A Brief History of the field of VLSI

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ECE 410

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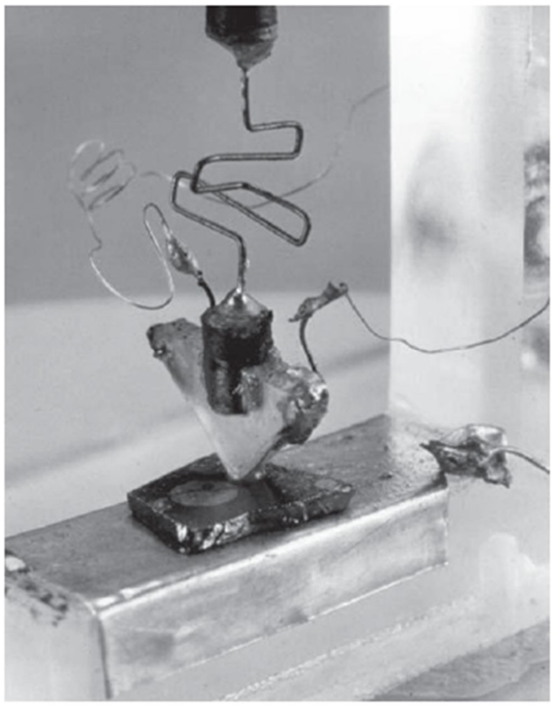
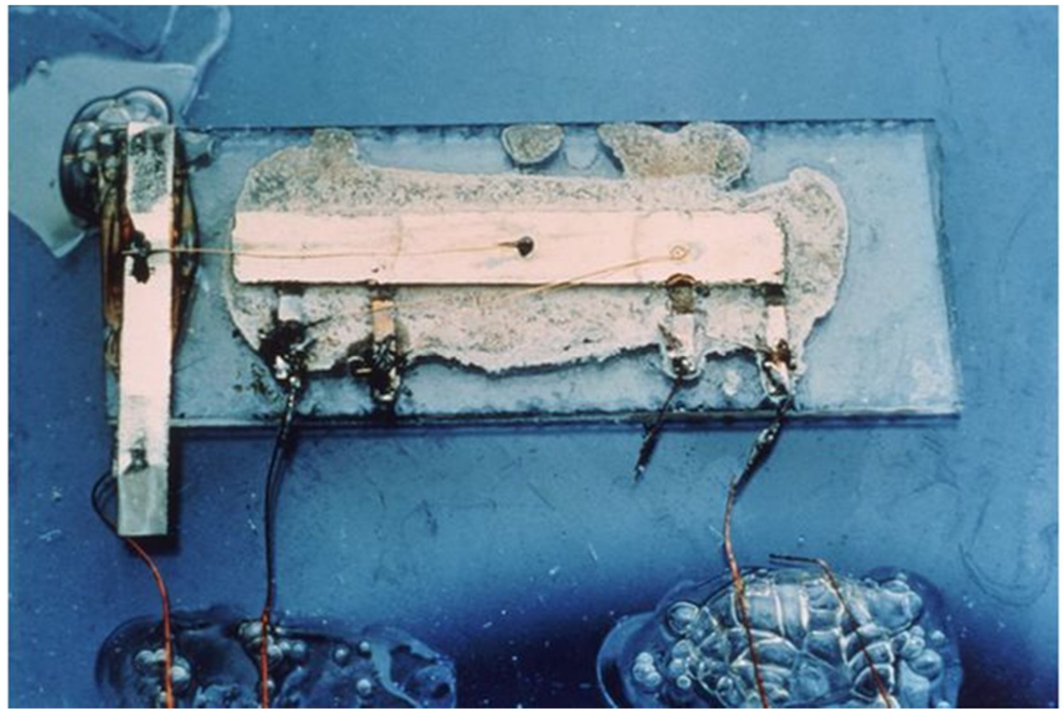
The First Transistor

in 1947 John Bardeen and Walter Brattain built the first functioning point contact transistor at Bell Labs



First Transistor (Bell Labs)



First IC (Texas Instruments)

Wikipedia.org, Neil H.E. Weste and David Money Harris *CMOS VLSI Design* 4th ed.

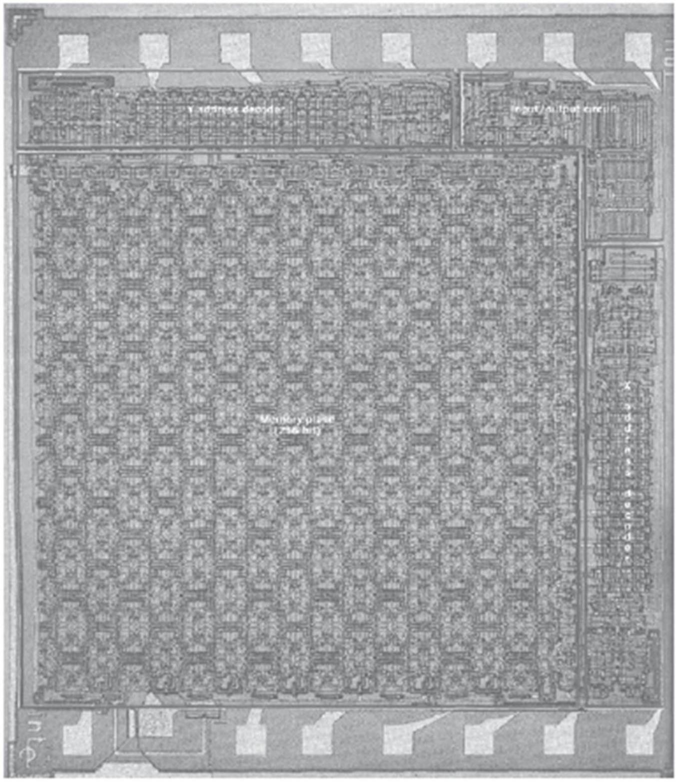
Complementary Metal Oxide Semiconductor

- In 1959, Dawon Kahng and Martin M. (John) Atalla at Bell Labs invented the metal–oxide–semiconductor field-effect transistor (MOSFET) as an offshoot to the patented FET design.
- The method of coupling two complementary MOSFETS (P-channel and N-channel) into one high/low switch, known as **CMOS**, means that digital circuits dissipate very little power except when actually switched.
- As the number of transistors per chip increased, the idle power consumption of BJTs (which have other advantages over MOSFETS) made CMOS the dominant technology

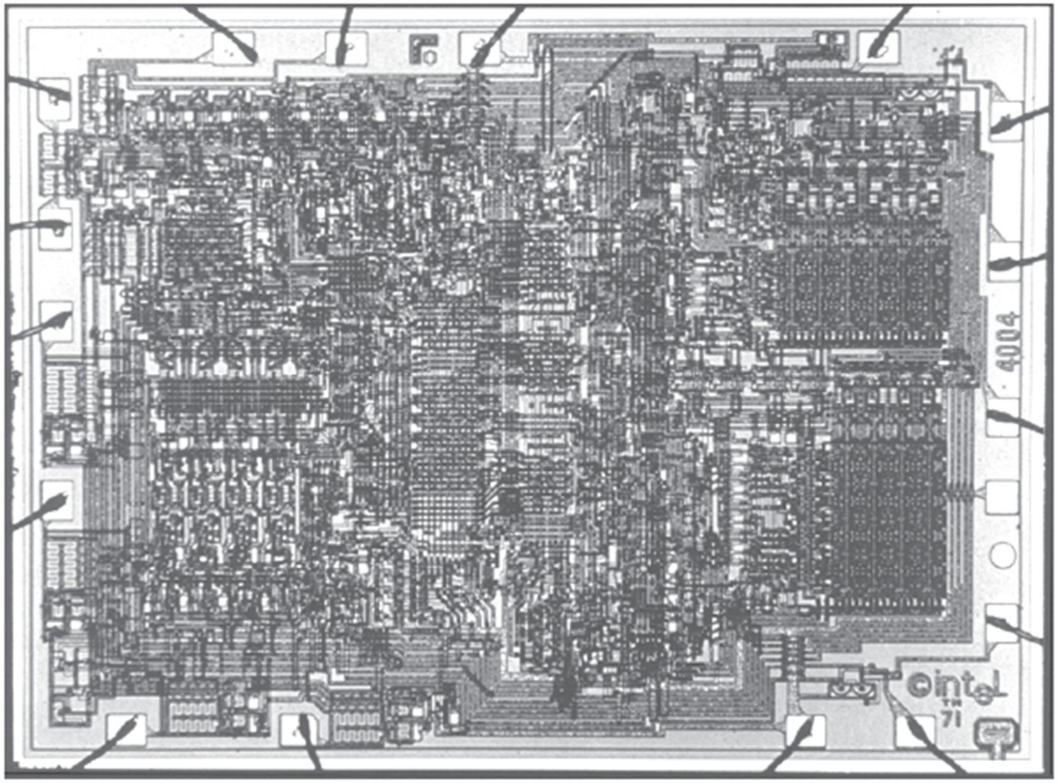
Wikipedia. Org, and Neil H.E. Weste and David Money Harris *CMOS VLSI Design* 4th ed.

1970s - nMOS Technology –

Intel 1101 SRAM – 256 bit static random access memory and 4004 4-bit microprocessor



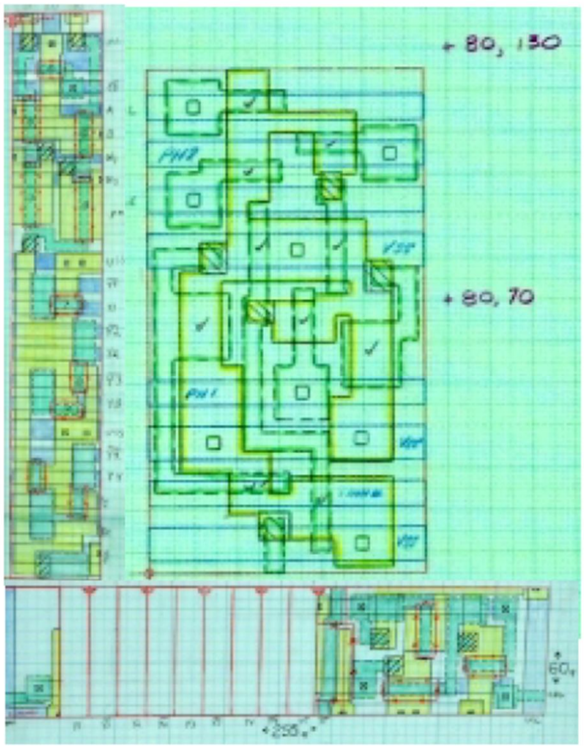
(a)



(b)

FIGURE 1.3 (a) Intel 1101 SRAM (© IEEE 1967 [Vadasz69]) and (b) 4004 microprocessor (Reprinted with permission of Intel Corporation.)

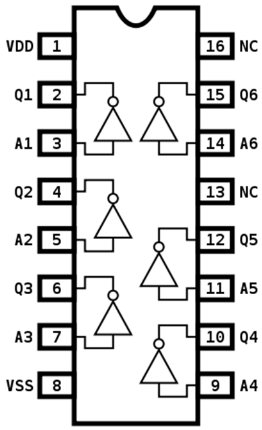
How were ICs designed before computer tools?



Layers were hand drawn, checked with magnifying glasses, manually checked for design rules and layout vs. schematic checks. The final layout was cut out of rubylith, and painstakingly checked for peeling and cutting errors. The first Intel product, the 3101 64-bit RAM was actually a 63-bit RAM due to a peeling error

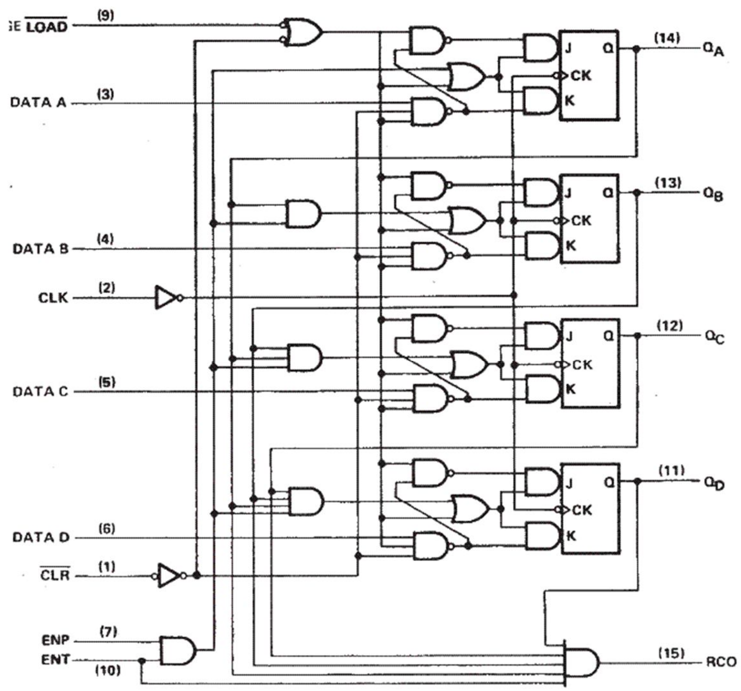
VLSI - “Very Large Scale Integration”

Small Scale Integration (SSI)
~10 gates



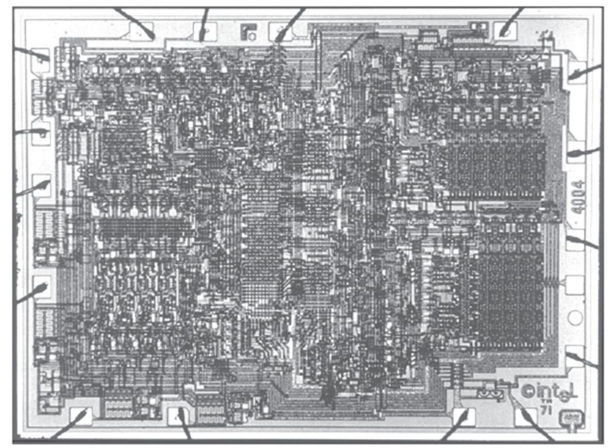
4049 Inverter

Medium Scale Integration (MSI)
~1000 gates



74161 Counter

Large Scale Integration (LSI)
~10,000 gates



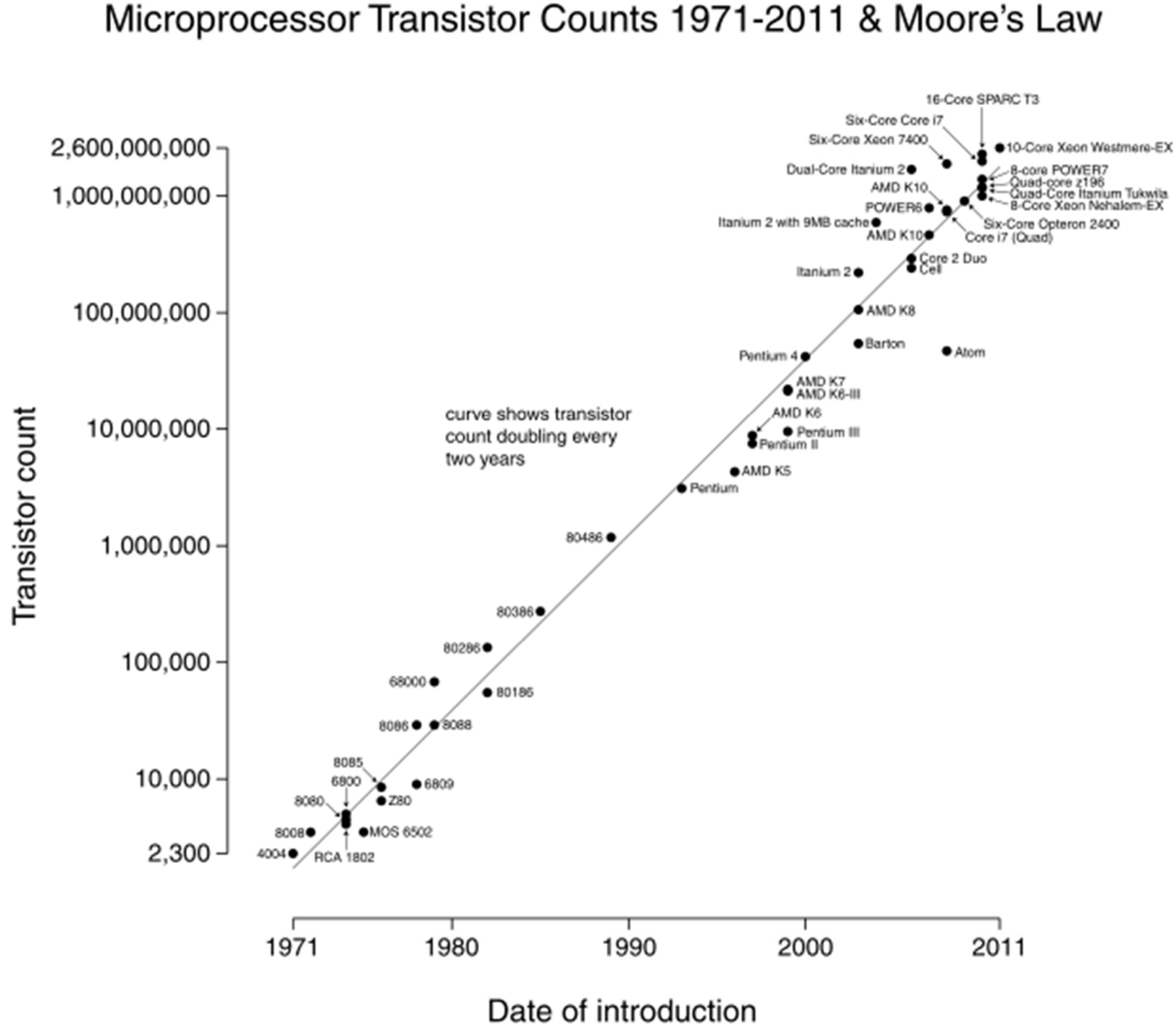
Intel 4004 4-bit Microprocessor

Very Large Scale Integration (VLSI) – This naming convention has become a hassle. Let’s just call everything with more transistors “VLSI.”

Wikipedia.org, Neil H.E. Weste and David Money Harris *CMOS VLSI Design* 4th ed., http://makeyourownchip.tripod.com/74161.html

Moore's Law

The transistor count doubles every 18 months

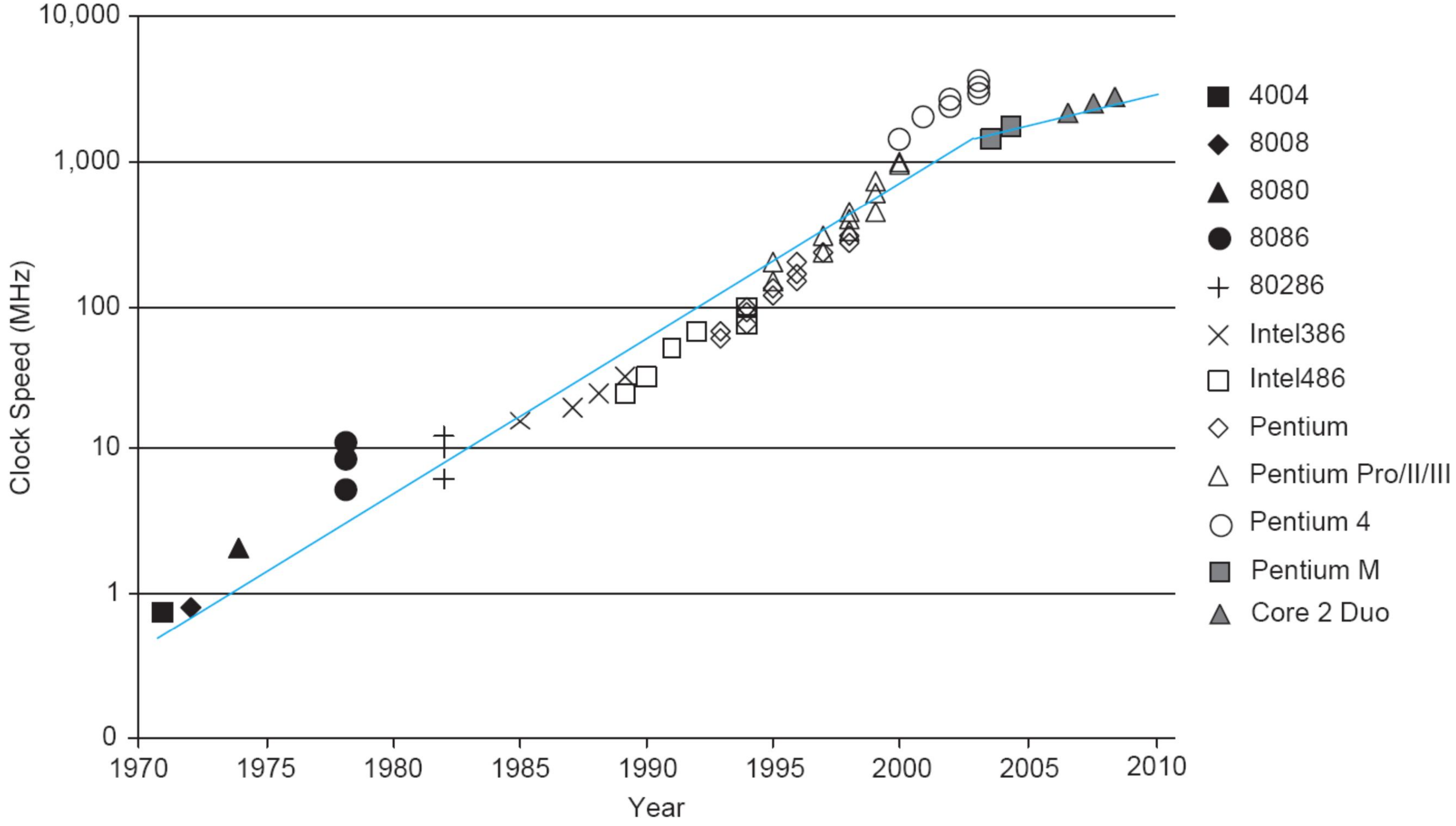


Wikipedia.org, Neil H.E. Weste and David Money Harris *CMOS VLSI Design* 4th ed.

Steady Miniaturization

- Compound annual growth rate of 53% for over 50 years
- No other technology in history has sustained such a high growth rate for so long
- How is it possible?
  No tradeoff in performance, power and price:
- As transistors get smaller, they also get faster, dissipate less power, and are cheaper to manufacture
- The only question is: how small can they get?

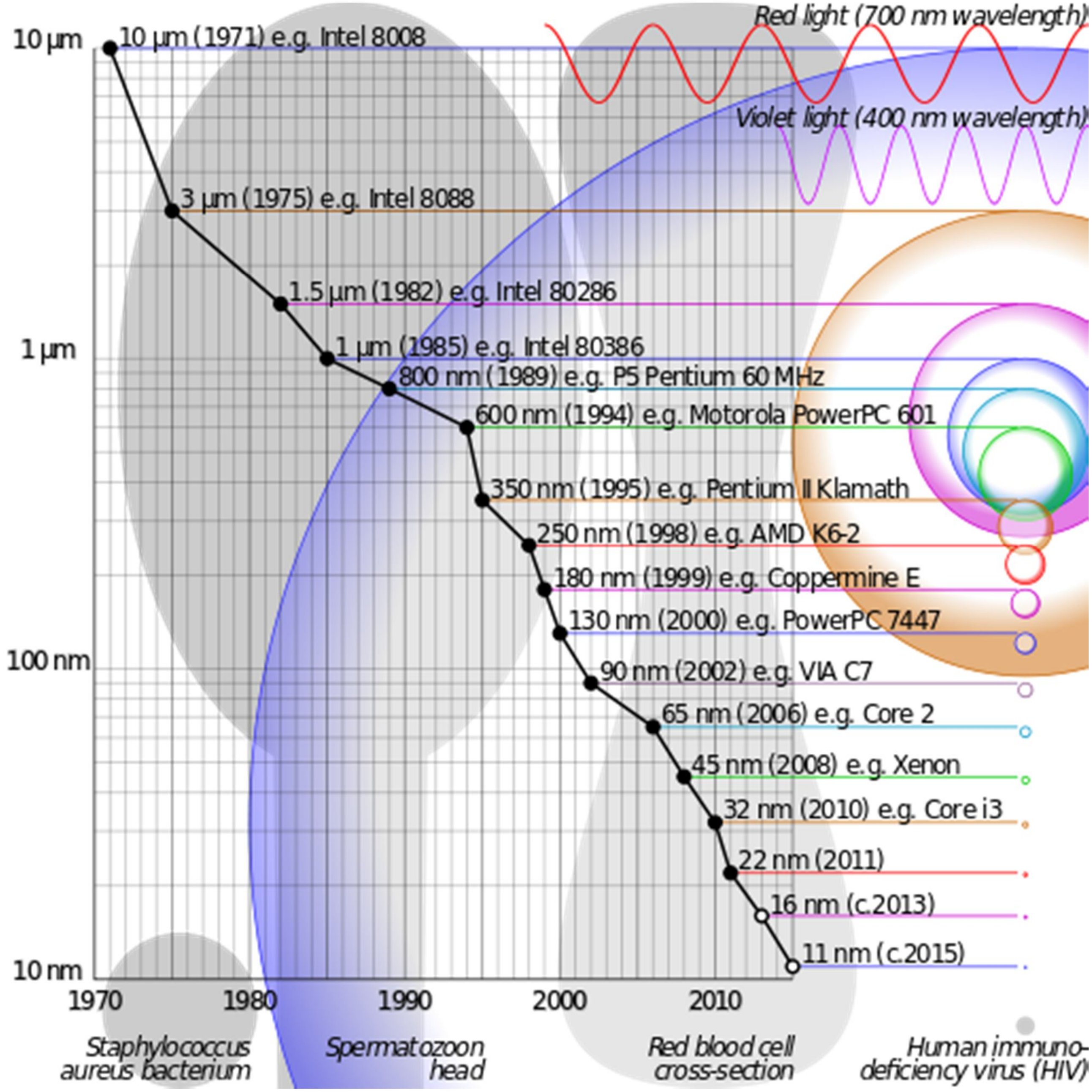
Concern 1 – "The Power Wall"



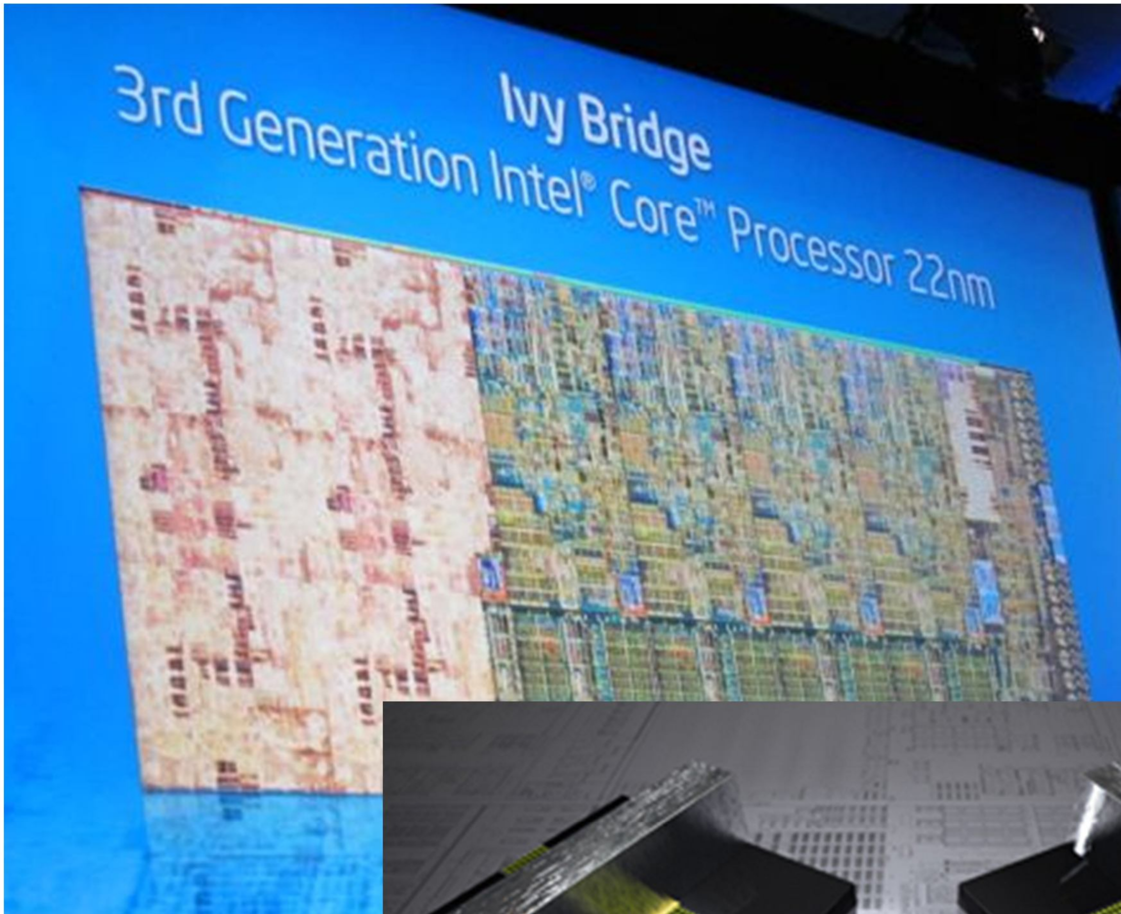
- Enormous numbers of gates- switching incredibly fast – even with low consumption power (and heat) become major design issues.
- Especially as transistors get smaller – harder to get a complete OFF – leakage currents make it worse

Concern 2 – atomic size

- Ultimate minimum feature size may be determined by atomic spacing – in Si the lattice constant is ~0.5 nm.



The future – 22nm and beyond



- Intel's next generation, made in 22nm fab, will hit stores around April
- The "3D" transistor redesign that has made 22nm and 14 nm processes possible
- How small is possible? The future is in your hands