ELECTRONICS AND COMMUNICATION TECHNOLOGIES: ELECTRONICS SYSTEMS

LM Cyber Security – Fall 2024

Federico Baronti, Luca Crocetti

Dip. Ing. Informazione

Via G. Caruso, 16 – Stanza B-1-09

050 2217581 – federico.baronti@unipi.it

Office hours:

Friday 14-16. Please, contact me in advance before showing up. We can also arrange an appointment remotely on Microsoft Teams.

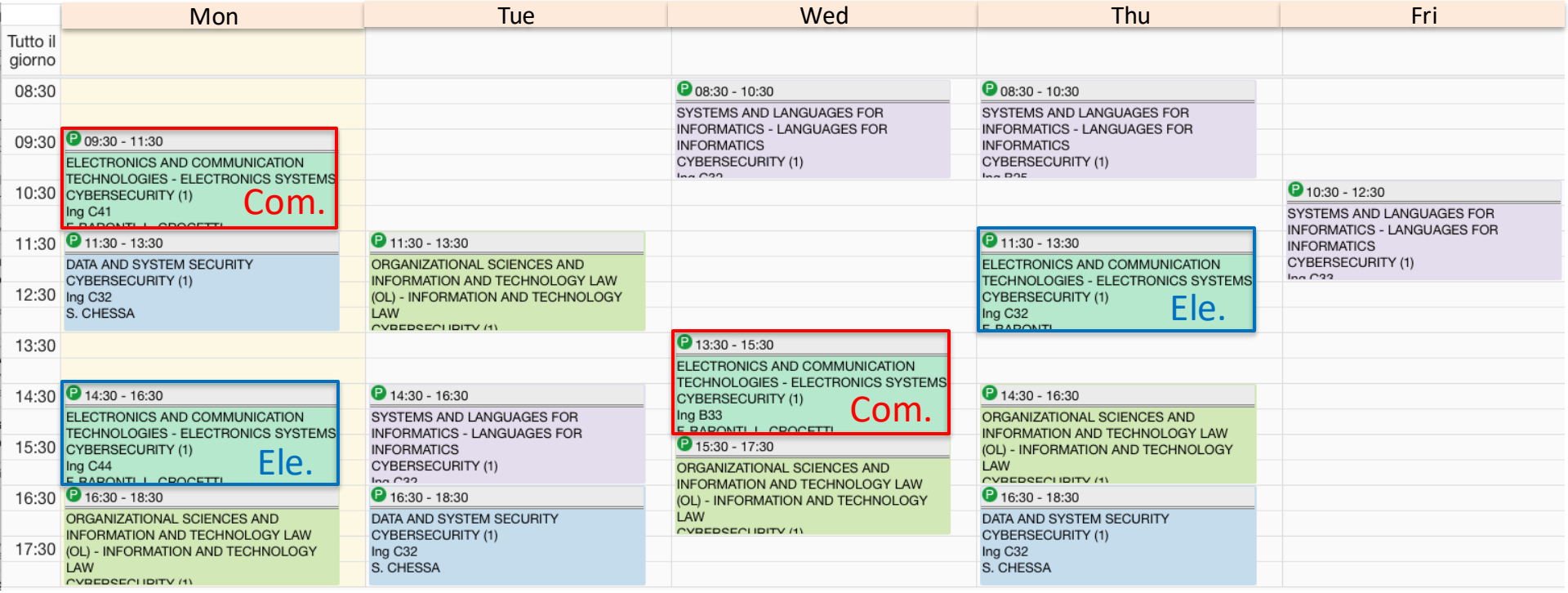
Objectives

- Provide a common **Electronics background** to students from different bachelor studies
- Acquire a common and shared vocabulary on the Electronic System domain
- Acquire competences on and knowledge about the main electronic platforms used in cybersecurity-sensitive applications
- Knowledge of design methodologies for the hardware implementation of complex logic functions and systems, such as processors

Syllabus

- Basic principles: Digital data representation and CMOS technology (FB)
- Introduction to digital design with HDL: the Verilog language (LC)
- Combinational and Sequential logic elements (LC)
- Finite State Machine (LC)
- Memories (LC)
- CPU Organisation (FB)
- ADC, DAC (FB)

Class schedule



Electronics definition

Discipline that focuses on the study and applications of the electrical conduction within gases, vacuum and **semiconductors** (in general non metallic materials)

First observation of SEMICONDUCTOR behaviour: 1833

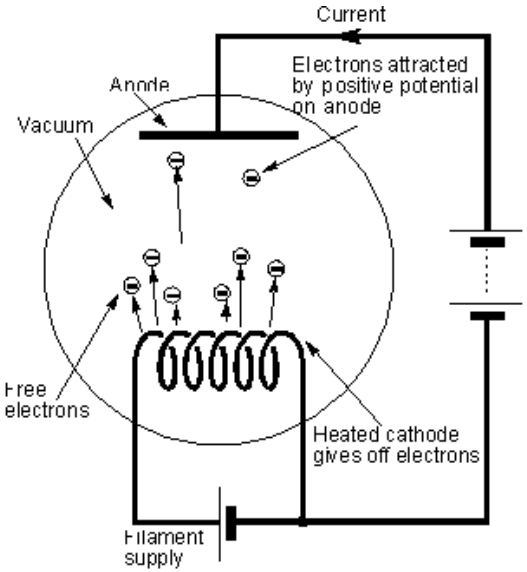
1833 Michael Faraday (natural philopher)

"I have lately met with an extraordinary case ... which is in direct contrast with the influence of heat upon metallic bodies ... On applying a lamp ... the conducting power rose rapidly with the heat ... On removing the lamp and allowing the heat to fall, the effects were reversed."

http://www.computerhistory.org/siliconengine/first-semiconductor-effect-is-recorded/

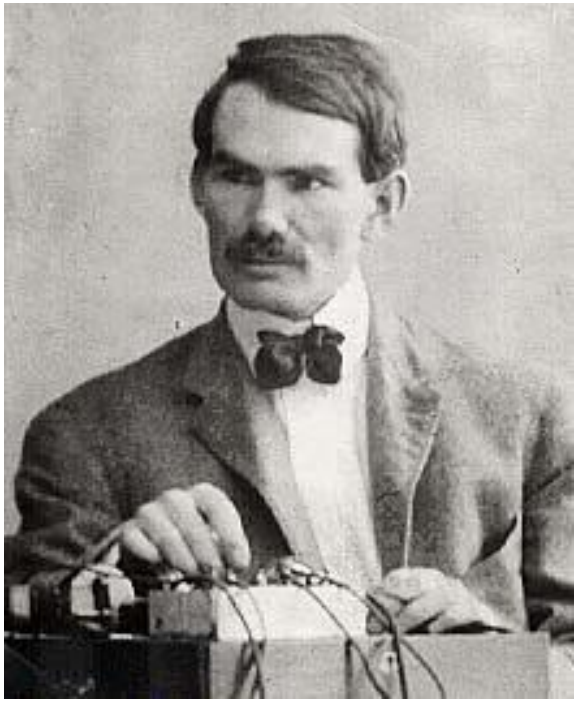
Vacum diode – John Fleming - 1904

Sir John Ambrose Fleming (1849–1945)



https://history-computer.com/technology/thermionic-tube/

Audion – Lee De Forest - 1906



Lee De Forest (1873–1961)

https://history-computer.com/technology/the-audion-vacuum-tube/

Born of electronics

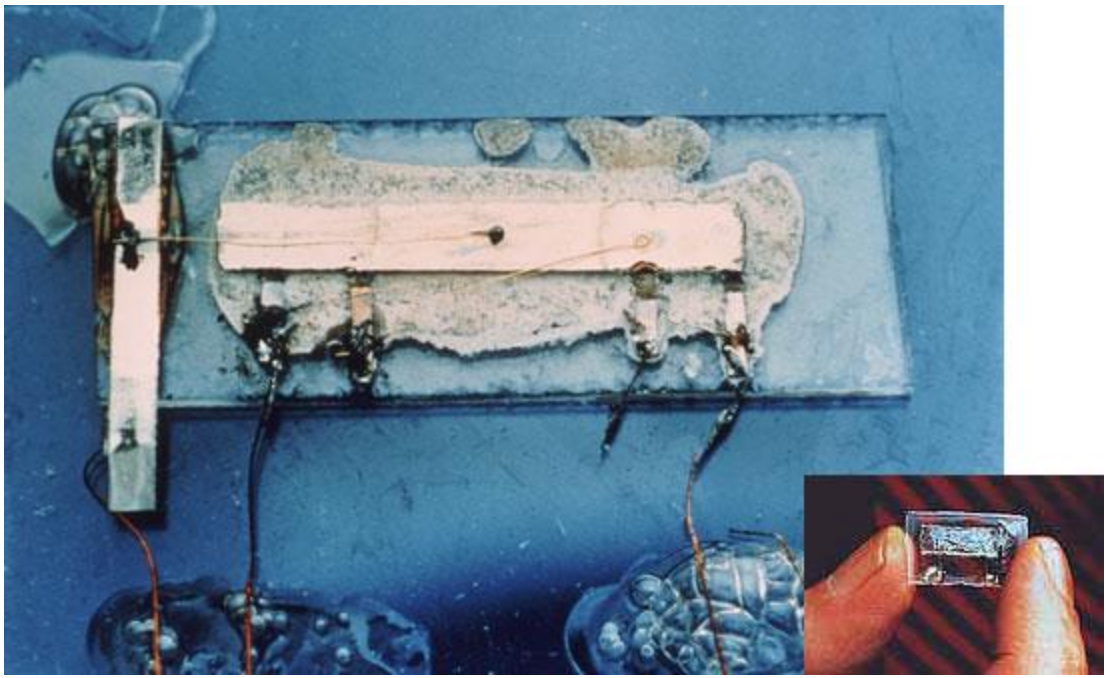
- 1915: first cost-to-cost telephonic link in US
- 1930: TV B/N (~100 vacuum tubes)
- 1940: radar (Magnetron, creates high power oscillations)
- 1950: TV colour using vacuum tubes

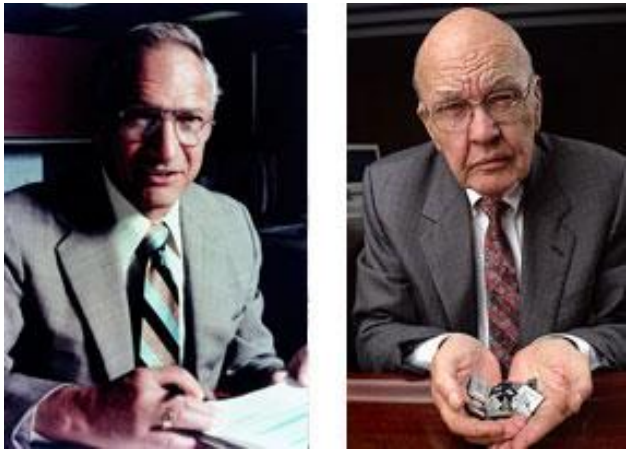
Point-Contact transistor - 1948

Bardeen (left), Shockley (middle) and Brattain (right)

http://history-computer.com/ModernComputer/Basis/transistor.html

Integrated Circuits – Kilby, Noyce - 1959

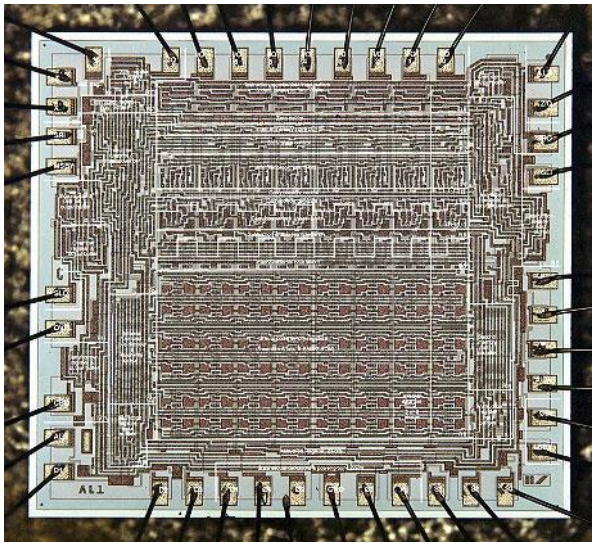


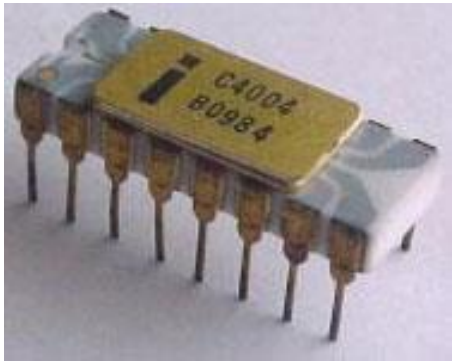


Robert Noyce (left) and Jack Kilby

http://history-computer.com/ModernComputer/Basis/IC.html

4004 Microprocessor – Faggin - 1971





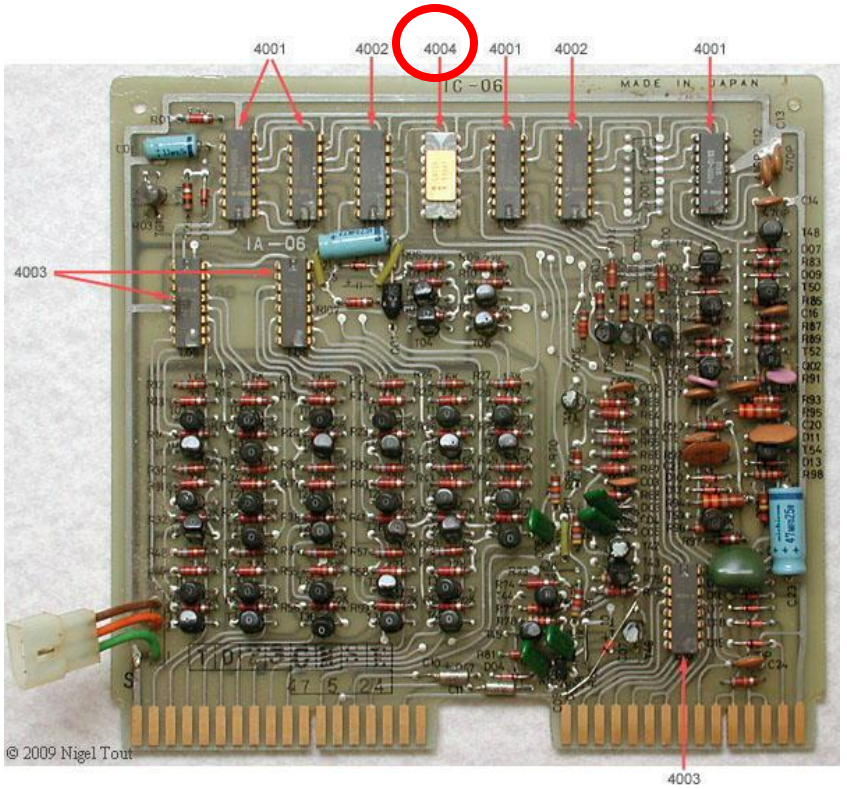
Stan Mazor, Ted Hoff, and Federico Faggin (seated, rightward)

4004
2300 PMOS transistors – 10 µm process
4 bits
108 kHz
3 mm x 4 mm

http://history-computer.com/ModernComputer/Basis/microprocessor.html

Busicom 141-PF Calculator

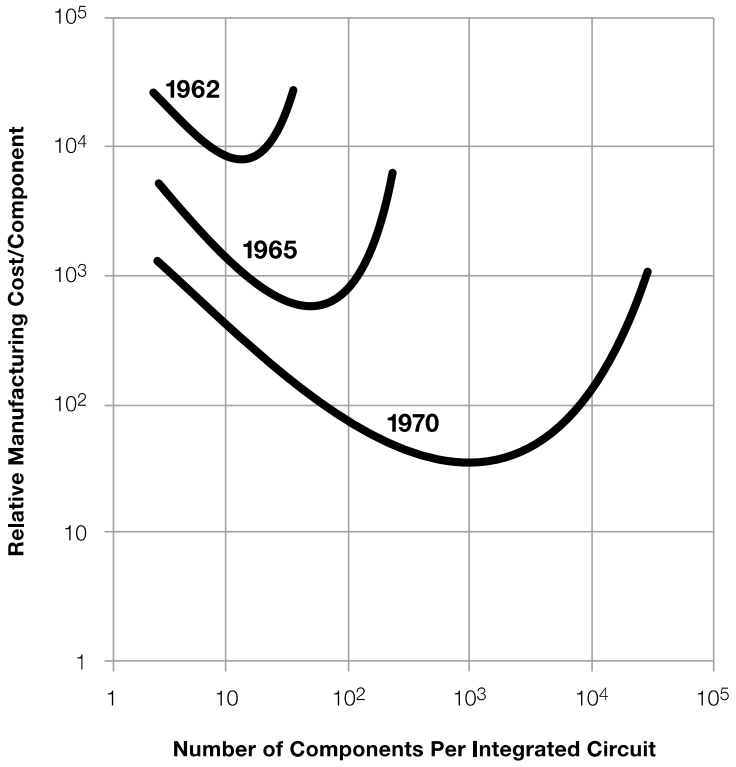
First commercial device with a processor, i.e., 4004

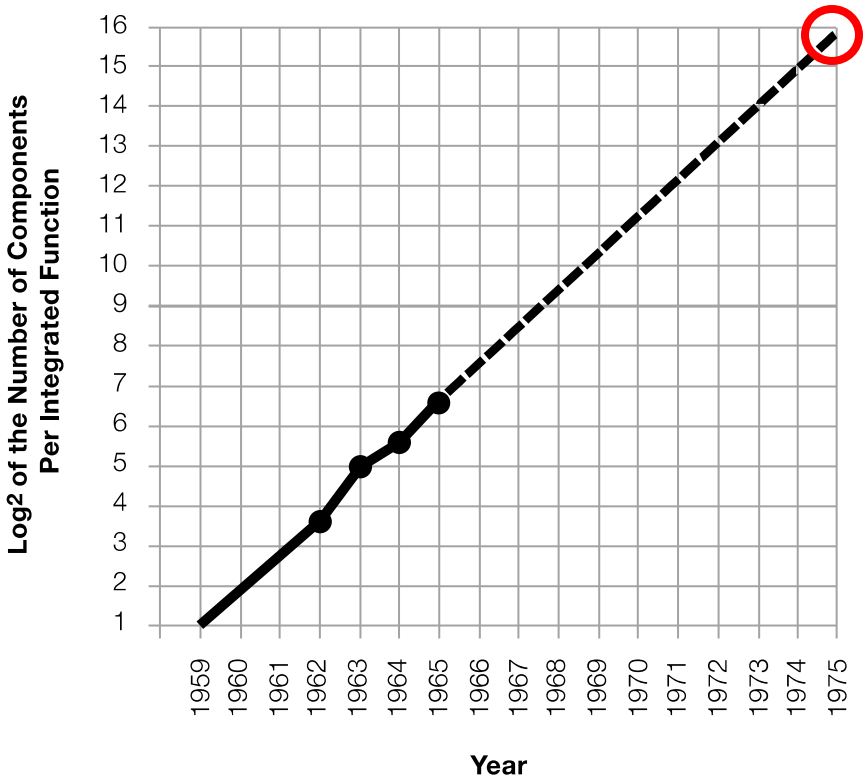


http://www.vintagecalculators.com/html/busicom_141-pf.html

Moore's law - 1965

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip





G.E. Moore "Cramming more components onto integrated circuits," Electronics, Vol. 38, No. 8, April 19, 1965

Chip density

2020s
M3 Max Processor

92,000,000,000 Transistors

2010s
3072-Core GPU

8,000,000,000 Transistors

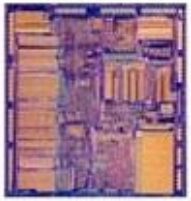
2000s
64-bit Microprocessor

592,000,000 Transistors

1990s
32-bit Microprocessor

3,100,000 Transistors

1980s
32-bit Microprocessor



275,000 Transistors

1970s
8-bit Microprocessor

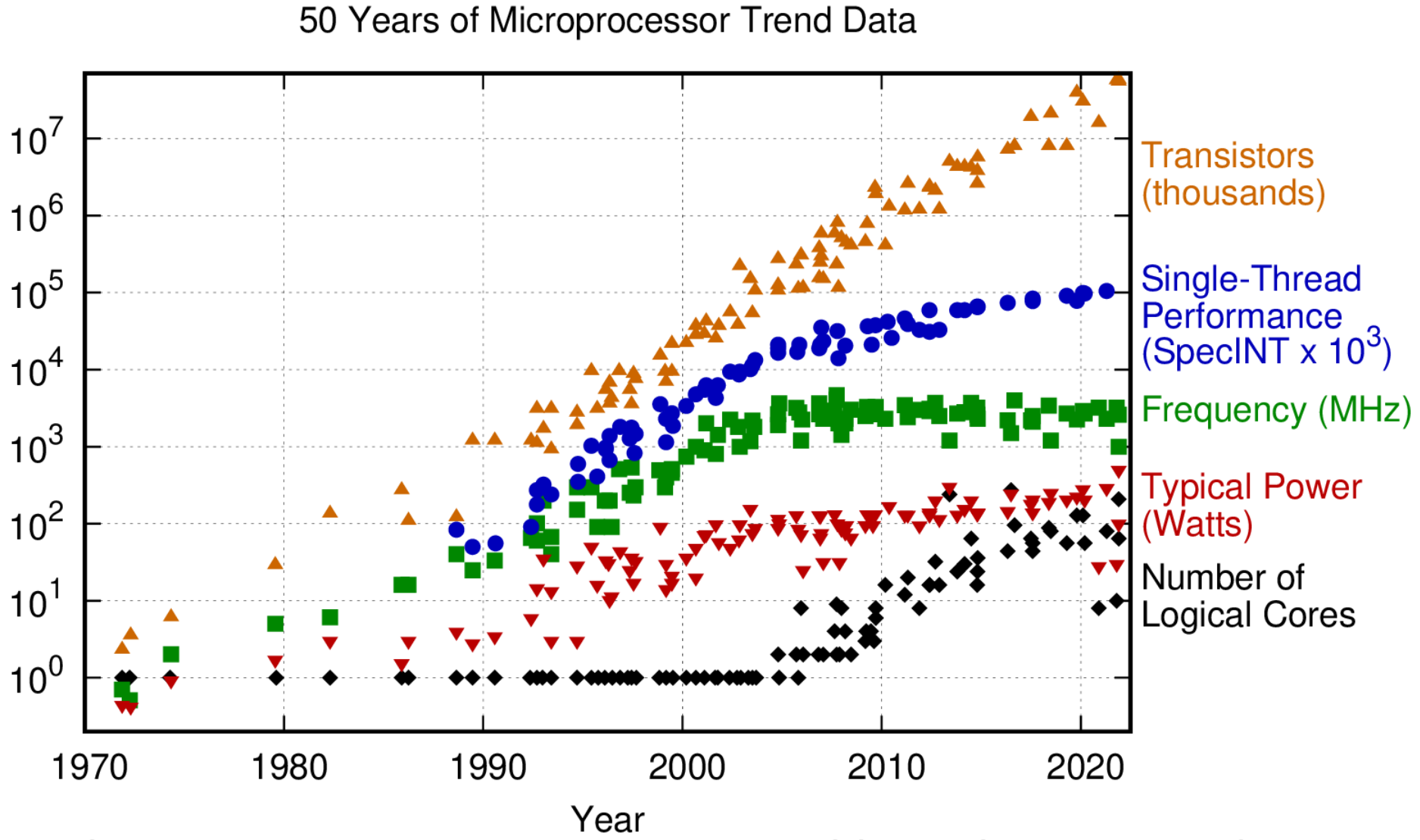
4500 Transistors

1960s
TTL Quad Gate

16 Transistors

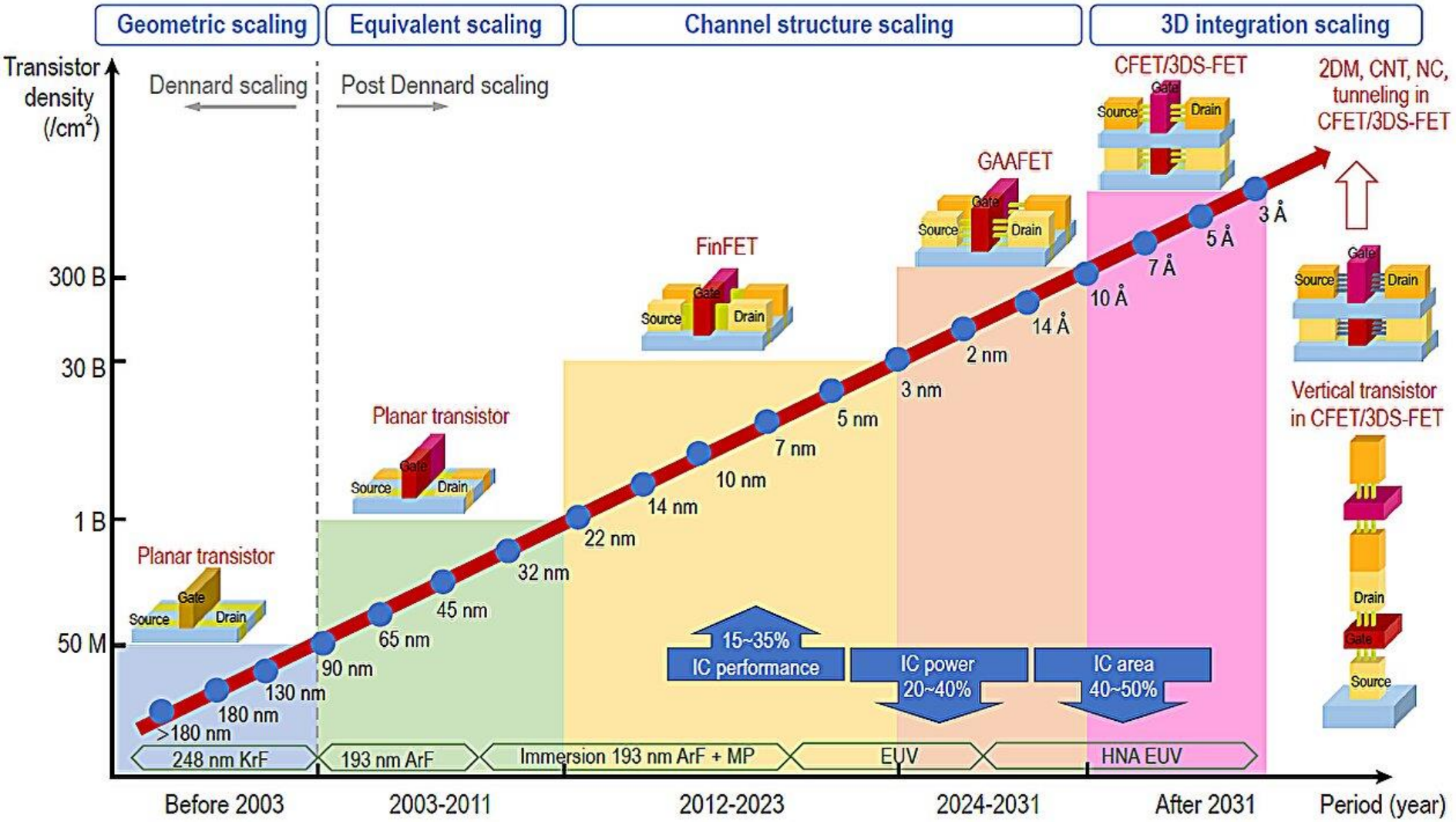
1950s
Silicon Transistor

1 Transistor



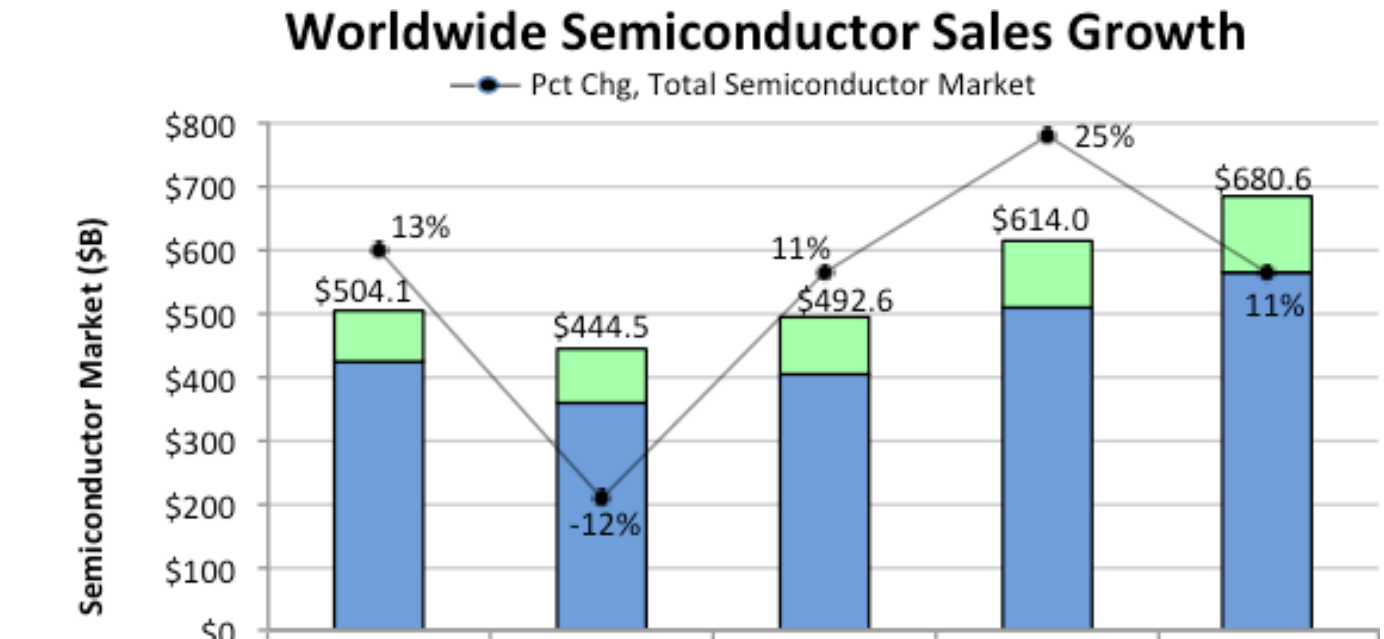
Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2021 by K. Rupp

CMOS nodes



Qingzhu Zhang et al, New structure transistors for advanced technology node CMOS ICs, *National Science Review* (2024). DOI: 10.1093/nsr/nwae008

Semiconductor Market



	2018	2019	2020	2021	2022F
OSD Market	82.4	86.1	88.3	104.2	115.5
IC Market	421.7	358.4	404.4	509.8	565.1

Source: IC Insights

OSD: Optoelectronics, Sensors and actuators, and Discrete semiconductors