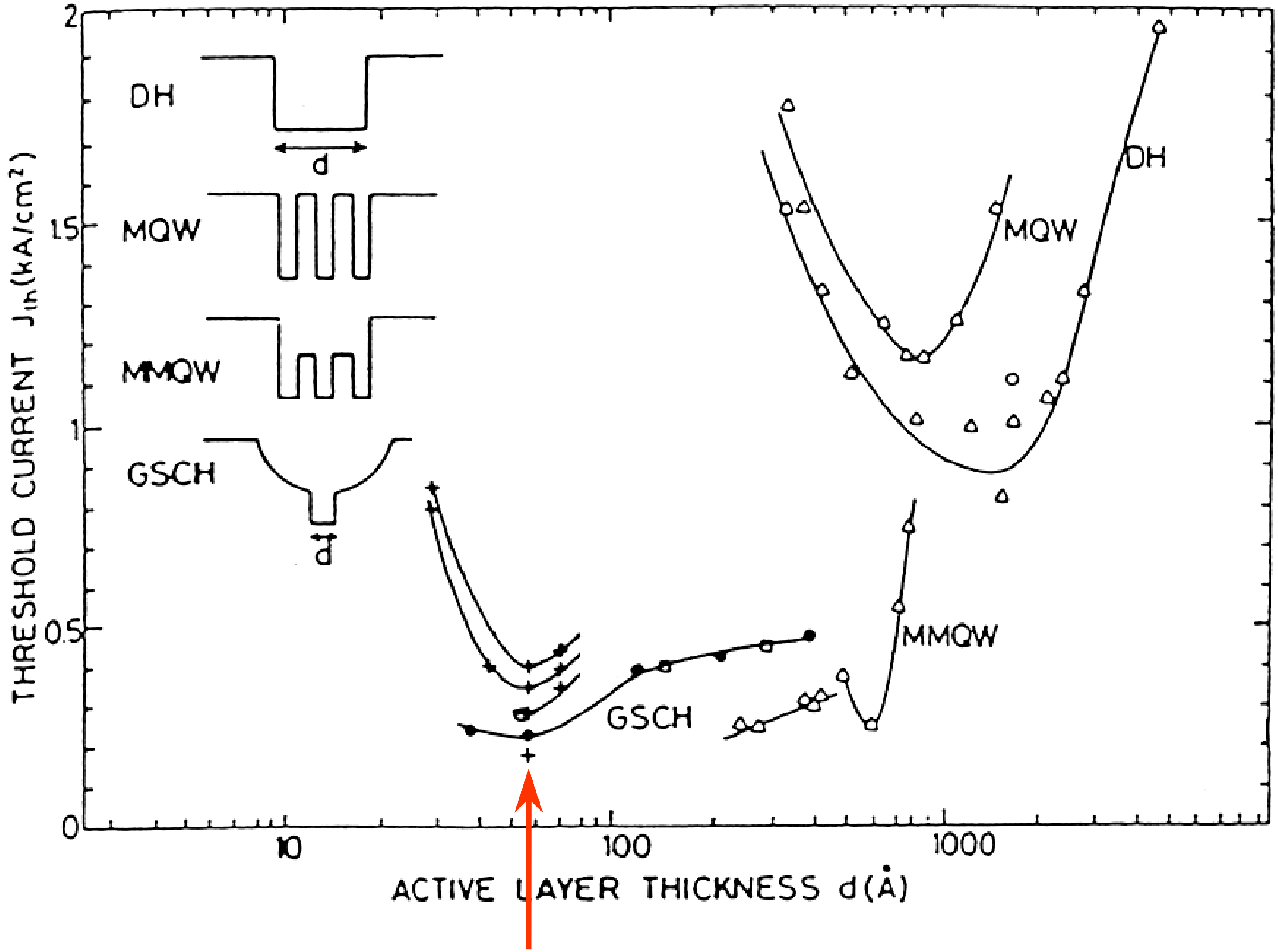
Transistor



Hard Disk



Quantum Well Laser: Designing the Perfect Trap



6 nm : Optimum Thickness

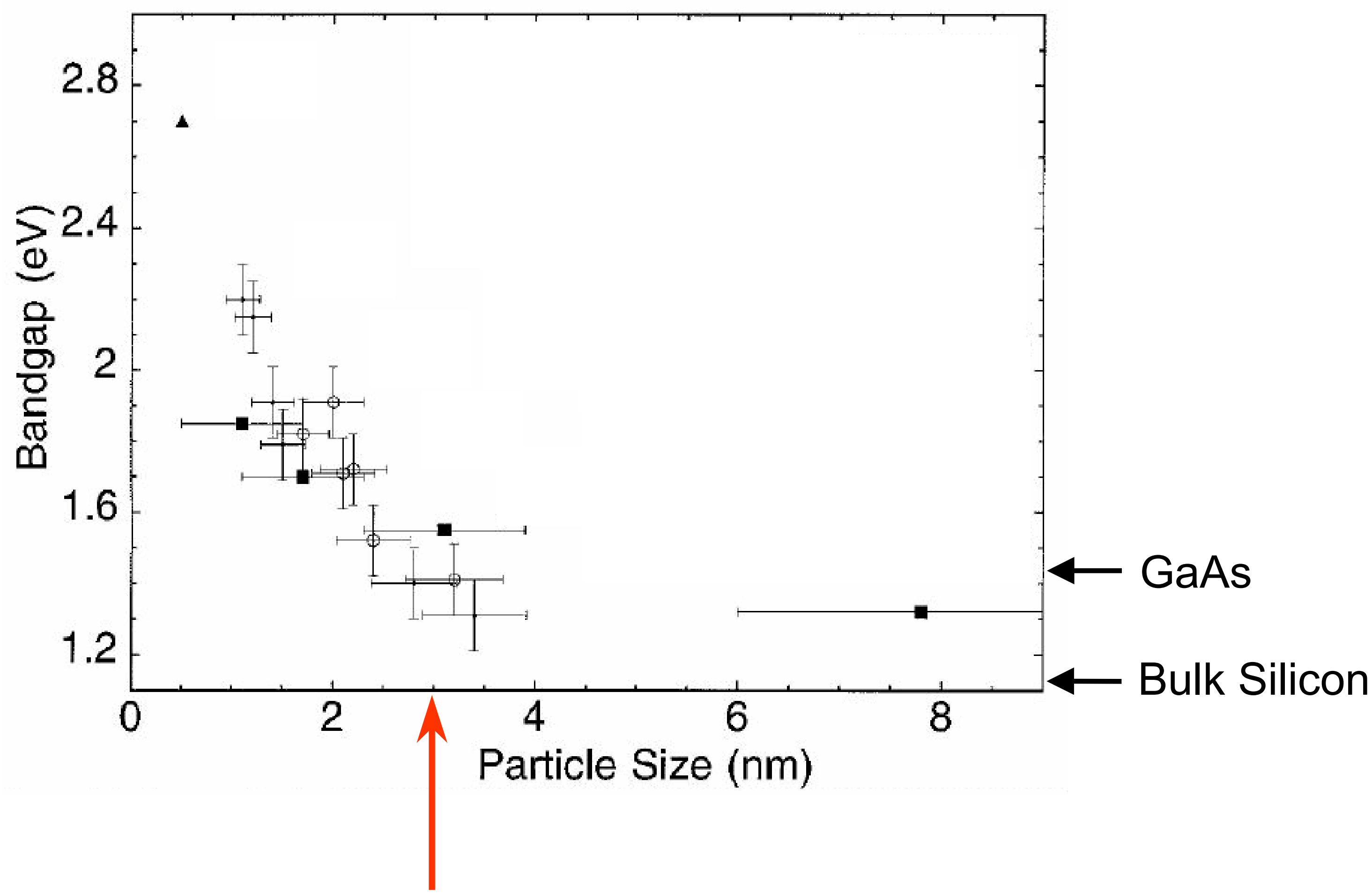
Nanocrystals

Quantum effect: Crystal size determines the color

(blue-shifted when smaller)

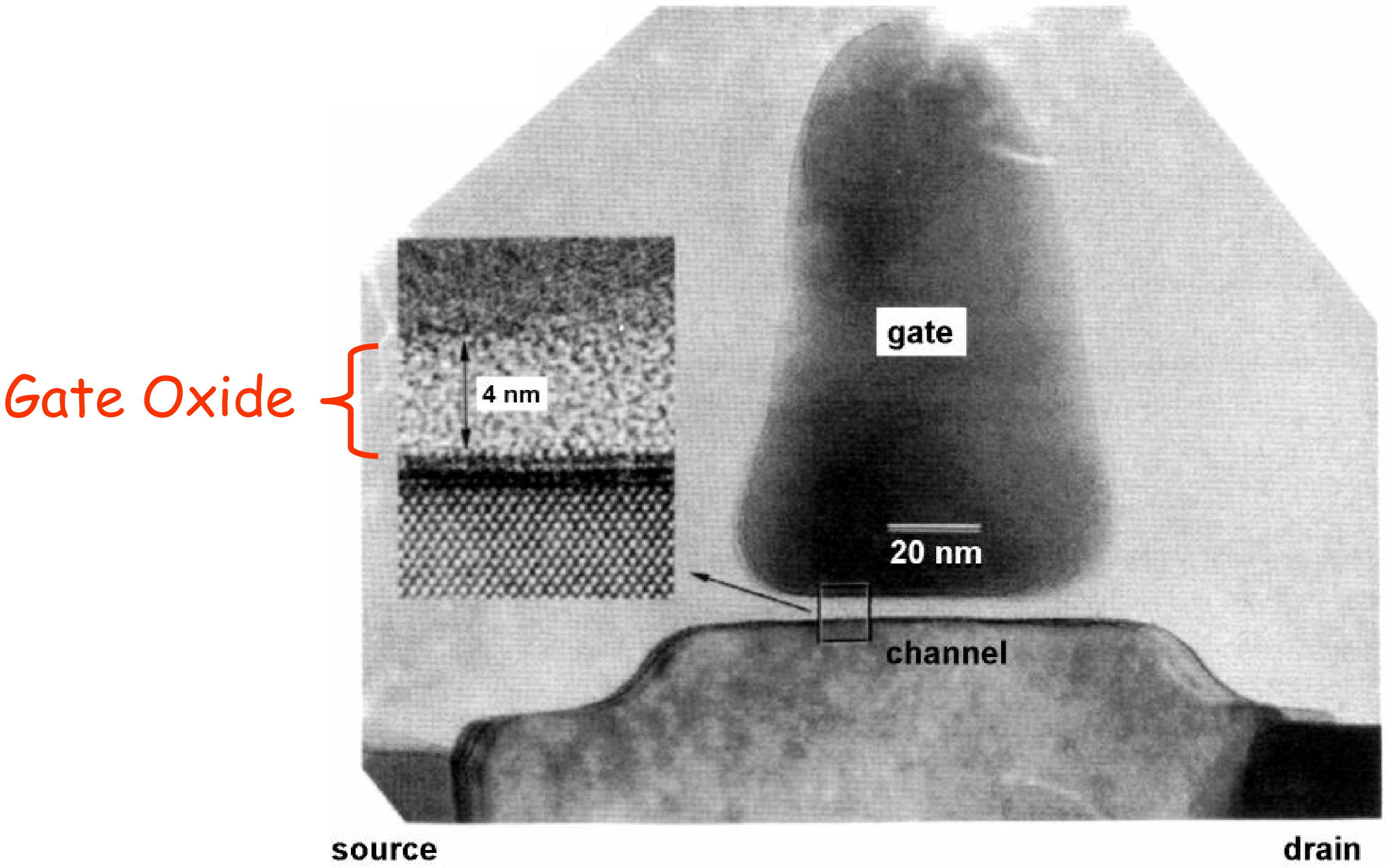
When does silicon cease to be silicon?

The band gap of silicon nanoclusters



3 nm : Gap begins to change

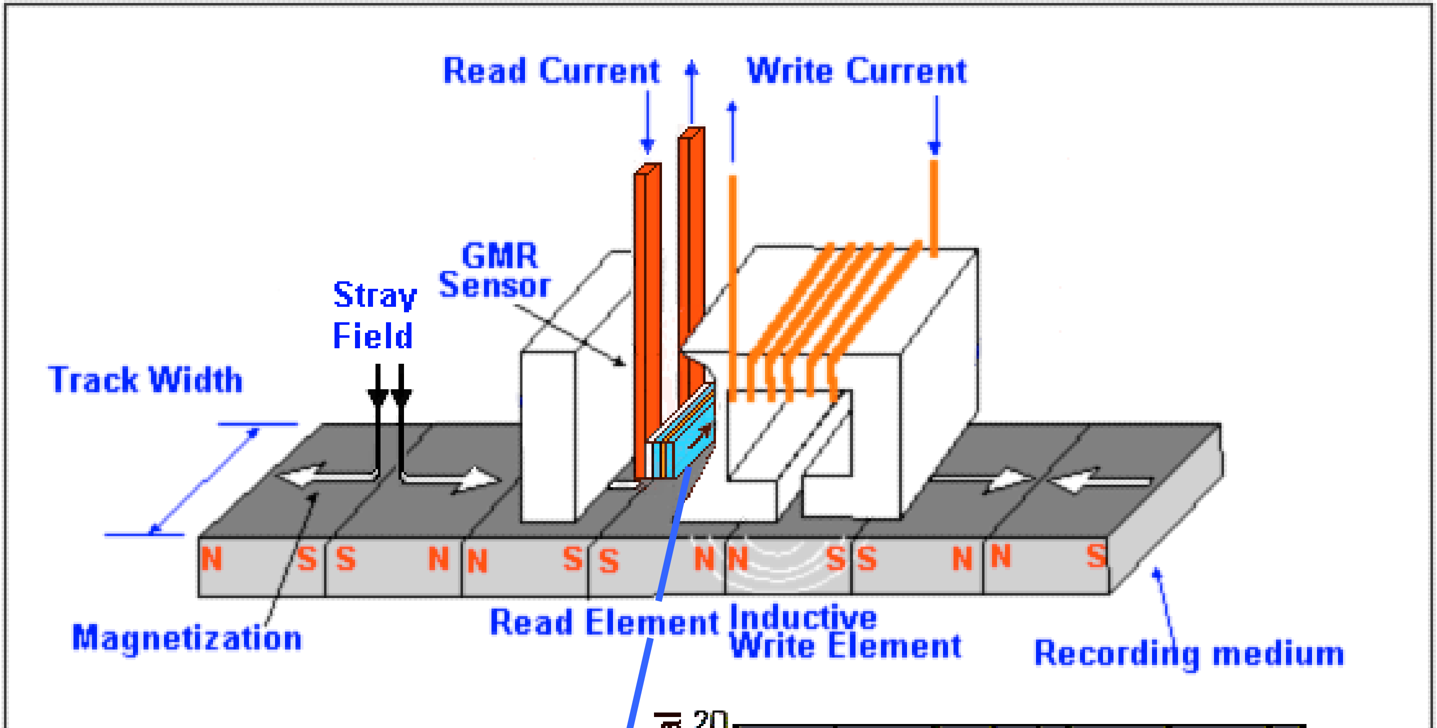
Transistor

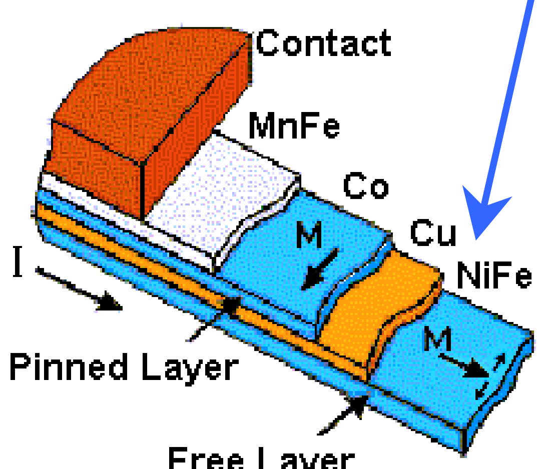


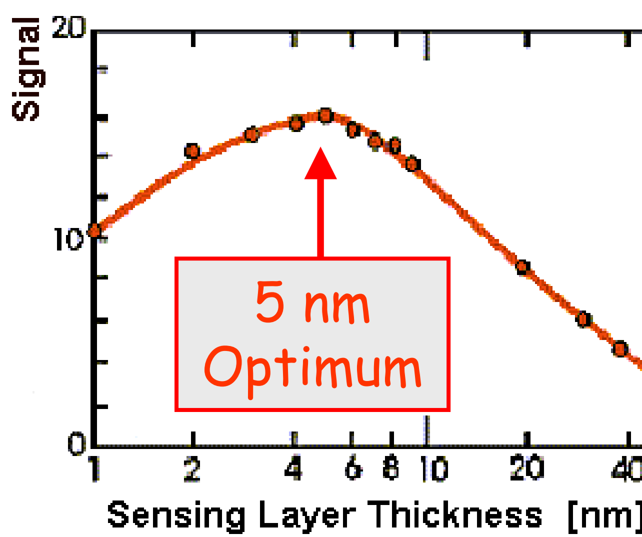
Power consumption by a leaky gate oxide

A show-stopper for silicon technology?

Hard Disk Reading Head





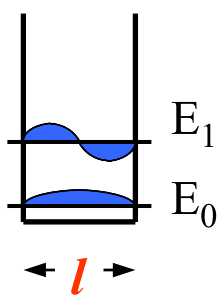


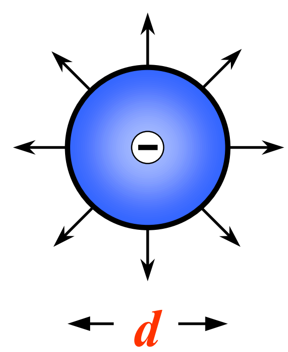
The Physicist's View: Fundamental Length Scales

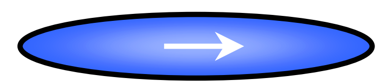
Energy → Length

Room temperature operation requires energies larger than the thermal energy: $k_B T = 25$ meV

Quantum	Electric	Magnetic
Quantum Well:	Capacitor:	Magnetic Particle:
Quantum Well Laser	Single Electron Transistor	Storage Media





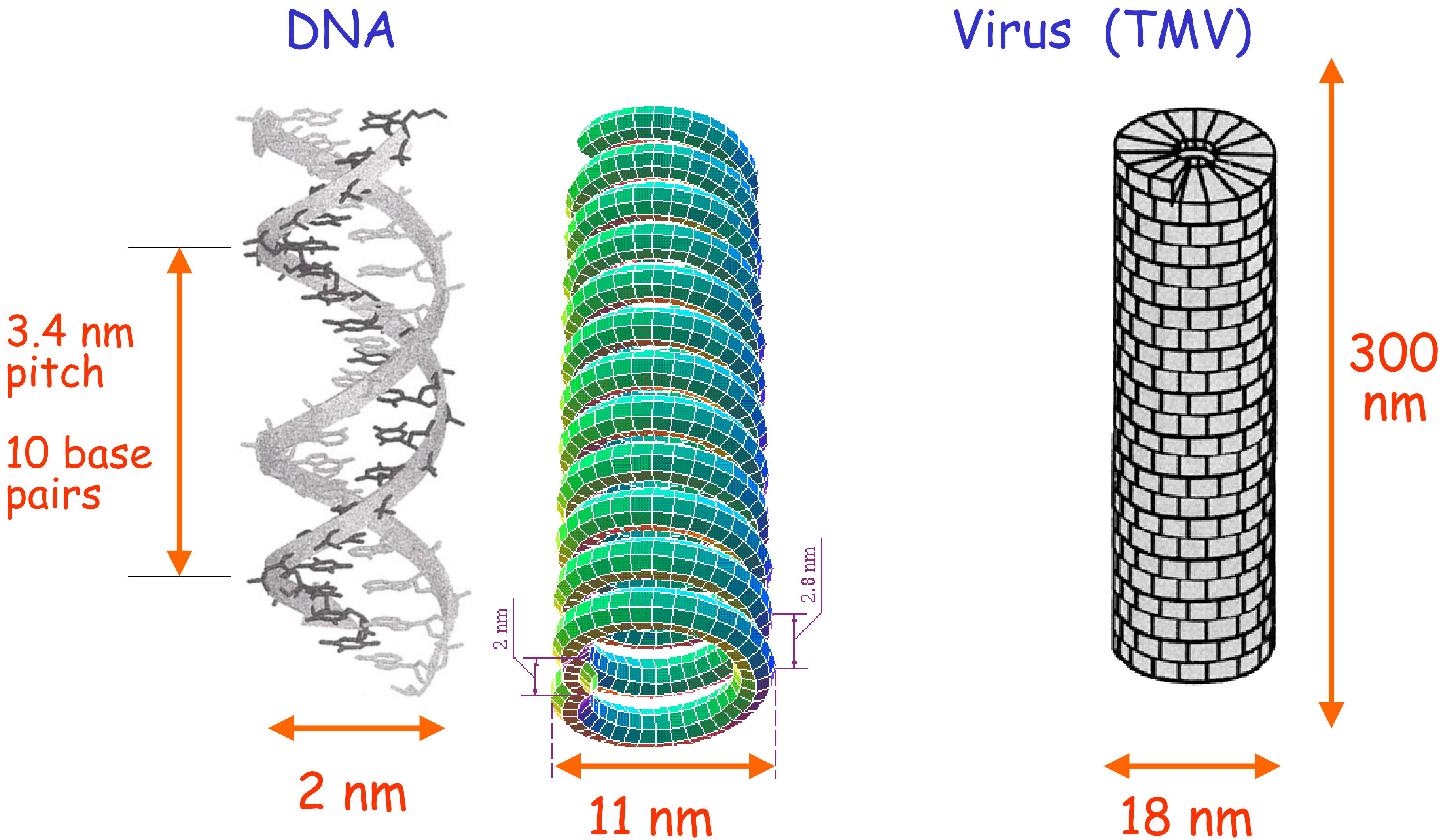


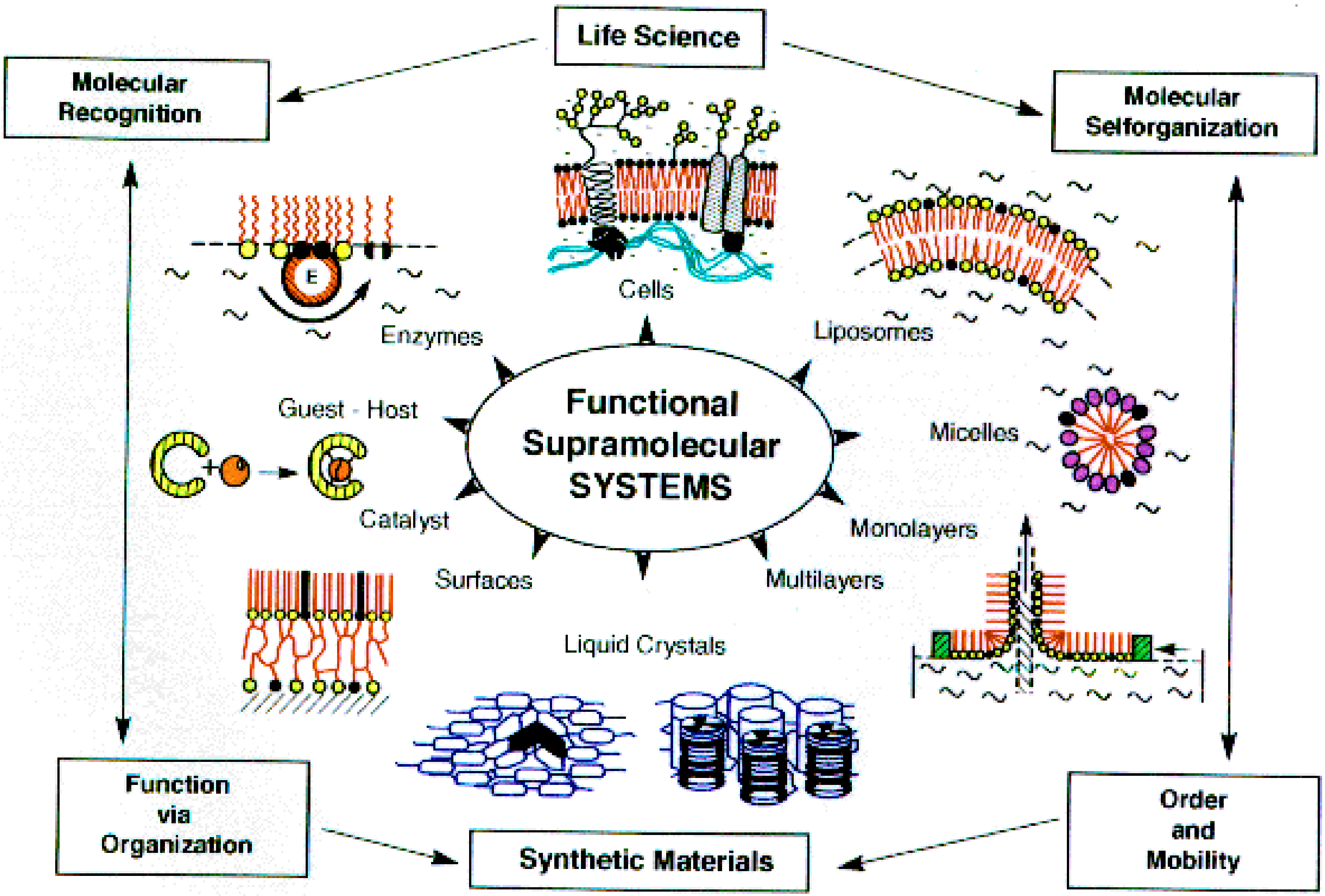
$a = V^{1/3}$

Energy Levels	Charging Energy	Spin Flip Barrier
$3h^2/8m\,l^2$	$2e^2/\varepsilon\, d$	$\frac{1}{2} M^2 a^3$

$l < 7$ nm	$d < 9$ nm	$a > 3$ nm

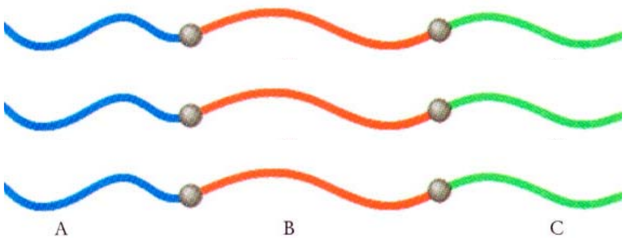
Biological Length Scales

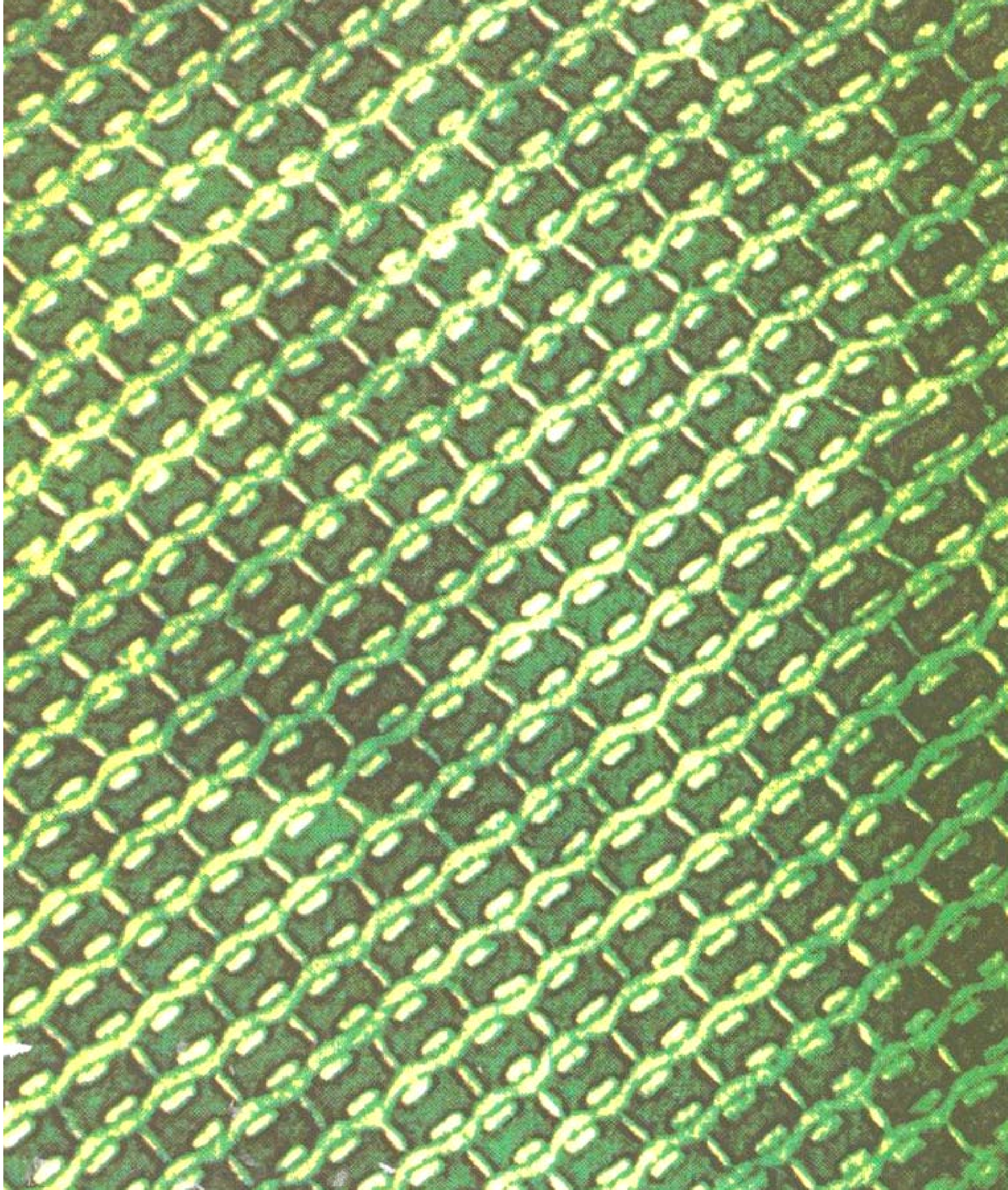




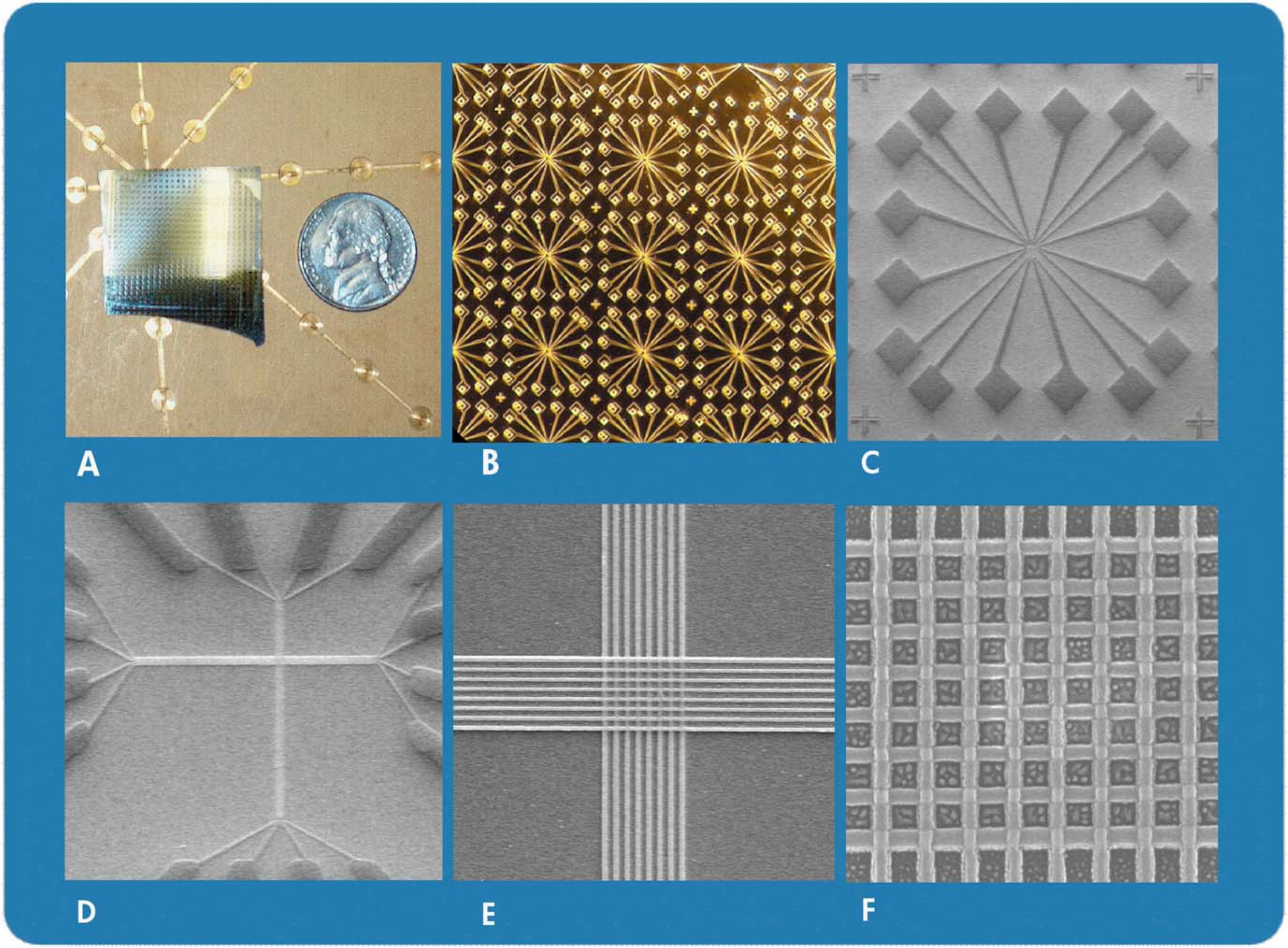
Life Science
Molecular Recognition
Molecular Selforganization
Cells
Enzymes
Liposomes
Guest - Host
Functional Supramolecular SYSTEMS
Micelles
Catalyst
Monolayers
Surfaces
Multilayers
Liquid Crystals
Function via Organization
Synthetic Materials
Order and Mobility

Knitting with Polymers





New Concepts: Molecular Electronics, Self-Assembly, Self-Correcting



Each panel x 10

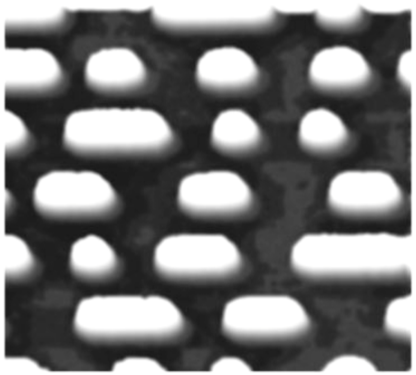
Hewlett-Packard molecular memory, teramac computer

In Pursuit of the Ultimate Storage Medium :

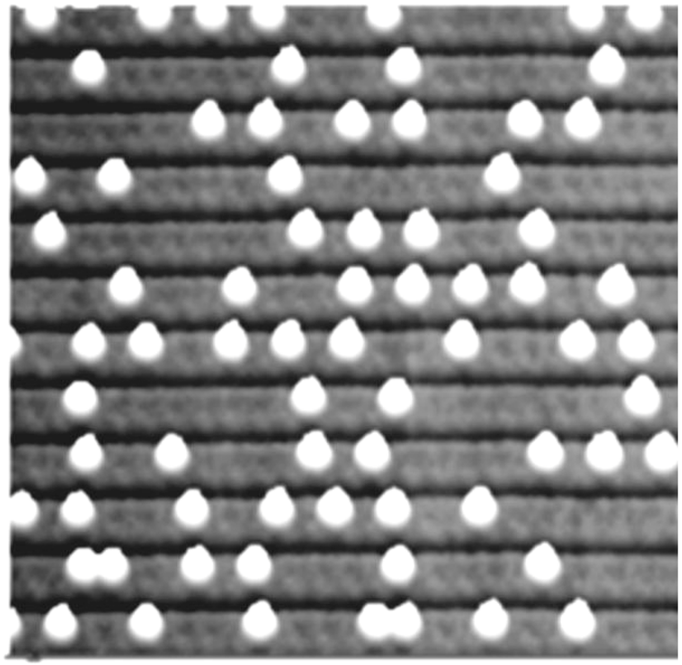
1 Bit = 1 Atom

Silicon Surface

CD-ROM



10 μm

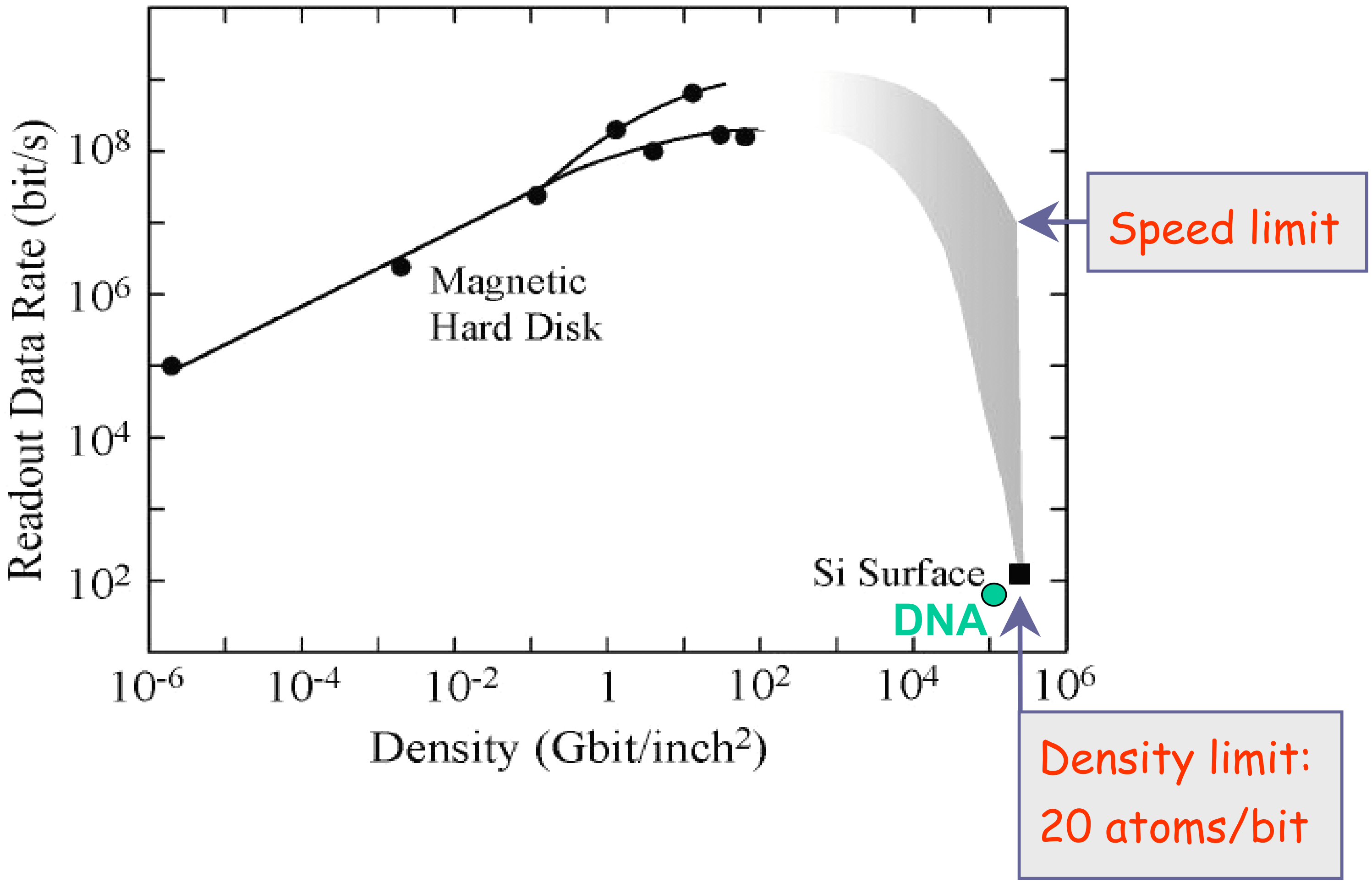


1.6 nm Track

10 nm

Density × 1 000 000

Speed versus Density



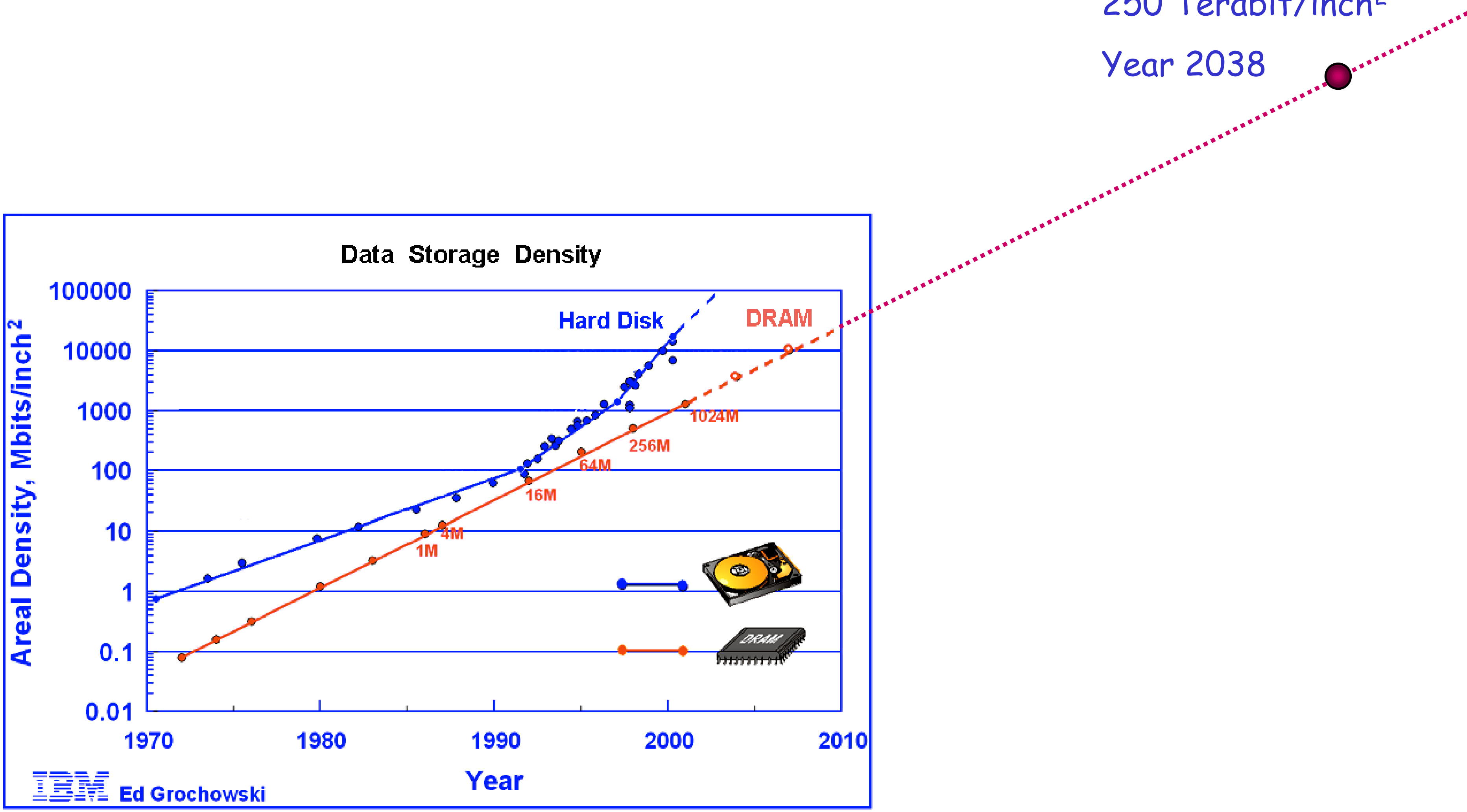
- Speed is sacrificed as density increases (less signal per bit)
- Density and speed in silicon are comparable to those in **DNA**

When will we be down to atoms ?

Using Moore's Law ...

250 Terabit/inch^2

Year 2038



"Disruptive technologies" start at the low end

Clayton Christensen, Harvard Business School

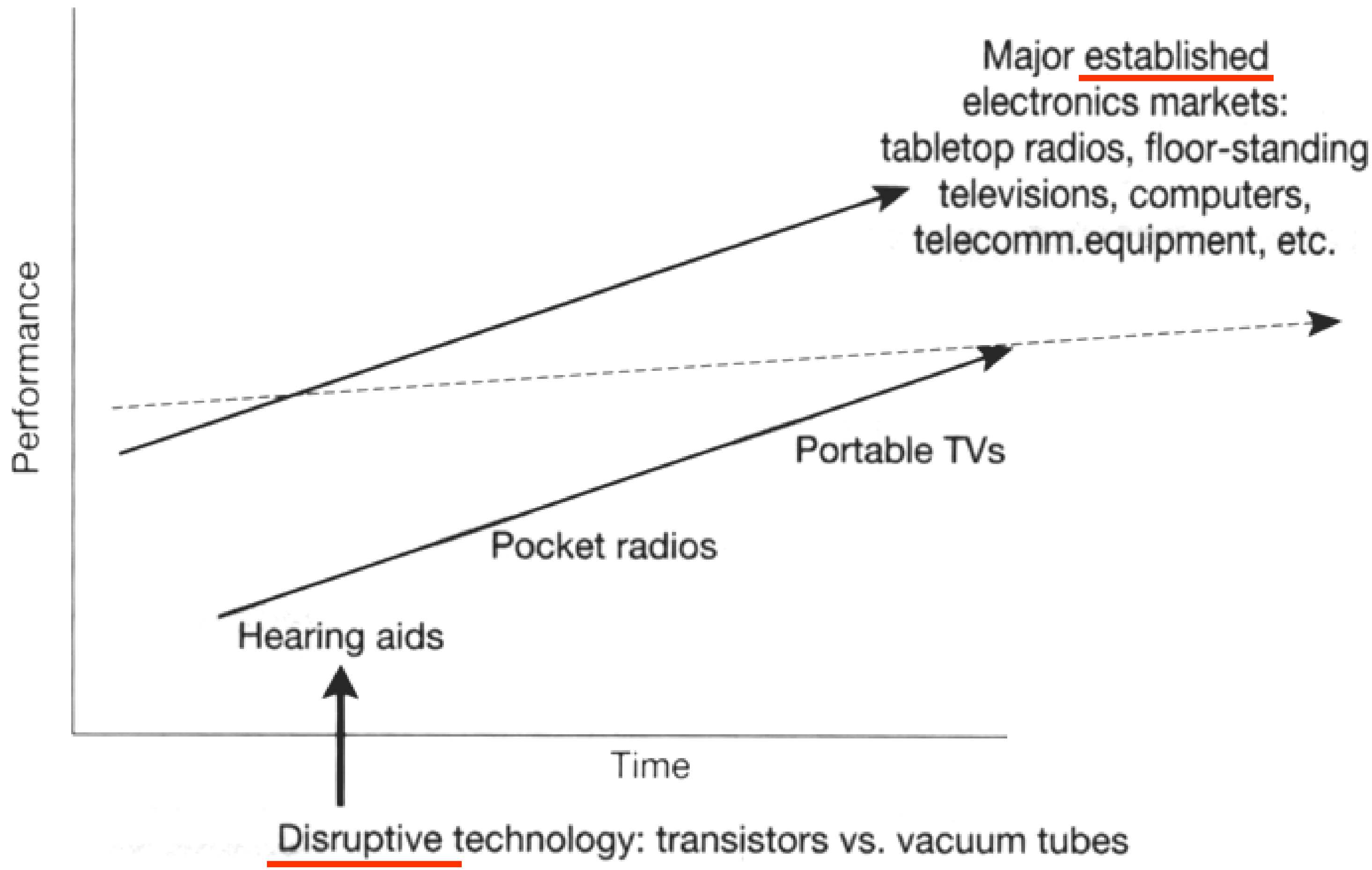


Figure 3. Successful disruptors target smaller, "green space" markets instead of stretching toward existing, larger markets.

PREY

A NOVEL

MICHAEL CRICHTON