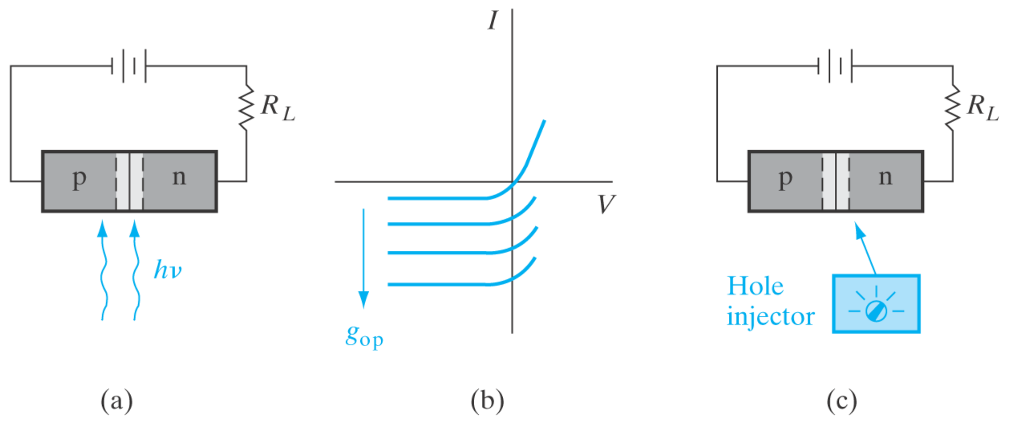
BJT and Integrated Circuits Chapter 6 & 9 – THE END!

ELEC 424
John Peeples

Bipolar Junction Transistors

Reverse Biased P-N Junction

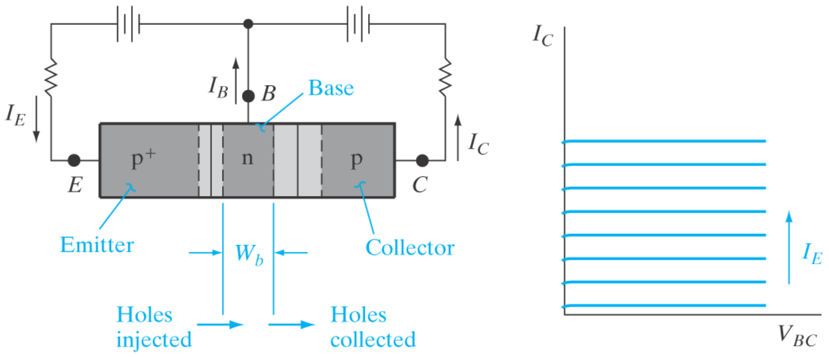
- I_o (reverse saturation current) depends on generation current, not electric field.



Bipolar Junction Transistors

Why not use a forward biased p^+-n junction as the generation source?

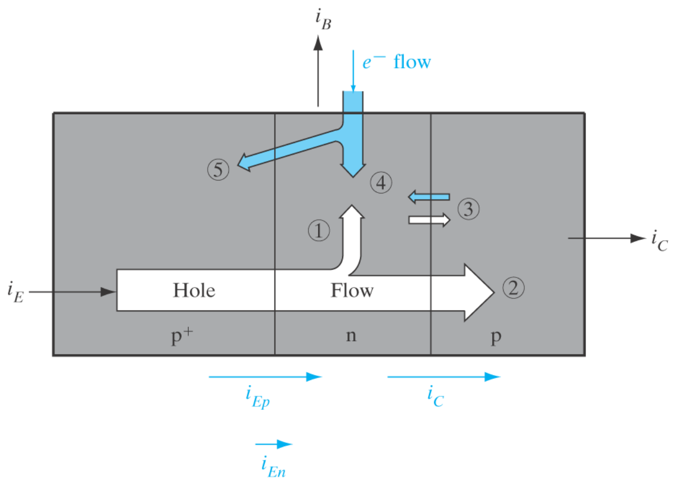
Common Base Configuration



Since the collected current will have little dependence on the load resistance, this is a pretty good constant current source.

Bipolar Junction Transistors

So, what is really going on?

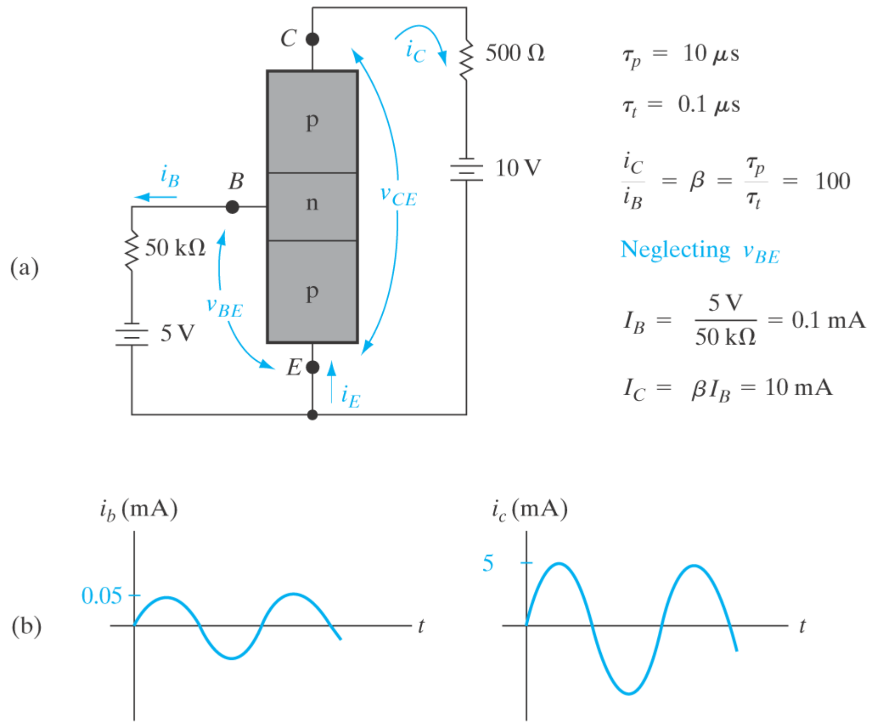


- *The base (n) region should be very thin relative to hole lifetime.*
- *Current at the emitter/base junction should be nearly entirely holes. Thus p^+ doping.*

- *A small amount of base current recombines with injected holes in the thin base region.*
- *A very small amount of base current will be injected into the emitter region across the forward biased junction.*
- *Some holes and electrons will recombine across the base collector junction (thermally generated)*

Bipolar Junction Transistors

Amplification



Semiconductor Processing

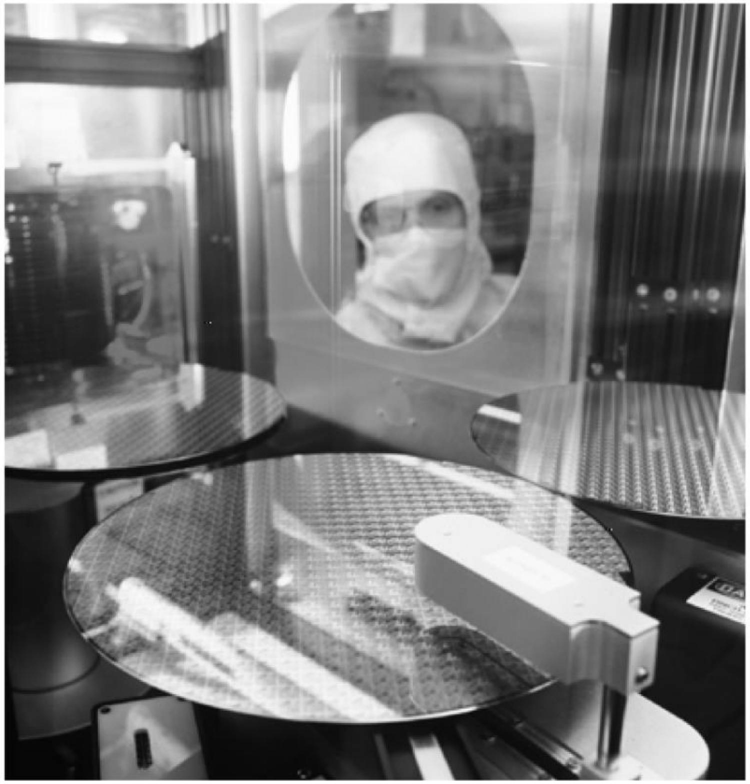
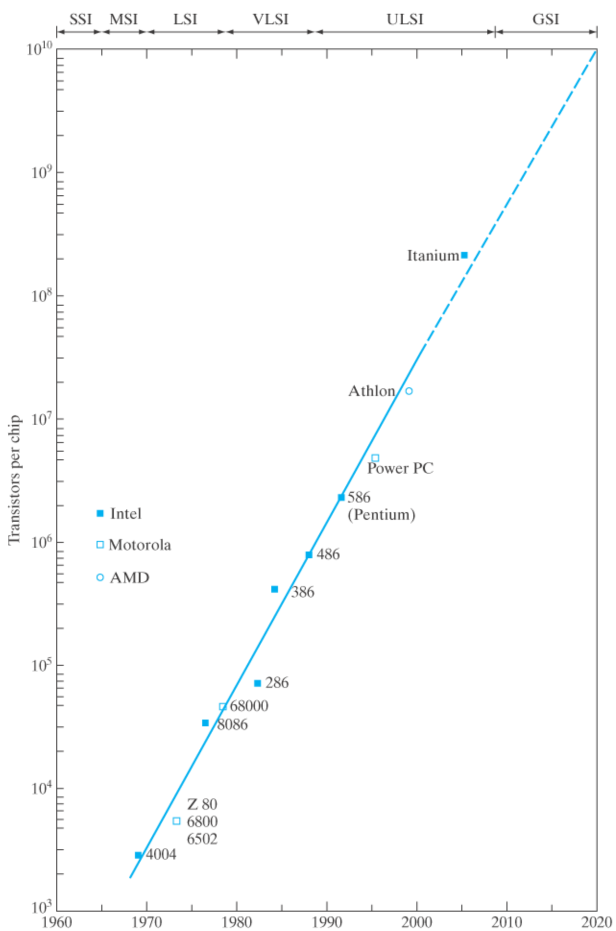


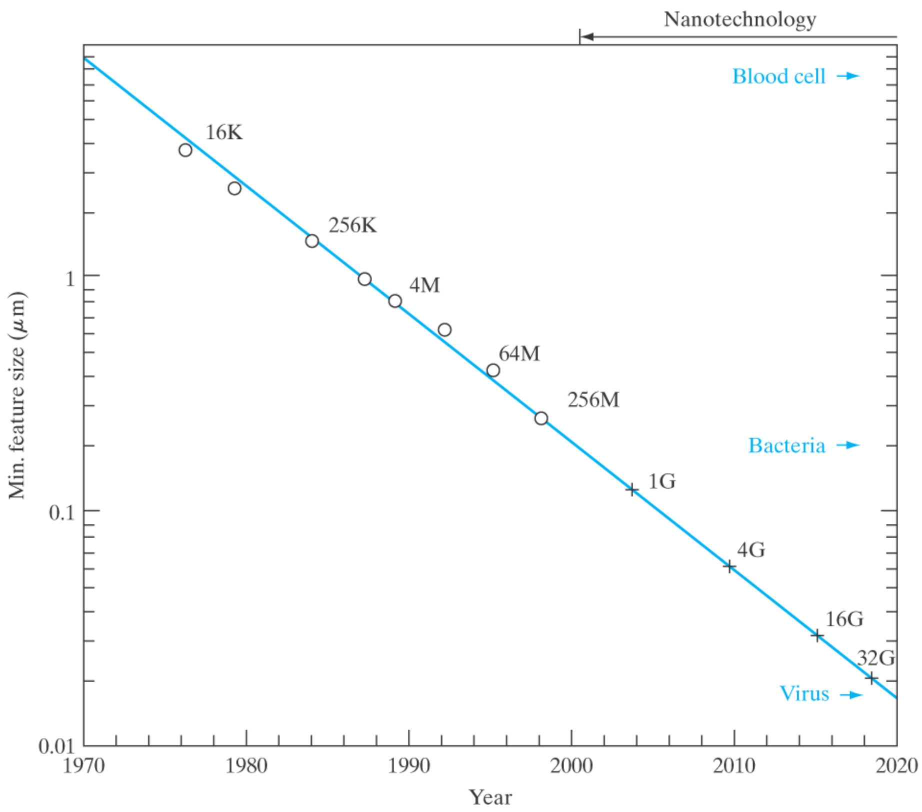
Figure 9.1

A 300-mm diameter (about 12-inch) wafer of integrated circuits. The circuits are tested on the wafer and then sawed apart into individual chips for mounting into packages. (Photograph courtesy of Texas Instruments.)

Moore’s Law



SSI
MSI
LSI
VLSI
ULSI
GSI
Transistors per chip
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
10^{8}
10^{9}
10^{10}
1960
1970
1980
1990
2000
2010
2020
Intel
Motorola
AMD
4004
Z 80
6800
6502
8086
68000
286
386
486
586
(Pentium)
Power PC
Athlon
Itanium



Nanotechnology
Min. feature size (μm)
0.01
0.1
1
1970
1980
1990
2000
2010
2020
Year
16K
256K
4M
64M
256M
1G
4G
16G
32G
Blood cell
Bacteria
Virus

CMOS

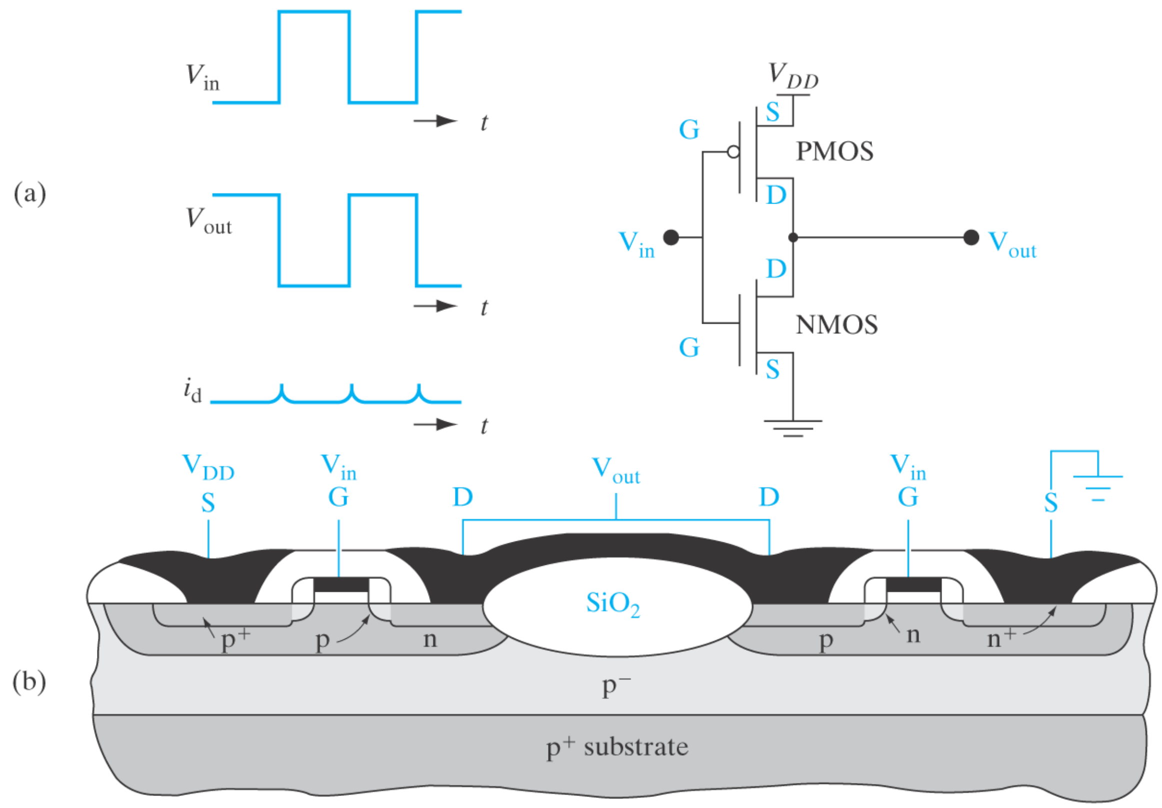


Figure 9.4

Complementary MOS structure: (a) CMOS inverter; (b) formation of p-channel and n-channel devices together.

Speed and Power Enhancements

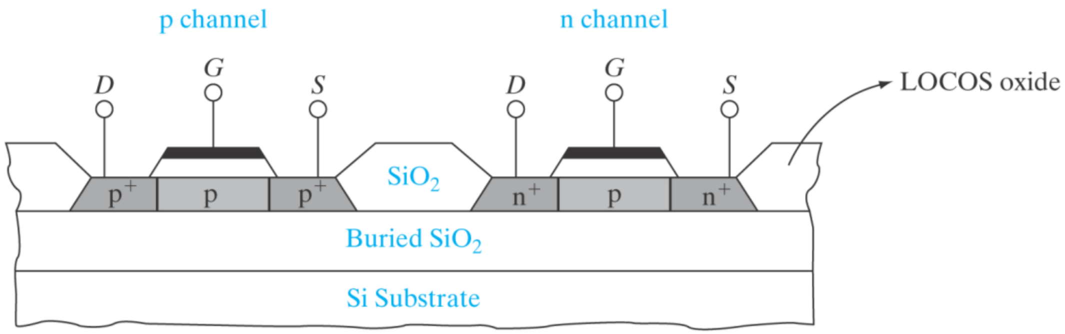
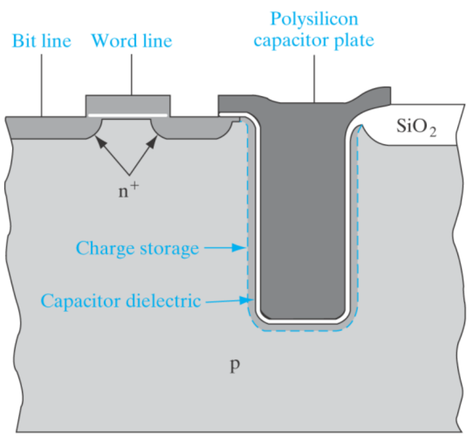


Figure 9.11

Silicon on insulator. Both n-channel and p-channel enhancement transistors are made in islands of Si film on the insulating substrate. These devices can be interconnected for CMOS applications.

SOI

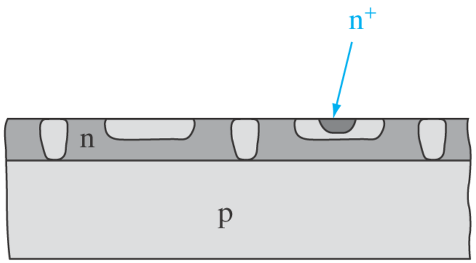


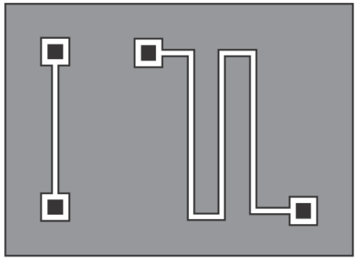
(a)

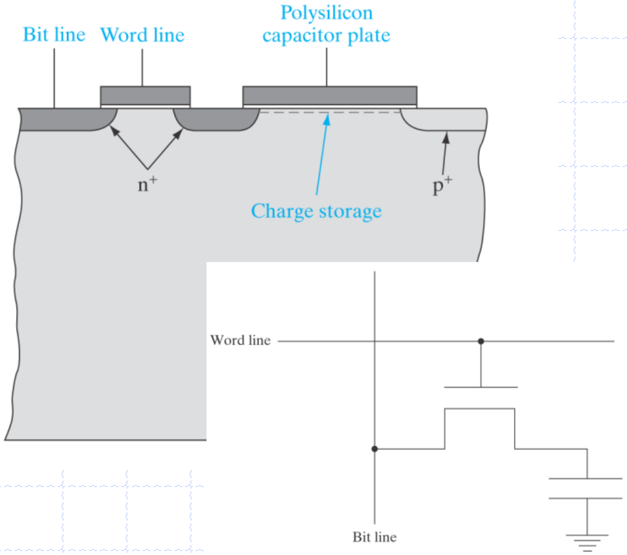
Vertical Integration

Resistors and Capacitors are Easy

Monolithic Resistors

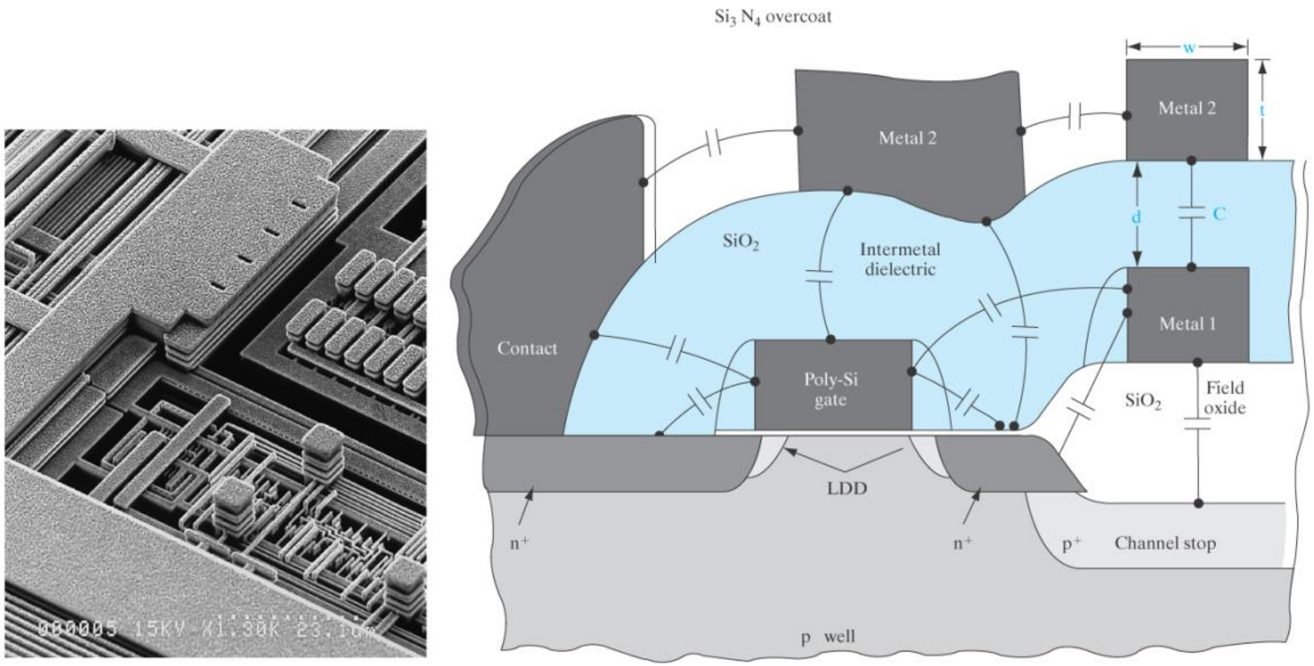






Memory cell capacitor and its bit and word lines

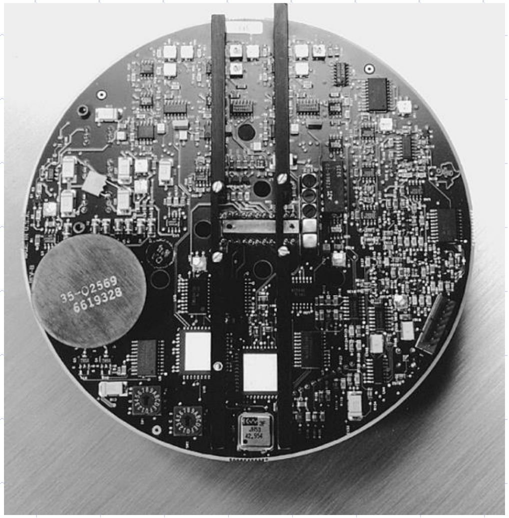
Wires (Interconnections) can be Hard

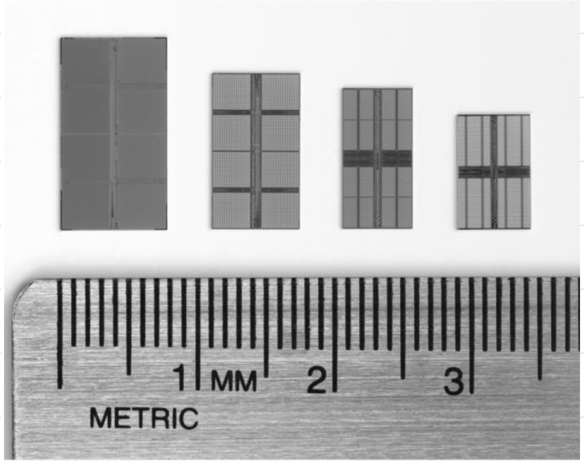


(a) (b)

What Great Applications

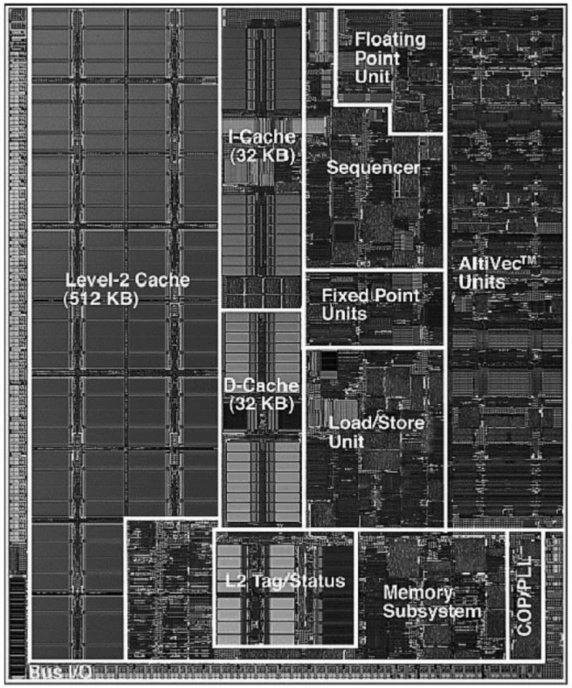
CCD Imaging (digital cameras) is just a bunch of capacitors.





DRAMS are getting smaller (or larger) all the time

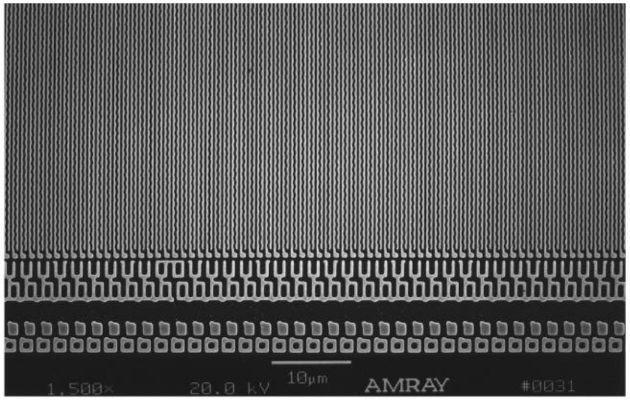
Smaller Features mean More on Each Chip



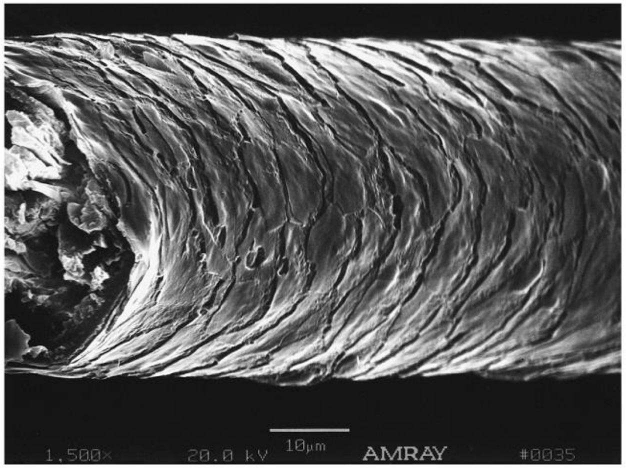
G4 Power PC for you Mac fans.

90 nm
1.5 GHz

Small is Pretty Small



(a)

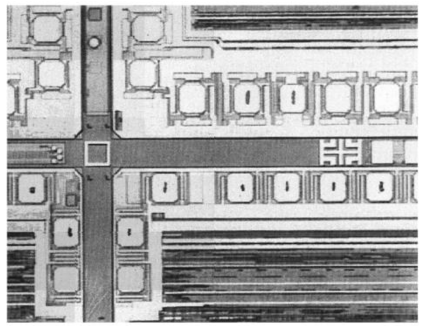


(b)

180 nm features
(the thin lines)

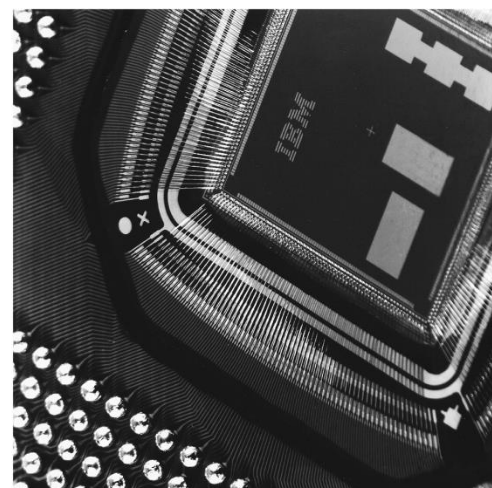
A big fat human hair

The Back End is Critical

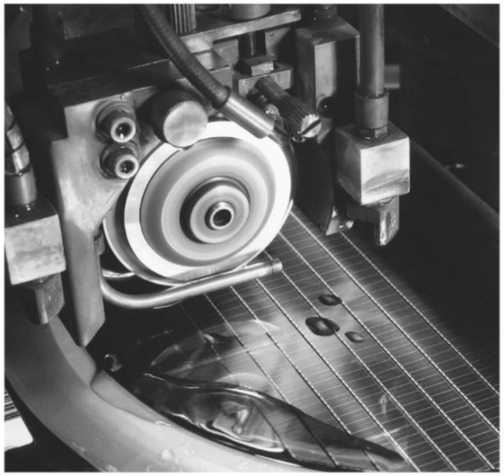


Testing is expensive

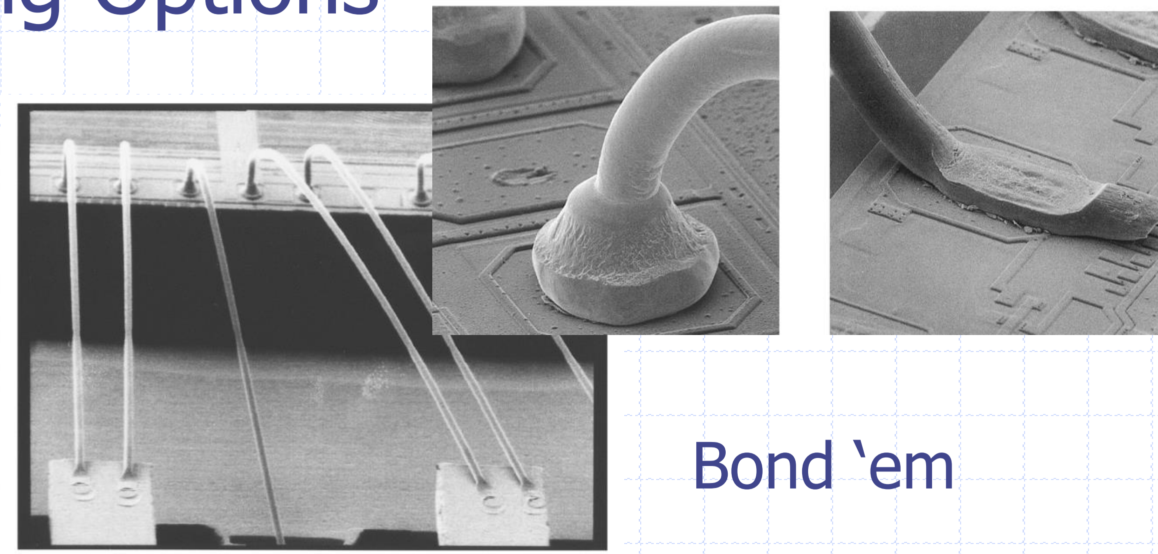
and so is packaging



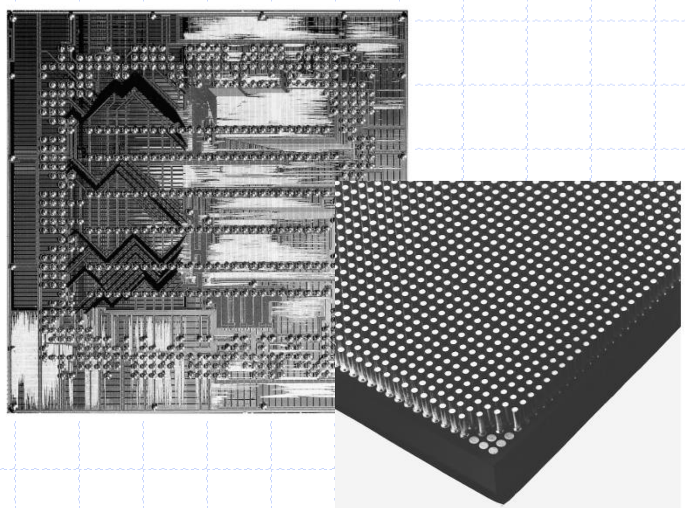
Many Packaging Options



Cut ‘em



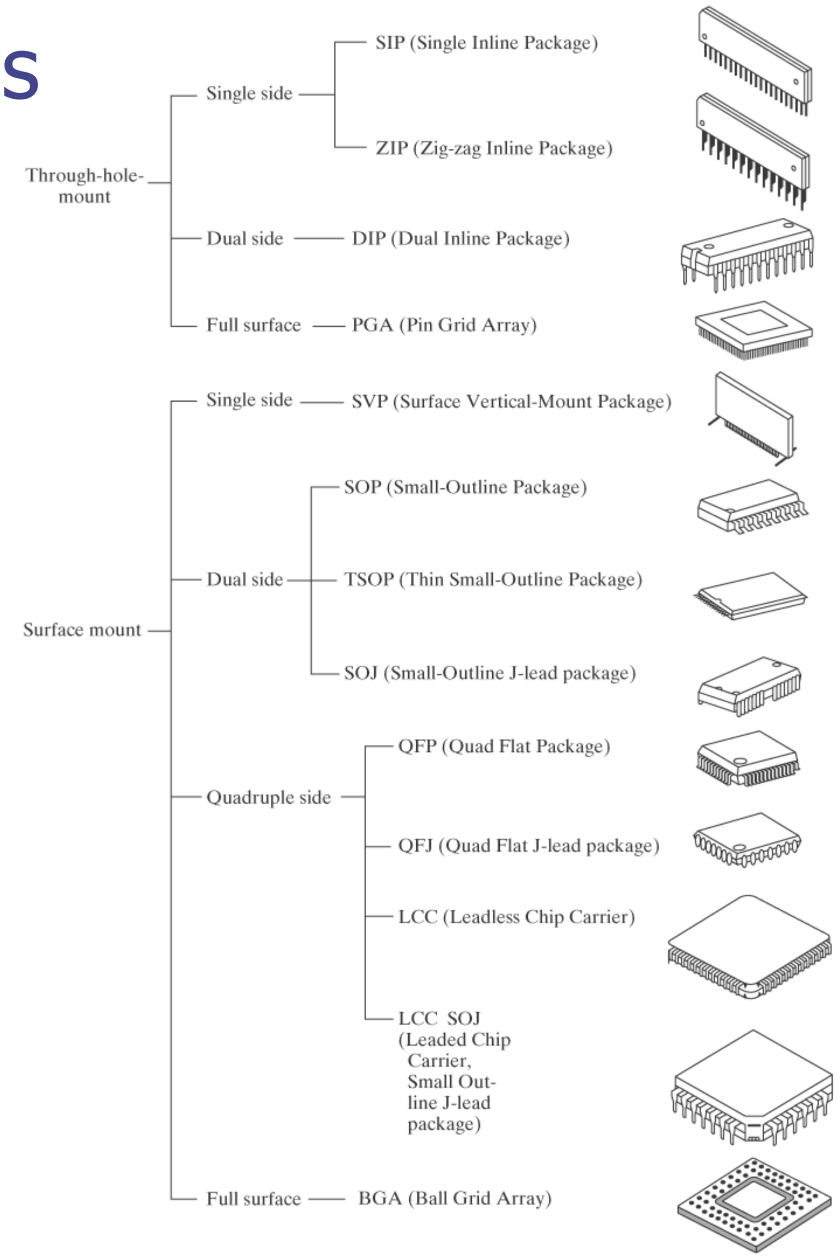
Bond ‘em



or Flip and/or Grid ‘em

Many Packaging Options

Smaller costs initially, but once it is commodity, is less expensive



Closing Thought

Regardless of your career choices, you will continue to be influenced by semiconductor technology in your everyday and professional lives. Knowing a little about its genesis, capabilities and promises is a good thing.

Thanks for taking my course.

April 18, 2014