COMPUTER HISTORY MUSEUM




# Timeline

Click on the thumbnail image or the blue headline text to access detailed information and references on each milestone.

## Pre-1940

**1833**: First Semiconductor Effect is Recorded
Michael Faraday describes the "extraordinary case" of his discovery of electrical conduction increasing with temperature in silver sulfide crystals. This is the opposite to that observed in copper and other metals.

**1874**: Semiconductor Point-Contact Rectifier Effect is Discovered
In the first written description of a semiconductor diode, Ferdinand Braun notes that current flows freely in onl direction at the contact between a metal point and a galena crystal.

**1901**: Semiconductor Rectifiers Patented as "Cat's Whisker" Detectors
Radio pioneer Jagadis Chandra Bose patents the use of a semiconductor crystal rectifier for detecting radio wa

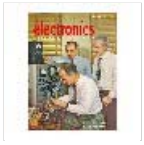
**1926**: Field Effect Semiconductor Device Concepts Patented
Julius Lilienfeld files a patent describing a three-electrode amplifying device based on the semiconducting prop of copper sulfide. Attempts to build such a device continue through the 1930s.

**1931**: "The Theory Of Electronic Semi-Conductors" is Published
Alan Wilson uses quantum mechanics to explain basic semiconductor properties. Seven years later Boris Davyd (USSR), Nevill Mott (UK), and Walter Schottky (Germany) independently explain rectification.

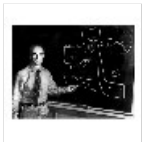
## 1940s

**1940**: Discovery of the *p-n* Junction
Russell Ohl discovers the p-n junction and photovoltaic effects in silicon that lead to the development of junctio transistors and solar cells.

**1941**: Semiconductor diode rectifiers serve in WW II
Techniques for producing high purity germanium and silicon crystals are developed for wartime radar microwa detectors.




**1947**: Invention of the Point-Contact Transistor
John Bardeen & Walter Brattain achieve transistor action in a germanium point-contact device in December 19



**1948**: Conception of the Junction Transistor
William Shockley conceives an improved transistor structure based on a theoretical understanding of the p-n ju effect.

**1948**: The European Transistor Invention
Herbert Mataré & Heinrich Welker independently create a germanium point-contact transistor in France.

## 1950s

**1951**: First Grown-Junction Transistors Fabricated
Gordon Teal grows large single crystals of germanium and works with Morgan Sparks to fabricate an *n-p-n* jun transistor.

**1951**: Development of Zone Refining
William Pfann and Henry Theurer develop zone refining techniques for production of ultra-pure semiconductor materials.

**1952**: Bell Labs Licenses Transistor Technology
Bell Labs technology symposia and licensing of transistor patents encourages semiconductor development.

**1952**: Transistorized Consumer Products Appear
Semiconductors appear in battery-powered hearing aids and pocket radios where consumers are willing to pay premium for portability and low power consumption.

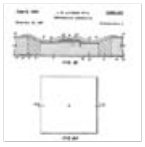
**1953**: Transistorized Computers Emerge
A transistorized computer prototype demonstrates the small size and low-power advantages of semiconductors compared to vacuum tubes.

**1954**: Silicon Transistors Offer Superior Operating Characteristics
Morris Tanenbaum fabricates the first silicon transistor at Bell Labs but Texas Instruments' engineers build and market the first commercial devices.

**1954**: Diffusion Process Developed for Transistors
Following the production of solar cells using high-temperature diffusion methods, Charles Lee and Morris Tanei

apply the technique to fabricate high-speed transistors.

**1955**: Development of Oxide Masking
Carl Frosch and Lincoln Derick grow a silicon dioxide film on wafers to protect their surface and allow controlle diffusion into the underlying silicon.

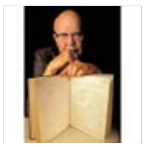


**1955**: Photolithography Techniques Are Used to Make Silicon Devices
Jules Andrus and Walter Bond adapt photoengraving techniques from printing technology to enable precise etc diffusion "windows" in silicon wafers.

**1956**: Silicon Comes to Silicon Valley
Shockley Semiconductor Laboratory develops Northern California's first prototype silicon devices while training engineers and scientists for the future Silicon Valley.

**1958**: Tunnel Diode Promises a High-Speed Semiconductor Switch
Leo Esaki's novel device is an example of many celebrated semiconductor breakthroughs that do not sustain th early promise as they are overtaken by competing technologies.

**1958**: Silicon Mesa Transistors Enter Commercial Production
Fairchild Semiconductor produces double-diffused silicon mesa transistors to meet demanding aerospace applications.



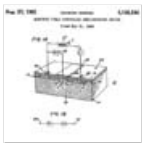
**1958**: All semiconductor "Solid Circuit" is demonstrated
Jack Kilby produces a microcircuit with both active and passive components fabricated from semiconductor ma

**1959**: Invention of the "Planar" Manufacturing Process
Jean Hoerni develops the planar process to solve reliability problems of the mesa transistor, thereby revolutior semiconductor manufacturing.

**1959**: Practical Monolithic Integrated Circuit Concept Patented
Robert Noyce builds on Jean Hoerni's planar process to patent a monolithic integrated circuit structure that car manufactured in high volume.

## 1960s

**1960**: First Planar Integrated Circuit is Fabricated
Jay Last leads development of the first commercial IC based on Hoerni's planar process and Noyce's monolithic approach.



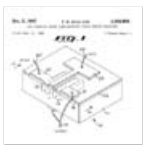
**1960**: Metal Oxide Semiconductor (MOS) Transistor Demonstrated
John Atalla and Dawon Kahng fabricate working transistors and demonstrate the first successful MOS field-effe amplifier.

**1960**: Epitaxial Deposition Process Enhances Transistor Performance
Development of thin-film crystal-growth process leads to transistors with high switching speeds.

**1961**: Silicon Transistor Exceeds Germanium Speed
Computer architect Seymour Cray funds development of the first silicon device to meet the performance dema the world's fastest machine.

**1961**: Dedicated Semiconductor Test Equipment Enters Commercial Market
Semiconductor and independent vendors build dedicated test equipment for high-throughput manufacturing.

**1962**: Aerospace systems are first the applications for ICs in computers
The size, weight, and reduced power consumption of integrated circuits compared to discrete transistor design justify their higher cost in military and aerospace systems.



**1963**: Complementary MOS Circuit Configuration is Invented
Frank Wanlass invents the lowest power logic configuration but performance limitations impede early acceptan today's dominant manufacturing technology.

**1963**: Standard Logic IC Families introduced
Diode Transistor Logic (DTL) families create a high-volume market for digital ICs but speed, cost, and density advantages establish Transistor Transistor Logic (TTL) as the most popular standard logic configuration by the 1960s.

**1964**: Hybrid Microcircuits Reach Peak Production Volumes
Multi-chip SLT packaging technology developed for the IBM System/360 computer family enters mass producti

**1964**: First Commercial MOS IC Introduced
General Microelectronics uses a Metal-Oxide-Semiconductor (MOS) process to pack more transistors on a chip bipolar ICs and builds the first calculator chip set using the technology.

**1964**: The First Widely-Used Analog Integrated Circuit is Introduced
David Talbert and Robert Widlar at Fairchild kick-start a major industry sector by creating commercially succes ICs for analog applications.

**1965**: "Moore's Law" Predicts the Future of Integrated Circuits
Fairchild's Director of R & D predicts the rate of increase of transistor density on an integrated circuit and esta a yardstick for technology progress.

**1965**: Mainframe Computers Employ ICs
Large computer manufacturers announce machines based on custom and special purpose integrated circuits.

**1965**: Package is the First to Accommodate System Design Considerations
The Dual In-line Package (DIP) format significantly eases printed circuit board layout and reduces computer assembly cost.


**1965**: Semiconductor Read-Only-Memory Chips Appear
Semiconductor read-only-memories (ROMs) offer high density and low cost per bit.

**1966**: Semiconductor RAMs Serve High-speed Storage Needs
Bipolar RAMs enter the computer market for high-performance scratchpad and cache memory applications.

**1966**: Computer Aided Design Tools Developed for ICs
IBM engineers pioneer computer-aided electronic design automation tools for reducing errors and speeding de time.

**1967**: Turnkey Equipment Suppliers Change Industry Dynamics
Third-party vendors develop specialized knowledge of semiconductor fabrication and emerge as vendors of pro technology and turnkey manufacturing facilities.

**1967**: Application Specific Integrated Circuits employ Computer-Aided Design
Automated design tools reduce the development engineering time to design and deliver complex custom integ circuits.

**1968**: Dedicated Current Source IC Integrates a Data Conversion Function
The precision manufacturing requirements of combining analog and digital capability on one chip made them o the last product areas to yield to monolithic solutions.

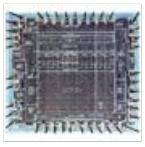
**1968**: Silicon Gate Technology Developed for ICs
Federico Faggin and Tom Klein improve the reliability, packing density, and speed of MOS ICs with a silicon-ga structure. Faggin designs the first commercial silicon-gate IC – the Fairchild 3708.

**1969**: Schottky-Barrier Diode Doubles the Speed of TTL Memory & Logic
Design innovation enhances speed and lowers power consumption of the industry standard 64-bit TTL RAM architecture. Is quickly applied to new bipolar logic and memory designs.

## 1970s

**1970**: MOS Dynamic RAM Competes with Magnetic Core Memory on Price
The Intel i1103 Dynamic RAM (DRAM) presents the first significant semiconductor challenge to magnetic cores primary form of computer memory.

**1971**: Reusable Programmable ROM Introduces Iterative Design Flexibility
Dov Froman's ultra-violet light erasable ROM design offers an important design tool for the rapid development microprocessor-based systems, called an erasable, programmable read-only-memory or EPROM.



**1971**: Microprocessor Integrates CPU Function onto a Single Chip
Silicon-gate process technology and design advances squeeze computer central processing units (CPU) onto si chips.

**1974**: General-Purpose Microcontroller Family is Announced
A single-chip calculator design emerges as the TMS 1000 micro-control unit or MCU, a concept that spawned fa of general-purpose digital workhorses that power the tools and toys of the developed world.

**1974**: Digital Watch is First System-On-Chip Integrated Circuit
The Microma liquid crystal display (LCD) digital watch is the first product to integrate a complete electronic sys onto a single silicon chip, called a System-On-Chip or SOC.

**1974**: Scaling of IC Process Design Rules Quantified
IBM researcher Robert Dennard's paper on process scaling on MOS memories accelerates a global race to shrir physical dimensions and manufacture ever more complex integrated circuits.

**1978**: PAL User-Programmable Logic Devices Introduced
John Birkner and H. T. Chua of Monolithic Memories develop easy-to-use programmable array logic (PAL) devi and tools for fast prototyping custom logic functions.

**1979**: Single Chip Digital Signal Processor Introduced
Bell Labs' single-chip DSP-1 Digital Signal Processor device architecture is optimized for electronic switching sy

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