Semiconductor Artifacts in the *Silicon Engine* Exhibit

Computer History Museum,
Mountain View, CA
June 30, 2009

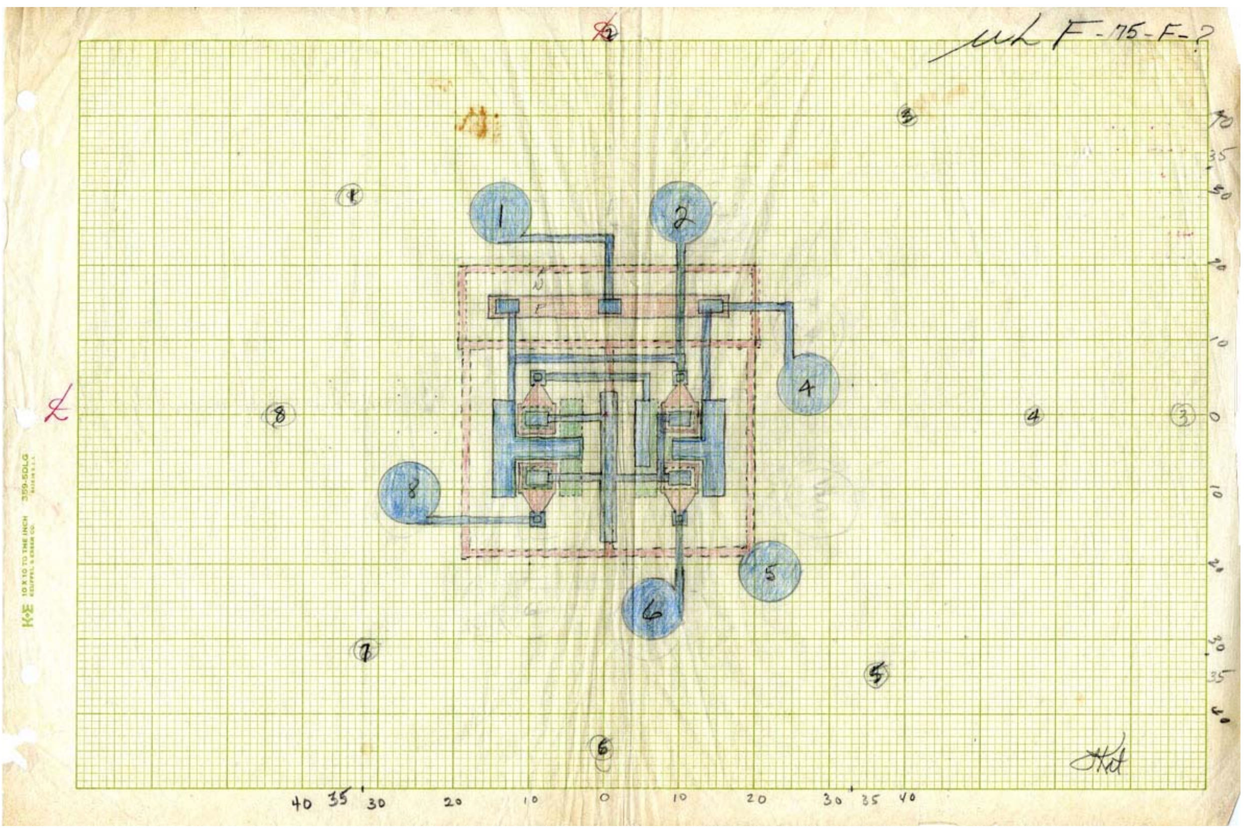


Exhibit Item IC-2: Original hand-drawn mask design of the
Fairchild "F" Element flip-flop planar integrated circuit by Lionel Kattner, 1960.
(Accession #:102658656. Gift of Lionel Kattner)

Major funding for the Silicon Engine exhibit is provided by the Gordon and Betty Moore Foundation.
Additional support is provided by Intel Corporation.

COMPUTER HISTORY MUSEUM

Silicon Engine Exhibit Artifact Listing

Silicon Engine exhibit artifacts are housed in four display cases:

> **Case 1: Significant Firsts** – Artifacts that represent the first example of an important step in the development of semiconductor technology.
>
> **Case 2: Transistor related artifacts**
>
> **Case 3: Integrated Circuit related artifacts**
>
> **Case 4: Influential Books** - A selection of books that have had a significant influence on the development of semiconductor technology.

Artifact groups are labeled in chronological order. All items with a TX prefix are located in the "Transistor" display case (with the exception of TX-7) and those with an IC prefix are in the "Integrated Circuit" display case (with the exception of IC-2, -7 and -10). The excepted artifacts are in the "Significant Firsts" case.

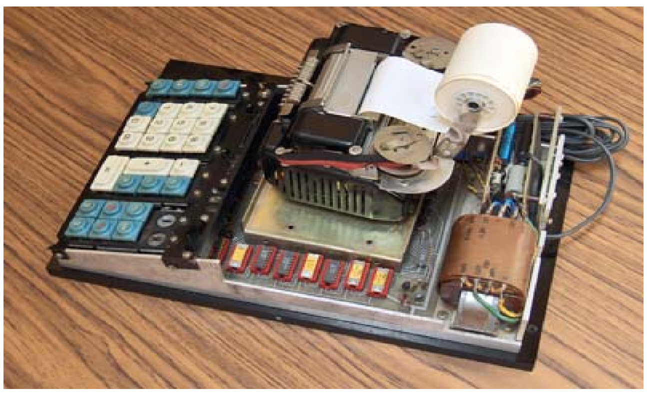
Each artifact group consists of one or several related items. The labels in the display cases include the title, the artifact and the credit lines noted below. Additional information provided in this document is a description of the function and significance of each item, the CHM collection accession numbers, and the URL of the Timeline page on the Museum's Silicon Engine Online exhibit website (www.computerhistory.org/semiconductor) that provides additional background and context.

Case 1 – Significant Firsts

This case contains four artifacts selected as unique items that represent the first example of an important step in the development of the applications of semiconductor technology. Full descriptions are provided in the chronological listings below.

> TX -7: Regency TR-1 is the first popular transistor radio (1954)
>
> IC-2: Planar IC process defines the future of microelectronics (1960)
>
> IC-7: Victor 3900 is first MOS calculator (1965)
>
> IC-10: Illiac IV first all semiconductor mainframe memory system (1970)

Another significant first on display within the museum is the Busicom 141-PF calculator built with the MCS-4 chip set, the initial application of Intel's 4004 microprocessor unit. A gift to the collection by design team manager Federico Faggin, the machine is part of the *Innovation in the Valley: A Celebration of Silicon Valley Companies and Pioneers* exhibit in the lobby gallery.



Busicom 141-PF calculator with case removed to show the microprocessor chip-set

Case 2 - Transistor Related Artifacts

TX-1: "Cat's Whisker" is first commercial semiconductor (c. 1930)

Artifact: Philmore Open Type Crystal Detector and shipping box
Description: Patented in 1901 by Jagadis Chandra Bose, a professor of physics in Calcutta, India, the "cat's whisker" crystal radio signal detector was the first commercial application of the rectifying properties of semiconductor materials. Although crystal rectifiers allowed simple sets to operate without external power, by the mid-1920s the predictable performance of vacuum-tubes replaced them in most radio applications. This example was sold by the Philmore Manufacturing Company of New York.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1901-semiconductor.html
Credit: Gift of Len Shustek **Accession #:** 102711521

TX-2: WWII rectifiers advance materials technology (c. 1945)

Artifact: 1N21 silicon rectifier for airborne radar applications built by the Western Electric manufacturing arm of AT&T
Description: Semiconductor rectifiers regained prominence in World War II because of their ability to operate at signal frequencies higher than attainable with vacuum tube diodes. Experience gained in fabricating millions of silicon and germanium crystal rectifier diodes for use in Allied radar receivers facilitated the production of high purity materials essential for building the first transistor.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1941-semiconductor.html
Credit: Purchase by Computer History Museum **Accession #:** 102711174

TX-3: Bardeen and Brattain invent the transistor at Bell Labs (1947)

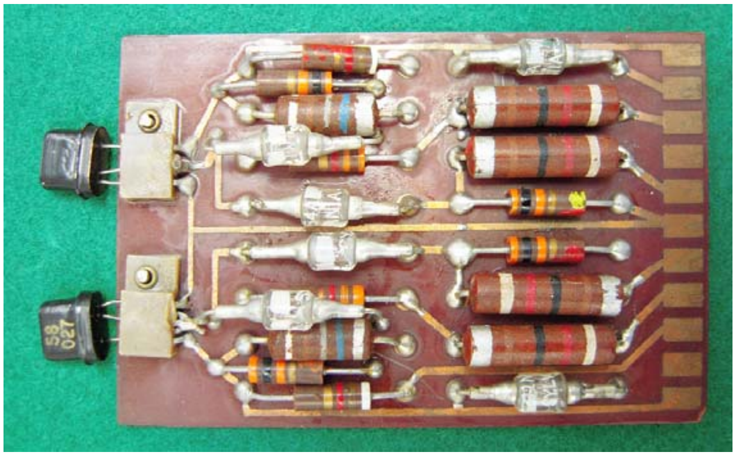
Artifact: Replica of the original 1947 point contact transistor and Western Electric 2N67 production version (mid-1950s).
Description: Extensive research into a solid-state replacement for bulky vacuum tubes in the AT&T telephone system by Bell Telephone Laboratory physicists John Bardeen and Walter Brattain, culminated in operation of the first successful transistor, a germanium point contact transistor amplifier, on December 16, 1947. The 2N67, an example of a "ruggedized" version of their fragile prototype device, was developed by Western Electric in the 1950s for military applications. This model of their experimental device was built for the museum by LSI Corporation, successor to the Western Electric semiconductor operation.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1947-invention.html
Credit: Replica - Gift of LSI Corporation. 2N67 - Gift of Jack Ward, transistormuseum.com
Accession #s: Replica – 102677103; 2N67 – 102711710

TX-4: "Ma Bell's Cookbook" teaches transistor technology (1951)

Artifact: *The Transistor: Selected Reference Material on Characteristics and Applications* published by Western Electric.
Description: Beginning in 1951, Bell Labs hosted a series of symposia to teach potential users and manufacturing licensees the basics of transistor technology. The proceedings of the first symposium - *The Transistor,* fondly recognized as "Ma Bell's Cookbook" - became the bible of the early semiconductor industry. Shown in the display of influential books, the

three volume series *Transistor Technology* written by Bell Labs' staff and published by D. Van Nostrand updated and significantly expanded this information in 1958.
***Silicon Engine* Timeline entry:** www.computerhistory.org/semiconductor/timeline/1952-transistor-technology-education-and-licensing-begins.html
Credit: Gift of Ray Polivka **Accession #:** Lot X3853.2007

TX-5: Vacuum tube vs. transistor size comparison (1953)
Artifact: IBM CS-501 tube module & transistor card precursor to the IBM SMS (Standard Modular System) format.
Description: Two vacuum tubes mounted in a CS-501 pluggable module from the IBM 650, the first mass produced digital computer, are compared with a card designed in 1953 for the engineering evaluation of a transistorized version of the IBM 604 Electronic Calculating Punch. The two black encased transistors at the top of the card performed the same function at a fraction of the size and power consumption of the tubes. They are IBM type 58 NPN germanium alloy junction devices. This card is the only known example of this precursor to the SMS (Standard Modular System) cards used in IBM equipment from the late 1950's to the mid 1960s. It was presented to the designer, Joseph Logue, who worked for IBM for 35 years.
***Silicon Engine* Timeline entry:** None. For more information see *IEEE Annals of the History of Computing,* Vol. 20, No. 3, 1998 p. 61
Companion exhibit in Visible Storage: An example of the IBM SMS card format from 1960 is included in the *Transistor based Computer Circuit Boards* display
Credit: Vacuum tubes – Gift of Murray Allen; Transistorized card – Gift of Joseph C. Logue
Accession #s: Tubes - XD12.75; Card – 102711702



Early IBM transistorized card

TX-6: Shockley's junction transistor enables mass production (1951)
Artifact: Germanium and silicon computer transistors (c. 1954 to 1957) representing several generations of junction technology.
Description: A year after Bardeen and Brattain's invention, their boss, physicist William Shockley, conceived an improved structure based on the *p-n* junction that overcame the delicate mechanical construction of the point contact device. Announced in 1951, over the next decade many different manufacturing methods were introduced to produce faster, cheaper, and even more reliable junction transistors. An important development in

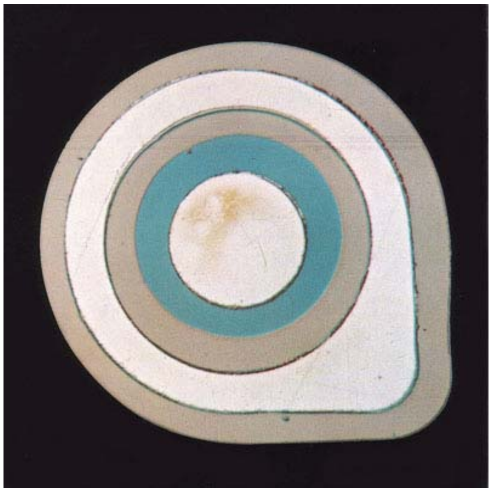
1954 was the silicon transistor from Bell Labs and upstart Texas Instruments. Devices (germanium unless otherwise noted) developed specifically for computer applications on display are (a) General Electric 2N167 NPN Grown Junction, (b) Philco 2N240 PNP Surface Barrier (SBT), (c) Philco 2N501 PNP Micro Alloy Diffused (MADT), (d) RCA 2N404 PNP Alloy Junction, (e) TI R212 PNP Alloy Junction, and (f) IBM 154 NPN Diffused Base/Mesa. Item (g) is the first TI Type 905 Silicon grown-junction NPN, (h) is the first Fairchild device, the 2N697 Double diffused silicon mesa NPN.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1948-conception.html
Companion exhibits in Visible Storage: The IBM Model 1401 (1959) and Philco 212 (1962) computers used similar transistors
Credit: Items (a) - (f) Gift of Jack Ward, transistormuseum.com, (g) Gift of Texas Instruments, (h) Gift of Robert Glorioso.
Accession #s: (a) 102711706, (b) 102711707 (c) 102711708, (d) 102711705, (e) 102711704, (f) 102711703 (g) 102711691, (h) X71.82

TX-7: Regency TR-1 is the first popular transistor radio (1954) – located in the "Significant Firsts" case
Artifact: Regency Model TR-1 (Ivory) Transistor Pocket Radio with four Texas Instruments' germanium transistors.
Description: A joint venture between Texas Instruments and the Regency Division of Industrial Development Engineering Associates developed the world's first commercially marketed transistor radio in 1954. Powered by a 22.5 volt battery, the four germanium transistors manufactured by TI provided over 20 hours of operation. At a price of $49.95, the TR-1 generated sales of over 100,000 units and introduced the word "transistor" into the public lexicon.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1952-Consumer.html
Credit: Gift of Texas Instruments
Accession #: 102711690

TX-8: Silicon wafers sliced from ingot grown from seed (1958)
Artifact: Dupont seed crystal, Fairchild ¾" silicon ingot with bare wafer slices, and finished wafer.
Description: Semiconductor quality ingots are pulled from a crucible of molten silicon using a seed with the desired crystal orientation. According to the donor this crystal was supplied by Dupont and was used to grow Fairchild's first ingot. The ingot is then cut into wafers and polished. The 5/8" transistor wafer was processed circa 1958.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1952-Consumer.html
Companion exhibit in Visible Storage: A larger ingot and generations of wafers are shown in the *How Integrated Circuits are Made* display.
Credit: Processed wafer - Gift of Arthur Zafiropoulo, Others - Gift of Lars Lunn
Accession #: Ingot - 102690031, Blank wafers - 102690040, Processed wafer - X2351.2002, Seed crystal - 102690038

TX-9: Minuteman I: Major early user of silicon transistors (1958)
Artifact: Typical Minuteman I missile amplifier, electronic control module with Fairchild, Motorola and other transistors.
Description: After spinning off from Shockley Semiconductor Lab in 1957, Fairchild Semiconductor developed the first double-diffused silicon mesa transistors. The unique characteristics of these devices quickly found applications in aerospace systems including the Minuteman I missile guidance computer at the Autonetics Division of North American Aviation. A potential reliability problem with 2N697 mesa devices [See TX-6 (h)] stimulated Fairchild's rapid development of the planar structure and conversion of the transistor to the new process.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1958-Mesa.html
Companion exhibit in Visible Storage: The *Minuteman I Guidance Computer* (1962)
Credit: Gift of Aron Insinga
Accession #: X1477.97E

TX-10: Jean Hoerni's planar process revolutionizes the industry (1959)
Artifact: Fairchild Semiconductor planar transistor (2N1613) with "teardrop" geometry in open and sealed packages.
Description: Seeking a solution to reliability issues with the mesa transistor described in TX-9, Fairchild physicist Jean Hoerni developed a new process in which a flat oxide layer grown on the silicon wafer is used to protect the sensitive *p-n* junctions underneath. Fairchild introduced the 2N1613 planar transistor commercially in April 1960 and licensed rights to the process across the industry. The billion-transistor integrated circuits of today rely on Hoerni's breakthrough idea. Technology historian Christophe Lécuyer ranks the planar process as "the most important innovation in the history of the semiconductor industry."
***Silicon Engine* Timeline entry:**
http://www.computerhistory.org/semiconductor/timeline/1959-invention-of-the-planar-manufacturing-process-24.html
Credit: Gift of Lars Lunn
Accession #s: Open transistors - 102690042, Sealed transistors – 102690043



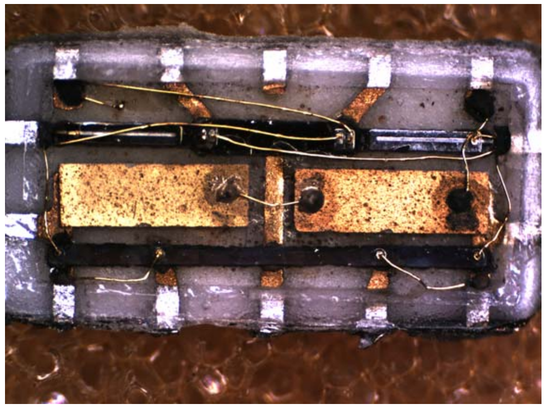
Teardrop geometry of the first planar transistor

TX-11: Silicon transistors surpass germanium in speed (1961)
Artifact: CDC 6600 supercomputer "cordwood" logic module containing Fairchild 2N709 epitaxial, "gold-doped" transistors.
Description: Control Data Corporation computer architect Seymour Cray awarded Fairchild Semiconductor a development contract to build a silicon transistor that would switch in less than 3 nanoseconds as a key element of his plan to make the CDC 6600 the world's fastest supercomputer. Jean Hoerni met the specification by combining "gold-doping" - the addition of gold impurities - together with the new epitaxial deposition process. The 2N709 *n-p-n* device was introduced in July 1961 as the first silicon transistor to exceed germanium speed. The cordwood module format minimized system interconnection delays.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1961-Speed.html
Companion exhibit in Visible Storage: The CDC6600 (1964) computer system uses this module
Credit: Gift of Control Data Corporation
Accession #: X402.84A

TX-12: System/360 SLT modules: Hundreds of millions consumed (1964)
Artifacts: "Life Cycle "presentation of the IBM Solid Logic Technology (SLT) hybrid microcircuit module.
Description: IBM developed Solid Logic Technology (SLT) multi transistor hybrid circuit modules for the System/360 computer family in 1964 prior to the ability of monolithic ICs to meet the cost and speed demands of large computers. Silicon transistor chips and passive components mounted on 0.5" square ceramic modules with vertical pins consumed less power and space while offering faster speed and superior reliability compared to printed-circuit boards with packaged transistors. IBM produced hundreds of millions of SLT modules in a highly-automated, specially-built plant in East Fishkill, NY.
***Silicon Engine* Timeline entry:**
http://www.computerhistory.org/semiconductor/timeline/1964-Hybrid.html
Companion exhibit in Visible Storage: The IBM System/360 (1965) used these SLT modules
Credit: Loan of Al Kossow

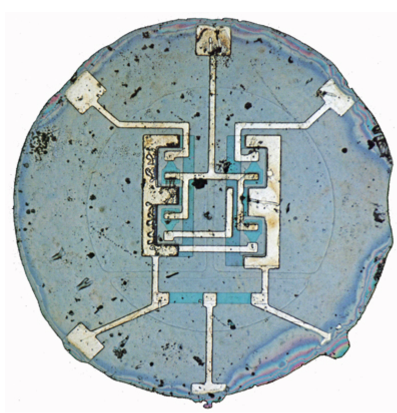
Case 3 - Integrated Circuit Related Artifacts

IC-1: Kilby invents the "Solid Circuit" at Texas Instruments (1958)
Artifact: Replica of Jack Kilby's laboratory notebook pages of September 12 & 19, 1958 and a "flying wire" integrated circuit die.
Description: Kilby recorded the successful demonstration of his first integrated circuit on page 20 of his engineering notebook. Signed JS Kilby, the page is dated September 12, 1958. Page 21 describes his construction of a bistable (flip-flop) circuit on September 19. This replica was produced by TI to display at the fiftieth anniversary of the integrated circuit celebration at the Computer History Museum in May 2009. The chip in the plastic case is a first generation Solid Circuit die prior to mounting in a package, circa 1960. The separate components on the chip were interconnected by fine gold "flying wires" and electrically isolated from each other by etching air gaps in the silicon.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1958-Miniaturized.html
Credit: Notebook Gift of Texas Instruments
Accession #: Notebook – 102703910, Die – 102669830



TI Solid Circuit "bar" prior to mounting in a package, circa 1960

IC-2: Planar IC process defines the future of microelectronics (1960) – artifacts are located in the "Significant Firsts" case
Artifact: Copy of mask design drawing and two versions of the Fairchild Micrologic "F" element flip-flop, the first planar IC.
Description: In August 1959 Fairchild Semiconductor Director of R&D, Robert Noyce asked co-founder Jay Last to begin development of an integrated circuit based on Hoerni's planar process. Integrating multiple interconnected devices on one chip posed many new engineering challenges. The first working devices were produced on May 26 1960 and devices were formally introduced under the trade name Micrologic in March 1961. Artifacts on display include a copy of the hand drawn mask design of the circuit by Lionel Kattner (the original is in the CHM collection) and two versions of the die. This basic approach to IC fabrication is still employed today. The TO-18 style package header holds an experimental metal mask version of the physical isolation process. The two unmounted round die employ the diffused isolation method selected for production. Their shape was etched to fit inside the circle of pins on the round package header.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1962-Apollo.html
Credit: Gifts of Lionel Kattner
Accession #: Original drawing - 102658656, Die - 102696650, Die on TO-18 header - 102696651



Diffused-isolation version of Micrologic "F" element flip-flop, the first planar IC

IC-3: Early monolithic ICs from Texas Instruments (1961)
Artifact: Series 51 Semiconductor Networks and Minuteman II custom ICs manufactured with TI's version of the planar process.
Description: Announced in late 1961, Series 51 DCTL was TI's first family of integrated circuits to use the planar process. The Litton AN/ASA27 radar computer indicator carried aboard the Navy's W2P-1 early warning radar aircraft was an early full scale commercial application of these devices. The board with four mounted flat pack units is encapsulated in the blue Litton module. The block with two Sprague transistors is the function replaced by the IC. In the fall of 1962, TI won a contract to develop and produce 13 custom circuits for the Autonetics, Minuteman II missile guidance platform. Examples of these circuits are shown in the plastic case. This was the industry's first major custom circuit design program and presented the company with many new engineering challenges. By 1965 Minuteman overtook NASA's Apollo procurement as the largest single consumer of ICs. The TI 7/8" silicon wafer patterned with ICs dates from the early 1960s.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1962-Apollo.html
Credit: Gift of D. C. McKenzie and Texas Instruments
Accession #: Series 51 devices - 102711358, Minuteman ICs - 102711695, Wafer – 102711694

IC-4: Apollo Guidance Computer pioneers the use of ICs (1962)
Artifact: Prototype of AGC Block 1 logic module built by Raytheon and Fairchild "G" element ICs in TO-5 style packages.
Description: NASA's Apollo Guidance Computer (AGC) was the most significant early project to commit to use ICs. Designed by MIT in 1962 and built by Raytheon, each system used about 4,000 Fairchild Micrologic "Type-G" (3-input NOR gate) circuits. Consuming 200,000 units at $20-30 each, the AGC was the largest user of ICs through 1965. The artifacts include the first package style, a modified TO-5 transistor can, and the engineering prototype of the Block 1 system built by Raytheon using flat packages.
Silicon Engine Timeline entry:
www.computerhistory.org/semiconductor/timeline/1962-Apollo.html
Companion exhibit in Visible Storage: The Apollo Guidance Computer system
Credit: Gifts of Eldon Hall and Vincent Schommer
Accession #: AGC module - X1067.91, TO-5 packages – 102711712

IC-5: DTL and TTL: First industry standard logic families (1964)
Artifact: Fairchild 930 DTL devices in flat pack carriers and TI SN54/74 TTL devices mounted on a Computer Controls Corp. card
Description: In the 1960s standard IC building blocks (gates, flip-flops, counters, decoders, etc.) comprised the workhorse logic solution for most digital designs. The two most popular families were the Fairchild 930 series DTL (Diode Transistor Logic) and TI SN54/7400 series TTL (Transistor Transistor Logic). Introduced initially in the flat package for the military market (as shown here), following the availability of the easier to handle dual inline package (DIP) in they gained widespread acceptance in commercial applications.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1963-TTL.html
Companion exhibit in Visible Storage: The Data General Nova (1968) and generations of the Digital Equipment PDP-8 family were based on TTL ICs in the plastic DIP
Credit: Gift of Fairchild Camera and Instrument Corporation and unknown
Accession #: DTL – 102682093, SN5400 - XD111.80

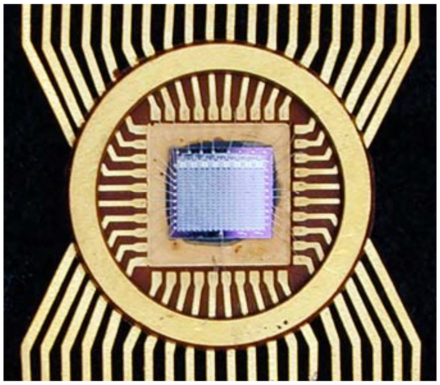
IC-6: Op amp opens mass market for analog ICs (1965)
Artifact: Fairchild µA709A operational amplifier by maverick analog circuit designer Robert Widlar.
Description: The Fairchild µA702 op amp, created in 1964 by the team of process engineer Dave Talbert and designer Robert Widlar, was the first widely-used device. Their 1965 successor, the µA709, established a mass market for analog ICs. Talbert and Widlar moved to Molectro (later acquired by National) in late 1965 where they built a linear dynasty beginning with the LM101. Then in 1968 Dave Fullagar of Fairchild one-upped the LM101 by adding an internal compensating capacitor to deliver the µA741, the most popular op-amp of all time. Widlar was renowned both for his creative approaches to analog circuit design and for his alcohol-fueled high jinks.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1964-analog.html
Credit: Gift of Fairchild Camera and Instrument Corporation
Accession #: 102682094

IC-7: Victor 3900 is first MOS calculator (1965) – artifact located in the "Significant Firsts" case
Artifact: Victor 3900 pc board with 23 MOS logic ICs and six 100-bit memory shift registers built by General Microelectronics.
Description: General Microelectronics in Santa Clara was the first company to offer commercial MOS ICs, shift registers, in 1964. Expertise in their design helped to win a contract to produce the first MOS LSI -based calculator for Victor Comptometer. To raise additional financing to fund the ambitious project to build 23 complex custom chips the company was sold to Philco Ford. Announced with great fanfare in 1965, the Model 3900 calculator suffered serious reliability issues related to the still infant MOS process. Many of them failed, seriously damaging Victor's image. Reliable MOS calculator chip sets were in production by 1969.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1964-Commecial.html
Credit: Don Farina
Accession #: 102682056

Photo of prototype Victor 3900 case that held the board on display

IC-8: IBM evaluates waferscale approach to custom logic (1966)
Artifact: IBM MOD2 120-gate discretionary wired logic function occupies a complete IC wafer fabricated by Texas Instruments.
Description: Gate arrays and standard cells were two of the most popular approaches to expediting the engineering development of custom ICs (called ASICs) in the 1980s. An ambitious early program pursued by TI called "discretionary wiring," that employed a unique computer-generated metal mask for every wafer, was less successful. The MOD2 circuit on display was built by TI for a Large Scale Integration experiment with IBM in 1966.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1967-ASICs.html
Credit: Gift of Joseph C. Logue
Accession #: 102711711

IC-9: Semiconductor arrays replace core memory (1968 - 1973)
Artifacts: Three MOS process technology generations: Fairchild P-channel, Mostek N-channel, RCA COS/MOS (CMOS).
Description: Semiconductor (also called solid-state) memory uses transistors and other components integrated on silicon chips to store bits of information. Initially expensive and reserved for high-speed applications, semiconductor elements began to enter the mainstream as a replacement for magnetic core memory in the early 1970s. Driven by increases in density and reductions in cost, semiconductors rapidly displaced cores while enabling new computer architectures that combined memory and logic on the same chip. Just three early examples of the numerous process developments, circuit design concepts and corporate business models that were pursued to accomplish this result are displayed here. The Fairchild multichip package used sixteen 64-bit P-channel MOS static RAMs to deliver a 1024-bit array in 1968. In the same year RCA built the experimental 288-bit SRAM with CMOS technology to achieve the lowest possible power consumption. Mostek employed ion implantation to produce the industry's most successful 4096-bit N-channel DRAM in 1973.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/xxx
Companion exhibit in Visible Storage: The rubylith mask (made at 200x final size) for the MK4069 is in the *How Integrated Circuits are Made* display
Credit: Gift of Dan Rose/SEMI, Mostek and Richard Ahrons
Accession #: FSC - 102676927, Mostek - x582.85, RCA – 102711713



RCA experimental COS/MOS 288-bit SRAM

IC-10: Illiac IV first all semiconductor mainframe memory system (1970) – artifact located in the "Significant Firsts" case
Artifact: One board from Illiac IV supercomputer Processor Element Memory system with Fairchild 256-bit TTL memory chips.
Description: Illiac IV was a high-performance computer system conceived by Daniel Slotnick of the University of Illinois for the U.S. Department of Defense. The design called for 131,072 bits of high-speed memory for each of the machine's 64 parallel processing elements. When the planned thin-film memory could not deliver adequate performance Fairchild Semiconductor contracted to design and build the systems using 256-bit static RAM devices. Fairchild shipped the full complement of systems by May 1971. According to Slotnick, "Illiac IV was the first machine to have all-semiconductor memories. Fairchild did a magnificent job of pulling our chestnuts out of the fire."
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1966-RAM.html
Companion exhibit in Visible Storage: The PEM system is included in the Illiac IV exhibit
Credit: Frank Greene
Accession #: 102696796

Illiac IV Processor Element Memory system that holds the board on display

IC-11: Complex MOS chips enable handheld consumer devices (1972)
Artifacts: Texas Instruments Datamath 2500 calculator, TMS0119NC calculator chip, TMS1000 microcontroller chip
Description: TI engineer Gary Boone applied design techniques from an early microprocessor project to two of the most familiar handheld consumer devices of the 1970s. TI's first single chip calculator IC theTMS1802C was introduced on September 17, 1971 and was used in the TI 2500 "Datamath" machine. The TMS0100, series announced in 1972, replaced and improved on the 1802. Version 0119 is on display. Together with Michael Cochran, Boone designed the TMS1000 microcomputer at the heart of "Speak and Spell," a popular educational toy introduced in 1978.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1974-MCU.html
Companion exhibits in Visible Storage: Many other calculator models are on display
Credit: Gift of Texas Instruments
Accession #: Calculator – 102711696, TMS0119NC – 102711698, TMS1000 - 102711697

IC-12: First generation of popular 8-bit microprocessors (1974)
Artifacts: Intel 8080 system development kit; Motorola 6800 graphics demonstration board.
Description: In 1974, Intel with the 8080 and Motorola with the 6800 introduced 8-bit devices and development tools that began to establish the microprocessor as the preferred approach to general purpose logic design. Intel 's inclusion of the 1702 EPROM (Erasable Programmable Read Only Memory) in the development kit allowed engineers to rapidly iterate design improvements. Motorola's expansive offering of peripheral devices for the 6800 offered high levels of system integration. The subsystem artifact designed by Chuck Peddle and John Buchanan demonstrated the 6800 graphics capability to chairman of the board Robert Galvin by displaying the message "Hi Bob".
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1971-MPU.html
Companion exhibit in Visible Storage: The Altair 8800 was the first popular PC to use the 8080. The Apple I & II both used the MOS Technology 6502 processor that was derived form the 6800
Credit: Gift of Myron A. Calhoun, Gift of Tom Bennett
Accession #: 8080 kit - 102673353, 6800 board - 102711296

IC-13: High-speed computer logic IC building blocks (late 1970s)
Artifacts: TI 74S00, MMI PAL, AMD 2901, and a Gate Array.
Description: Before the late 1980s, standard microprocessors were not fast or powerful enough for many large computer designs. This exhibit comprises four of the most important enabling logic chips of the 1970s that were used in the engineering breadboard of the Digital Equipment Corporation VAX 11/730 machine introduced in 1982. They are a Texas Instruments 74S00 Schottky high-speed TTL gate; a Monolithic Memories 16L8 PAL (Programmable Array Logic) device; Advanced Micro Devices Am2901 4-bit microprocessor slice, and a high pin-count gate array dual in-line package.
***Silicon Engine* Timeline entry:**
www.computerhistory.org/semiconductor/timeline/1969-Schottky.html
www.computerhistory.org/semiconductor/timeline/1978-PAL.html
Companion exhibit in Visible Storage: The VAX 11/730 was a low cost member of the larger VAX Family models on display
Credit: Gifts of Digital Equipment Corporation
Accession #: XD146.80

Case 4 – Influential Books

A selection of books that have had a significant influence on the development and applications of semiconductor technology. They are listed chronologically below.

1. *Electrons and Holes in Semiconductors with Applications to Transistor Electronics,* William. S. Shockley (D. Van Nostrand, 1950) Signed by the author, this copy was presented to Shockley Semiconductor labs employee Harry Sello in 1957 to acknowledge his "hot idea," the design of an improved diffusion furnace.
2. *The Transistor: Selected Reference Material on Characteristics and Applications,* Prepared by Bell Telephone Laboratories Staff (Western Electric Co., 1951) This copy of "Ma Bell's Cookbook" was hardbound for use in the Hughes Aircraft company library. See exhibit item TX-4
3. *Transistor Electronics*, RCA Staff Engineers (Prentice Hall, 1955)
4. *Transistor Technology, Vols. I, II, and III,* F. J. Biondi, et al eds., (D. Van Nostrand, 1958) This three volume set was written by Bell Labs staff members to update and expand on the information published in item 2 above.
5. *Miniature and Microminiature Electronics*, G. W. A. Dummer & J. W. Granville (John Wiley and Sons, 1961)
6. *Handbook of Semiconductor Electronics: A Practical Manual Covering the Physics, Technology and Circuit Applications of Transistors, Diodes and Photocells*, L. Hunter, ed. (McGraw-Hill, 1962)
7. *Microelectronics* E. Keonjian ed., (McGraw Hill, 1962) Open at Chapter 5, one of the first detailed descriptions of the planar process as applied to integrated circuits by Gordon Moore, the Director of R&D at Fairchild.
8. "Semiconductor Integrated Circuits" is the manuscript proof of Chapter 5 of *Microelectronics* (7 above) written by Gordon E. Moore in 1962.
9. *Fairchild Microcircuits Handbook*, Binder of 1960s-era Fairchild Semiconductor Technical Publications and Application Notes. Includes Jean Hoerni's classic paper "Planar Silicon Diodes and Transistors."
10. *Physics and Technology of Semiconductor Devices*, A. S. Grove (John Wiley and Sons, 1967)
11. *The TTL Data Book for Design Engineers.* TI Engineering Staff (Texas Instruments, 1973)
12. *Introduction to VLSI Systems,* Carver Mead, and Lynn Conway (Addison-Wesley, 1979)
13. *Bit-Slice Microprocessor Design,* John Mick & James Brick (McGraw-Hill, 1980)

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