

Digital IC & Sytems Design

Iain McNally

≈ 10 lectures

Koushik Maharatna

≈ 12 lectures

Basel Halak

≈ 12 lectures

1001

Digital IC & Sytems Design SoC Design Techniques

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Digital IC & Sytems Design

- Assessment

10% Coursework L-Edit Gate Design (BIM)
90% Examination

- Books

- **Integrated Circuit Design**

- a.k.a. Principles of CMOS VLSI Design - A Circuits and Systems Perspective
Neil Weste & David Harris
Pearson, 2011

- **Digital System Design with SystemVerilog**

- Mark Zwolinski
Pearson Prentice-Hall, 2010

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Integrated Circuit Design

• Content

- Introduction
- Overview of Technologies
- Layout
- CMOS Processing
- Design Rules and Abstraction
- Cell Design and Euler Paths
- System Design using Standard Cells
- Wider View

• Notes & Resources

<http://users.ecs.soton.ac.uk/bim/notes/icd>

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History

1947 First Transistor

John Bardeen, Walter Brattain, and William Shockley (Bell Labs)

1952 Integrated Circuits Proposed

Geoffrey Dummer (Royal Radar Establishment) - *prototype failed...*

1958 First Integrated Circuit

Jack Kilby (Texas Instruments) - *Co-inventor*

1959 First Planar Integrated Circuit

Robert Noyce (Fairchild) - *Co-inventor*

1961 First Commercial ICs

Simple logic functions from TI and Fairchild

1965 Moore's Law

Gordon Moore (Fairchild) observes the trends in integration.

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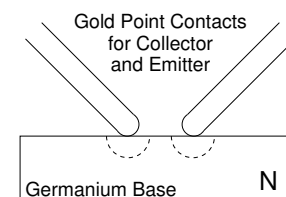
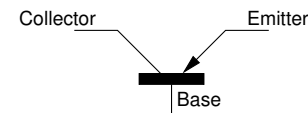
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1965 Moore's Law

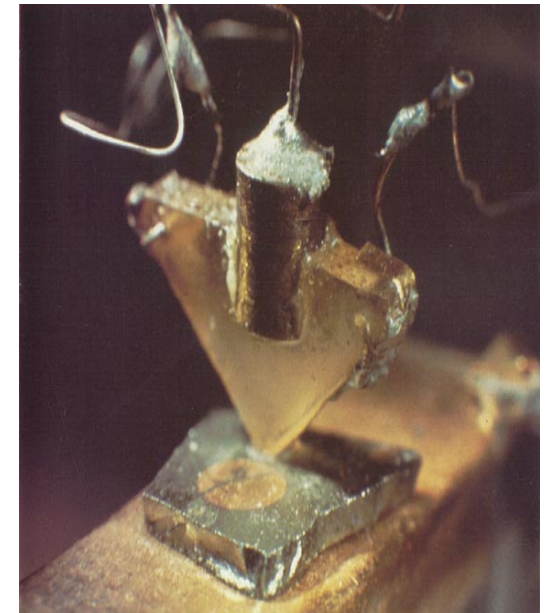
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1947 Point Contact Transistor



Each contact creates a metal/semiconductor (Schottky) diode. Depletion regions are shown for zero bias voltage.



Source: Bell Labs

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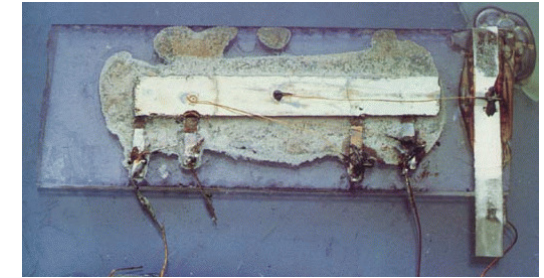
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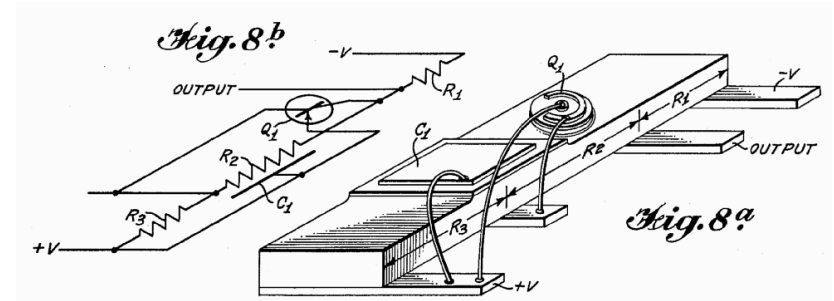
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1958 First Integrated Circuit

- 1 Transistor
 - 1 Capacitor
 - 3 Resistors
- Hand soldered interconnect



Source: Texas Instruments



Source: Jack Kilby (Patent Application)

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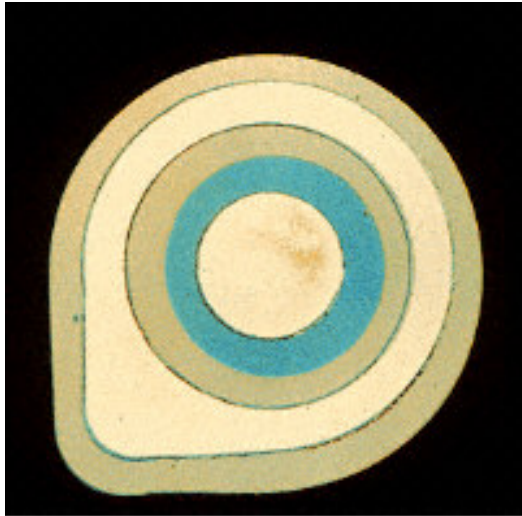
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Source: Fairchild

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April 25, 1961 R. N. NOYCE 2,981,877
 SEMICONDUCTOR DEVICE-AND-LEAD STRUCTURE
 Filed July 30, 1959 3 Sheets-Sheet 2

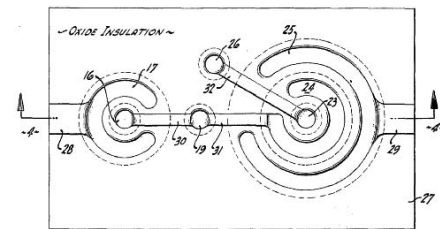


FIG-3

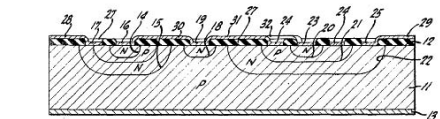
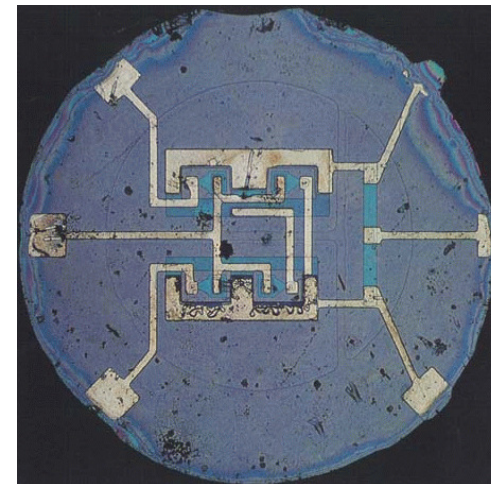
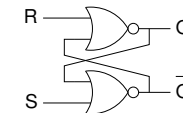


FIG-4

Source: Robert Noyce (Patent Application)

1961 First Commercial ICs

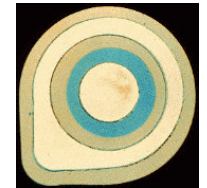
Fairchild Bipolar RTL RS Flip-Flop



Source: Fairchild

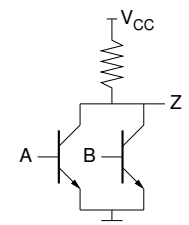
Using

- Planar Bipolar Transistors



Source: Fairchild

- Back to back PN junctions to provide isolation
- Integrated interconnect
- Resistor Transistor Logic



RTL NOR gate

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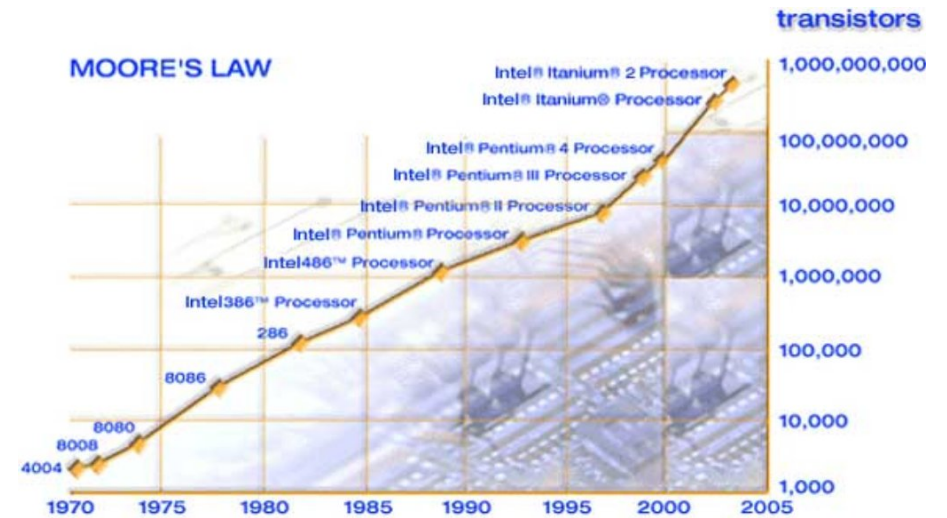
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Source: Intel

History

Moore's Law

Predicts exponential growth in the number of components per chip.

1965 - 1975 Doubling Every Year

In 1965 Gordon Moore observed that the number of components per chip had doubled every year since 1959 and predicted that the trend would continue through to 1975.

Moore describes his initial growth predictions as "ridiculously precise".

1975 - 2012 Doubling Every Two Years

In 1975 Moore revised growth predictions to doubling every two years.

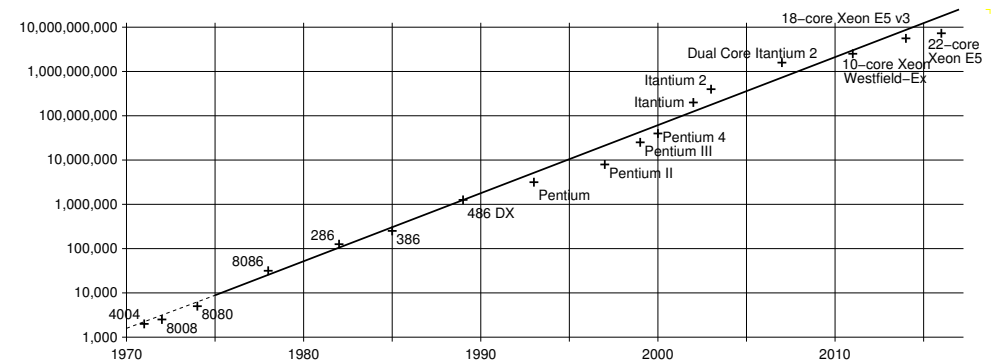
Growth would now depend only on process improvements rather than on more efficient packing of components.

In 2000 he predicted that the growth would continue at the same rate for another 10-15 years before slowing due to physical limits.

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History

Moore's Law at Intel¹



¹Intel was founded by Gordon Moore and Robert Noyce from Fairchild

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History

Moore's Law; a Self-fulfilling Prophecy

The whole industry uses the Moore's Law curve to plan new fabrication facilities.

Slower - wasted investment

Must keep up with the Joneses².

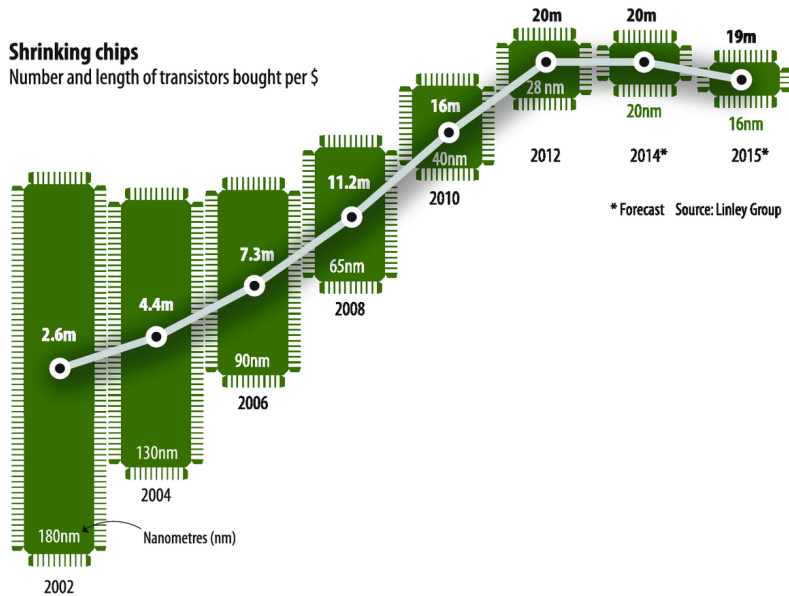
Faster - too costly

Cost of capital equipment to build ICs doubles approximately every 4 years.

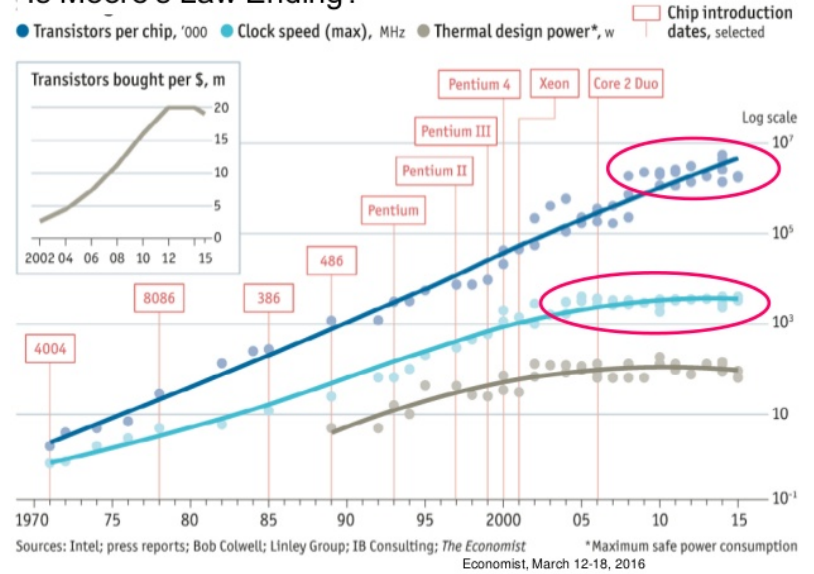
Moore's law is not dead (at least not quite), although there are worries that below 20nm, clever processing required for smaller transistors means that cost per transistor goes up rather than down.

²or the Intels

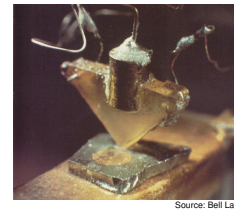
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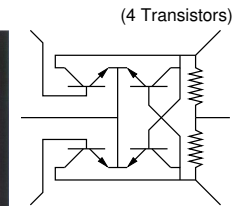
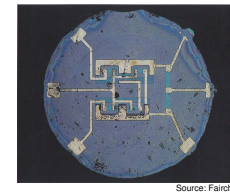
Is Moore's Law Ending?



1947 Point Contact transistor

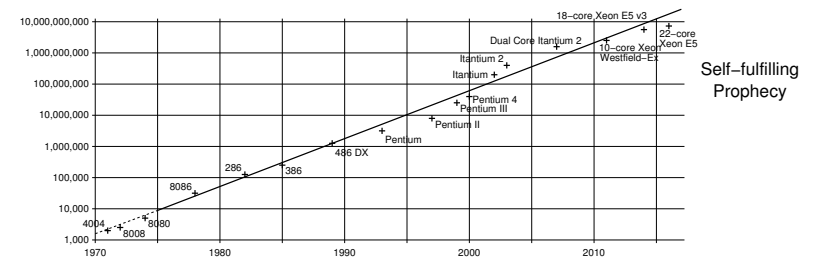


1961 Fairchild Bipolar RTL RS Flip-Flop



Moore's Law (1965) Number of transistor has doubled every year and will continue to do so until 1975

Moore's Law (1975) Number of transistors will double every two years



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