University of Chinese Academy of Sciences

IC Invention and Silicon Valley

Overview of Semiconductor Industry

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Topics

University of Chinese Academy of Sciences

- Inventions
- 60th Anniversary of Fairchild
- Intel and Moore's Law
- Stanford University and UC Berkeley
- The Creation of Silicon Valley

Invention of Junction Transistor

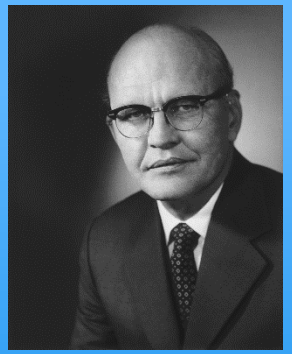
- 1947 the first junction transistor
  - John Bardeen, William Shockley & Walter Brattain
  - 1956 Nobel Prize in Physics
- BCS theor rieffer
  - 1972 Nobe
- Shockley S

Shockley Semiconductor Laboratory

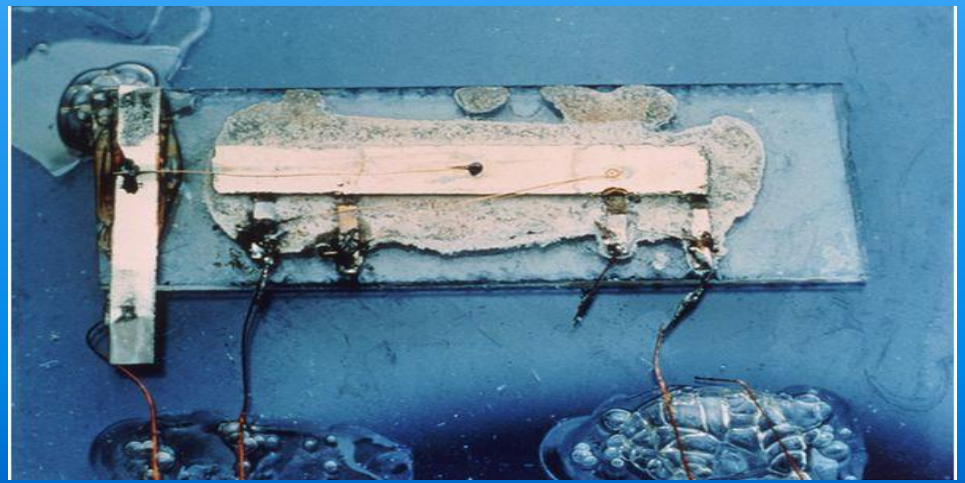
- 1956, William Shockley founded the Lab
- The first high tech company in Silicon Va
  - A division of Beckman Instruments

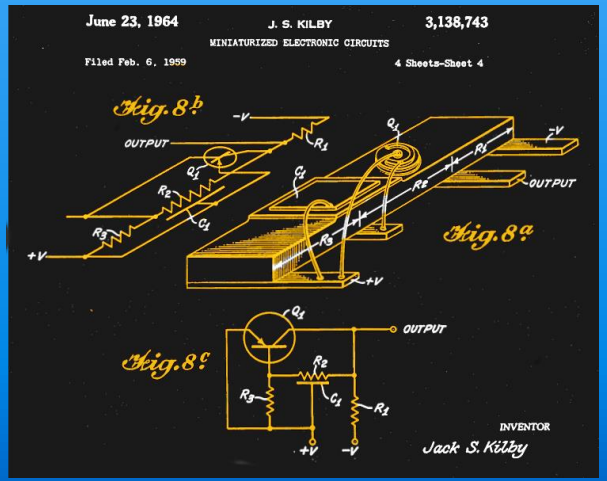
The First *Integrated Circuit* (1/2)

- **Jack Kilby (1923-2005)**
  - Inventor of (Ge) IC in 1958
  - IEEE milestones, Nobel Prize in 2000
  - 1964, U.S. Patent 3,138,743



US Patents filed:
3,138,743 (2/6/59)
3,138,744 (5/6/59)



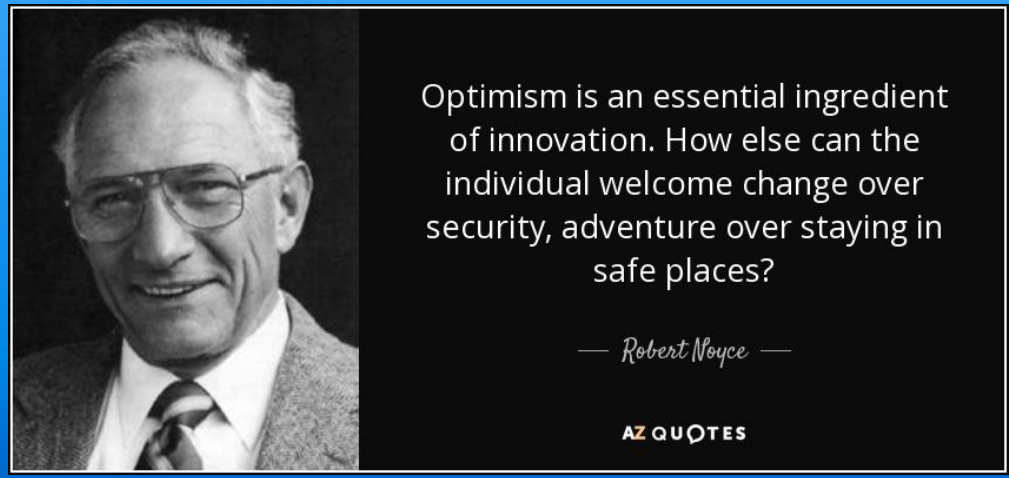


The First *Integrated Circuit* (2/2)

Arthur Rock, Chairman of Intel's Board, said:

Noyce: the visionary, born to inspire;
Moore: the virtuoso of technology; and
Grove: the technologist turned management scientist.

- **Robert Noyce (1927-1990)**
  - "The Traitorous 8"
  - Co-founded Fairchild in 1957
  - Co-inventor of (Si) IC in 1958
  - Co-founded Intel in **1968**
  - "The Mayor of Silicon Valley"



Computer History Museum

- Sept 2017
  - FAIRCHILD SEMICONDUCTOR: THE 60TH ANNIVERSARY OF A SILICON VALLEY LEGEND

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Fairchild Semiconductor

- 1956, William Shockley founded the Lab
- *1957, Fairchild Semi was* formed…
  - A division of Fairchild Camera & Instruments
  - 1959, "IC-Si“ (vs. "IC-Ge"); planar process
- IC-Si and Planar Process
  - Jean Hoerni, planar process (2 US patents)
  - Robert Noyce …

“The Traitorous Eight”

- 1956, Shockley Semiconductor Laboratory
- *1957, Fairchild Semi was* formed…
- *1957, “The Traitorous Eight” resigned …*
  - Gordon Moore, C. Sheldon Roberts, Eugene Kleiner, Robert Noyce, Victor Grinich, Julius Blank, Jean Hoerni and Jay Last

Fairchild Today

- 1957 Founded in San Jose
  - as A division of Fairchild Camera & Instruments
  - Schlumberger bought the firm in 1979
  - Schlumberger sold it to National Semiconductor in 1987;
- Fairchild was spun off as an independent company in 1997
- ON Semiconductor acquired Fairchild in September 2016

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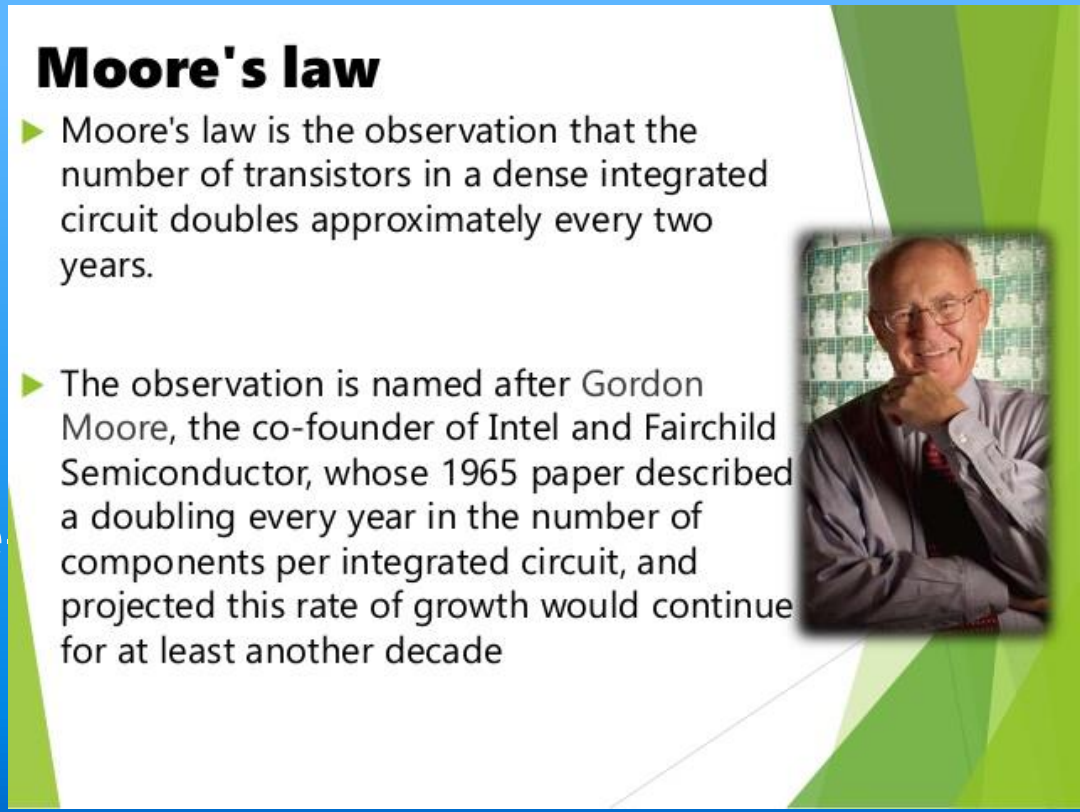
Intel and Microprocessors

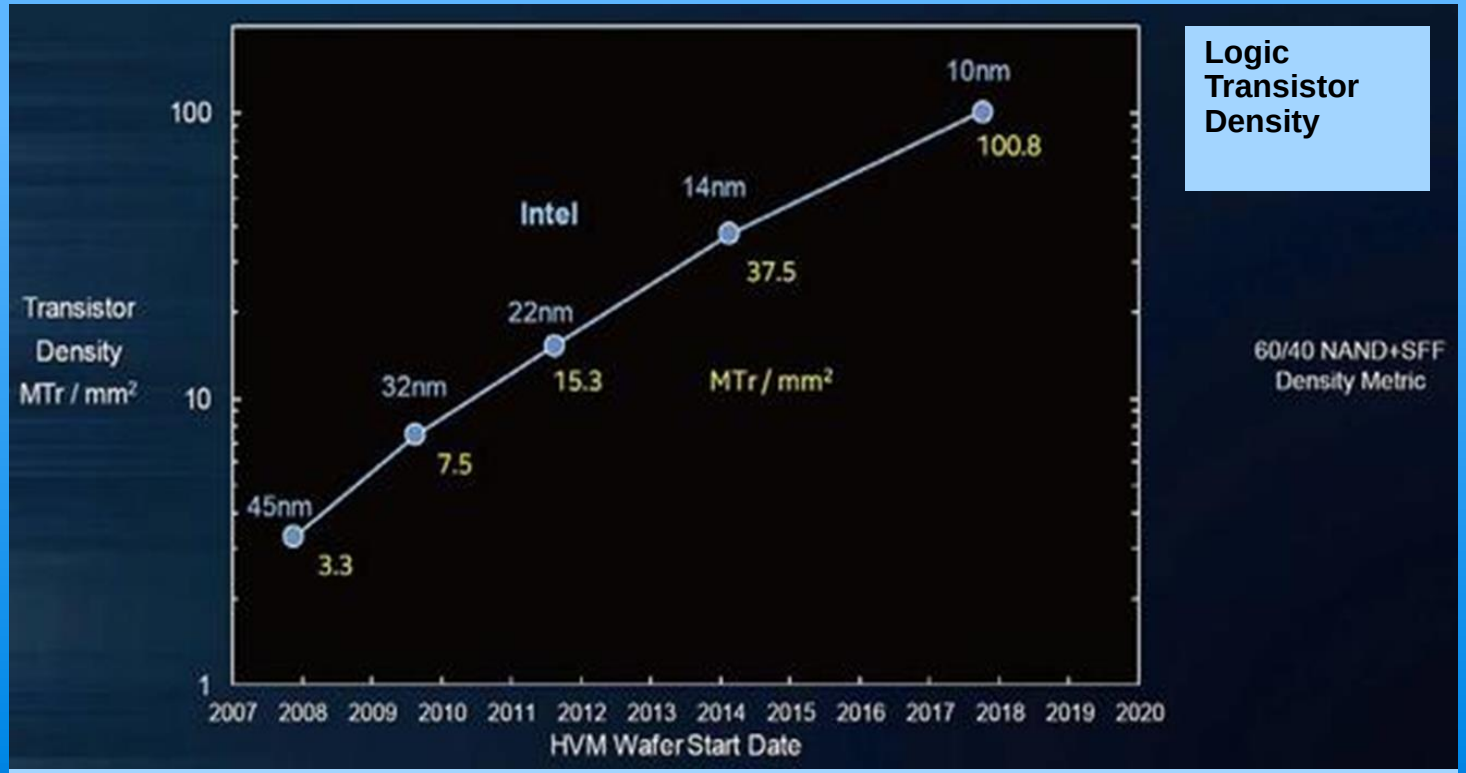
- An IDM of *Int*egrated *el*ectronics
  - x86 Series and PC
  - Supplies for Apple, Lenovo, HP and Dell
- Arthur Rock: “Intel needs Noyce, Moore and Grove…”
  - Robert Noyce, “The Mayor of Silicon Valley"
  - Gordon Moore, Moore’s Law (1965/1975)
  - Andrew Grove, *Only the Paranoid Survive (1996)*

Moore’s Law

- Moore’s Law
- Dennard Scaling
- Intel
  - Tick-Tock
  - Process-Architecture-Optimization



Transistor Density and Moore's Law



Intel, at 10nm, Transistor Density >100MTr/mm²

More Moore, More than Moore, & Beyond CMOS

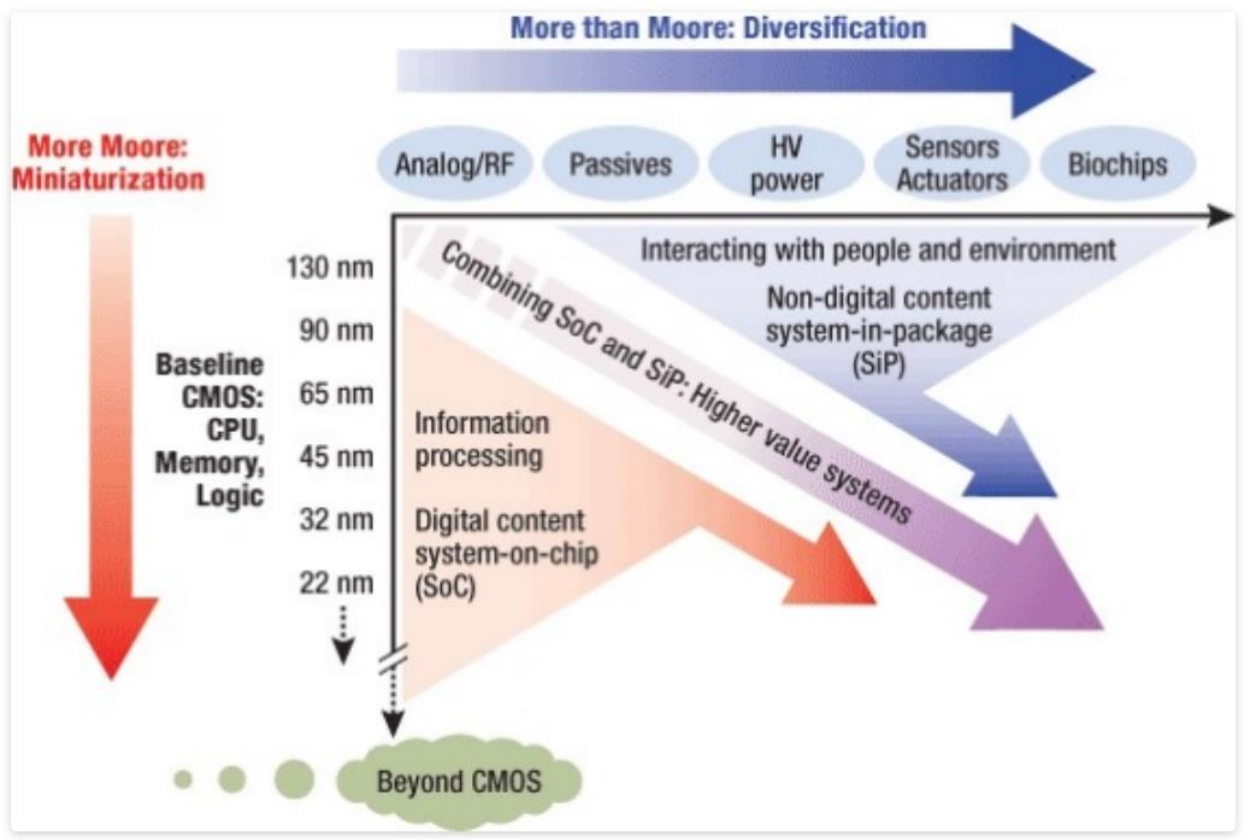


Figure 1: The combined need for digital and non-digital functionalities in an integrated system is translated as a dual trend in the *ITRS*: miniaturization of the digital functions ("More Moore") and functional diversification ("More-than-Moore").

Dennard Scaling Law

- Dennard (1974) observed that voltage and current should be proportional to the linear dimensions of a transistor
  - Thus, as transistors shrank, so did necessary voltage and current; power is proportional to the area of the transistor.
  - Capacitance is related to area
    - So, as the size of the transistors shrunk, and the voltage was reduced, circuits could operate at higher frequencies at the same power
    - Why haven’t clock speeds increased, even though transistors have continued to shrink?

End of Dennard Scaling

- Dennard scaling ignored the “leakage current” and “threshold voltage”, which establish a baseline of power per transistor.
  - As transistors get smaller, power density increases because these don’t scale with size
  - These created a “Power Wall” that has limited practical processor frequency to around 4 GHz since 2006

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Stanford and Silicon Valley

Storied past, uncertain future

Stanford University, 1950 vs Today

Stanford University: 1950 vs. Today

Undergraduate students	4,800	6,700
Graduate students	2,800	8,200
Faculty Members	370	1,800
Tuition	$600	$33,000
Endowment	$44M	$14B

OFFICE OF TECHNOLOGY LICENSING
STANFORD UNIVERSITY

CANCER and SPICE

1970, CANCER

Computer Analysis of Nonlinear Circuits, Excluding Radiation

1971, SPICE

Simulation Program with Integrated Circuit Emphasis

Laurence Nagel, Ron Rohrer, Don Peterson

UCB Today

- RISC-V ISA
  - Berkeley Architecture Research https://bar.eecs.berkeley.edu/projects/riscv.html
- Nobel Prize in EDA
  - Phil Kaufman Award, https://ieee-ceda.org/
- EECS
  - Courses, https://eecs.berkeley.edu/academics/courses

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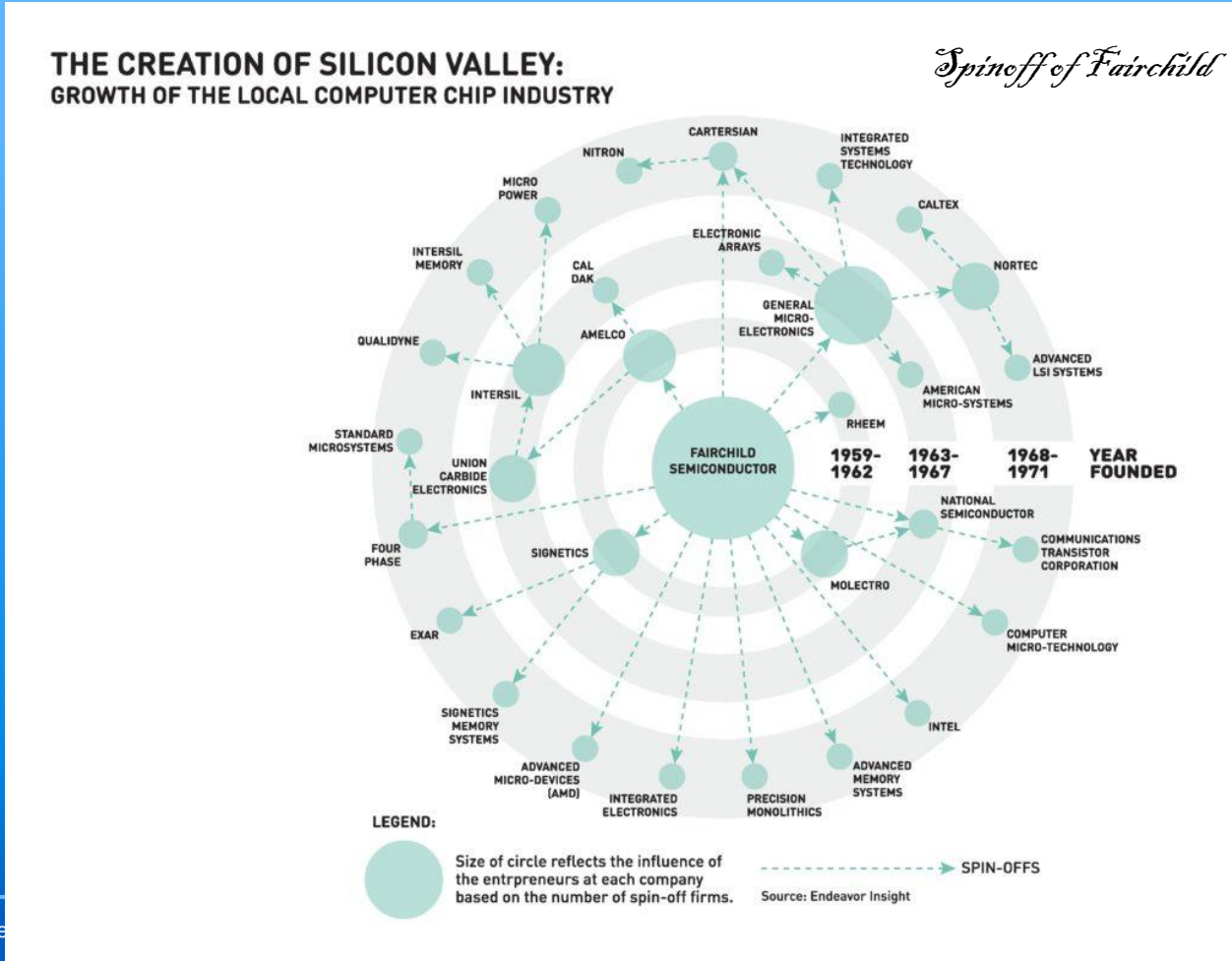
The Creation of Silicon Valley



Summary

- Geography
  - Climate in the Valley
- Incubator for Innovation
  - Incubate, Nourish & Grow
- Overtaking on *the* Curve?
  - Are driving and overtaking on right curves more dangerous than on left curves?

In the Silicon Valley

IC Design and EDA in 20th Century

SILICON

60s 70s 80s 90s