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1947 First pointcontact transistor

John Bardeen, Walter H. Brattain, and William B. Shockley of Bell Labs discover the transistor. Brattain and Bardeen build the first pointcontact transistor, made of two gold foil contacts sitting on a germanium crystal. When electric current is applied to one contact, the germanium boosts the strength of the current flowing through the other contact. Shockley improves on the idea by building the junction transistor—"sandwiches" of N- and P-type germanium. A weak voltage applied to the middle layer modifies a current traveling across the entire "sandwich." In November 1956 the three men are awarded the Nobel Prize in physics.

NATIONAL ACADEMY OF ENGINEERING

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6.Radio and Television7.Agricultural Mechanization
8.Computers9.Telephone10.Air Conditioning and Refrigeration
11.Highways12.Spacecraft13.Internet14.Imaging
15.Household Appliances16.HealthTechnologies
17.Petroleum and Petrochemical Technologies
18.Laser and Fiber Optics19.Nuclear Technologies
20.High-performance Materials

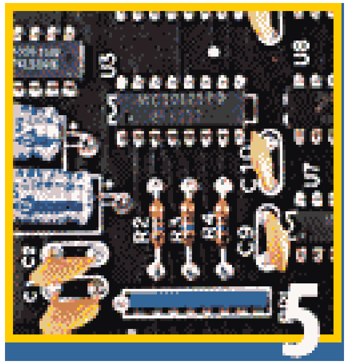
Electronics

- Barely *stifled yawns* greeted the electronics *novelty* that was introduced to the public " in mid-1948.
- A device called a transistor, which has several *applications* in radio where a *vacuum tube* ordinarily is employed, was demonstrated for the first time yesterday at Bell *Telephone Laboratories*," noted an obviously unimpressed New York Times reporter on page 46 of the day's issue.

抑える　あくび　新しいもの

応用　真空管

電話研究所



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点接触　金箔

接合トランジスタ

変調する

1952 First commercial device to apply Shockley's junction transistor

- Sonotone *markets* a $229.50 *hearing aid* that uses two *vacuum tubes* and one transistor—the first commercial device to apply Shockley's *junction* transistor. *Replacement* batteries for *transistorized* hearing aids cost only $10, not the nearly $100 of batteries for earlier vacuum tube models.

市場に出す　補聴器

真空管

接合型

置き換え　微細化された

1954 First transistor radio

- Texas Instruments introduces the first transistor radio, the Regency TR1, with radios by Regency Electronics and transistors by Texas Instruments. The transistor replaces De Forest's *triode*, which was the electrical component that *amplified* audio signals—making AM (*amplitude modulation*) radio possible. The door is now open to the transistorization of other *mass production devices*.

三極管
増幅する
振幅変調
大量生産　部品

1954 First truly consistent mass-produced transistor is demonstrated

- Gordon Teal, a *physical chemist* formerly with Bell Labs, shows *colleagues* at Texas Instruments that transistors can be made from pure silicon—demonstrating the first truly consistent mass-produced transistor. By the late 1950s silicon begins to replace germanium as the *semiconductor material* out of which almost all modern transistors are made.

物理化学者

同僚

半導体材料

1958-1959 *Integrated circuit invented* 集積回路 発明された

Jack Kilby, an electrical engineer at Texas Instruments and Robert Noyce of Fairchild Semiconductor *independently* invent the integrated circuit. In September 1958, Kilby builds an integrated circuit that includes *multiple components* connected with gold wires on a tiny silicon chip, creating a "*solid circuit*." (On February 6, 1959, a *patent* is issued to TI for "miniaturized electronic circuits.") In January 1959, Noyce develops his integrated circuit using the process of *planar* technology, developed by a colleague, Jean Hoerni. Instead of connecting individual circuits with gold wires, Noyce uses *vapor-deposited metal connections*, a method that allows for miniaturization and mass production. Noyce files a detailed patent on July 30, 1959.

個別に
複数の 部品
固体回路 特許
平面の
蒸着 金属接続

1962 MOSFET is invented

- The *metal oxide semiconductor field effect transistor* (MOSFET) is invented by engineers Steven Hofstein and Frederic Heiman at RCA's research laboratory in Princeton, New Jersey. Although slower than a *bipolar junction transistor*, a MOSFET is smaller and cheaper and uses less power, allowing greater numbers of transistors to be *crammed* together before a heat problem arises. Most microprocessors are made up of MOSFETs, which are also widely used in switching applications.

金属－酸化物－半導体

電界効果トランジスタ

両極性接合トランジスタ

詰め込む

1967 First handheld calculator invented

- A Texas Instruments team, led by Jack Kilby, invents the first handheld *calculator* in order to showcase the integrated circuit. Housed in a case made from a solid piece of aluminum, the *battery-powered* device fits in the palm of a hand and weighs 45 ounces. It accepts six-digit numbers and performs addition, subtraction, multiplication, and division, printing results up to 12 digits on a *thermal printer.*

計算機

電池駆動

感熱プリンタ

1971 Intel introduces "computer on a chip"

- Intel, *founded* in 1968 by Robert Noyce and Gordon Moore, introduces a "Computer on a chip," the 4004 four-bit microprocessor, design by Frederico Faggin, Ted Hoff, and Stan Mazor. It can execute 60,000 operations per second and changes the face of modern electronics by making it possible to include data processing hundreds of devices. A 4004 provides the computing power for NASA's Pioneer 10 *spacecraft*, launched the following year to survey *Jupiter*.

  3M Corporation introduces the ceramic chip carrier, designed to protect integrated circuits when they are attached or removed from circuit boards. The chip is bonded to a gold base inside a *cavity* in the square ceramic carrier, and the package is then *hermetically sealed*.

創立

宇宙船

木星

空隙　機密封止

1972 Home video game systems become *available*

利用可能な

- In September, Magnavox ships Odyssey 100 home game systems to *distributors*. The system is test marketed in 25 cities, and 9,000 units are sold in Southern California Alone during the first month at a price of $99.95. In November, Nolan Bushnell forms Atari and *ships* Pong, a coin-operated video arcade game, designed and built by Al Alcorn. The following year Atari introduces its home version of the game, which soon outstrips Odyssey 100.

卸売業者

出荷する

1974 Texas Instruments introduces the TMS 1000

Texas Instruments introduces the TMS 1000, destined to become the most widely used computer on a chip. Over the next quarter-century, more than 35 different versions of the chip are produced for use in toys and games, calculators, *photcopying machines*, *appliances*, *burglar alarms*, and jukeboxes. (Although TI engineers Michael Cochran and Gary Boone create the first microcomputer, a four-bit microprocessor, at about the same time Intel does in 1971, TI does not put its chip on the market immediately, using it in a calculator introduced in 1972.)

複写機
家電製品
盗難警報

1997 IBM *develops* a copper-based chip technology

開発する

- IBM announces that it has developed a copper-based chip technology, using *copper* wires rather than traditional aluminum to connect transistors in chips. Other chip *manufacturers* are not far behind, as research into copper wires has been going on for about a *decade*. Copper, the better *conductor*, offers faster *performance*, requires less electricity, and runs at lower temperatures, This *breakthrough* allows up to 200 million transistors to be placed on a single chip.

銅

製造業者

10年

導体　性能

限界突破

1998 Plastic transistors developed

13Ex

- A team of Bell Labs researchers—Howard Katz, V. Reddy Raju, Ananth Dodabalapur, Andrew Lovinger, and chemist John Rogers—present their *latest* findings on the first fully "printed" plastic transistor, which uses a process similar to *silk screening*. Potential uses for plastic transistors include flexible computer screens and "smart" cards, full of vital statistics and buying power, and virtually *indestructible*.

最新の
スクリーン印刷技術
非破壊

Vacuum Switches

Vacuum tubes, being much faster than any mechanical switch, were soon enlisted for the new computing machines. But because a computer, by its nature, requires switches in very large numbers, certain *shortcomings* of the tubes were glaringly obvious.

真空管

欠点

They were bulky and *power hungry*; they produced a lot of waste heat; and they were prone to *failure*. The first big, all-electronic computer, a calculating engine known as ENIAC that went to work in 1945, had 17,468 vacuum tubes, weighed 30 tons, consumed enough power to light 10 homes, and required constant maintenance to keep it running

消費電力

故障する

Transistors

Some *investigators* were *convinced* that *semiconductors* could be given the powers of a *triode* as well. In late 1947 that goal was met by John Bardeen and Walter Brattain at Bell Labs. Their invention (the little cylinder that *provoked a shrug* from the New York Times) essentially consisted of two "cat's whiskers" placed very close together on the surface of an electrically grounded *chunk* of germanium. A month later a *colleague*, William Shockley, came up with a more practical design—a three-layer semiconductor sandwich. The outer layers were *doped* with an *impurity* to supply extra electrons, and the very thin inner *layer* received a different impurity to create *holes*. By means of complex *interactions* at the junctions where the layers met, the middle portion of the sandwich functioned like the grid in a triode, with a very small voltage controlling a sizable current flow between the outer layers. Bardeen, Brattain, and Shockley would share a Nobel Prize in physics as inventors of the transistor

調査者 確信した 半導体
三極管
肩をすくめる
塊 同僚
添加する 不純物
層 正孔
相互作用

Silicon transistors

Although Shockley's version was incorporated into a few products where small size and low *power consumption* were critical—hearing aids, for example—the transistor didn't win widespread acceptance by manufacturers until the mid-1950s, because Germanium transistors suffered *performance limitations*.

消費電力

性能限界

A turning point came in early 1954, when Morris Tanenbaum at Bell Labs and Gordon Teal at Texas Instruments (TI), working independently, showed that a transistor could be made from silicon—a component of ordinary sand. These transistors were made by selective *inclusion* of *impurities* during silicon *single crystal* growth and TI manufactured Teal's version primarily for *military applications.* In early 1955, Tanenbaum and Calvin Fuller at Bell Labs produced high performance silicon transistors by the high temperature diffusion of impurities into silicon wafers sliced from a highly purified single crystal.

拡散

不純物 単結晶

軍事的応用

integrated circuits—chips

集積回路

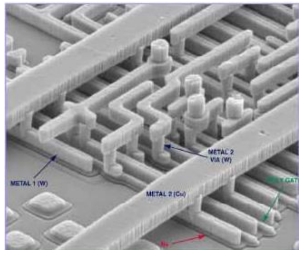
The following year, Robert Noyce, then at Fairchild Semiconductor, independently arrived at the idea of an integrated circuit and added a major *improvement*. His approach involved *overlaying* the slice of silicon with a thin coating of silicon *oxide*, the semiconductor's version of *rust*. From seminal work done a few years earlier by John Moll and Carl Frosch at Bell Labs, as well as by Fairchild colleague Jean Hoerni, Noyce knew the oxide would protect transistor junctions because of its excellent *insulating properties*.

改善 重ねる

酸化物 錆び

絶縁

特性



Delicate lines of metal could simply be printed on the coating; they would reach down to the underlying components via small holes etched in the oxide.

Jack Kilby

Any electronic circuit is an *assemblage* of several types of *components* that work together as a unit. Previously, the various circuit elements had always been made separately and then laboriously *connected* with *wires*. But in 1958, Jack Kilby, an electrical engineer at Texas Instruments who had been asked to design a transistorized adding machine, came up with a bold unifying *strategy.* By *selective* placement of impurities, he realized, a *crystalline* wafer of silicon could be *endowed* with all the elements necessary to function as a circuit. As he saw it, the elements would still have to be wired together, but they would take up much less space. In his *laboratory* notebook, he wrote: "Extreme miniaturization of many electrical circuits could be achieved by making resistors, capacitors and transistors & diodes on a single slice of silicon."

組み合わせ　部品

接続する　配線

戦略

選択的な　結晶の

賦与する

研究所

Gordon E. Moore *Chairman Emeritu* Intel Corporation 名誉会長 19E

The *discovery* of the electron in 1897 set the stage for electronics to develop over the *ensuing* century. Most of the first half of the 20th century was devoted to controlling electrons in a vacuum with *electric and magnetic fields* to make *amplifiers*, *oscillators*, and switches. These gave us, among other things, radio, television, radar, and the first computers.

発見 あとに続く
電磁界
増幅器
発振器

The last half of the century saw the rise of *solid-state* electronics, beginning with the invention of the transistor in 1947. I arrived on the scene in 1956 to join William Shockley, one of the inventors of the transistor, who was establishing the Shockley Semiconductor Laboratory to develop a commercial silicon transistor. By then the *advantages* of transistors over vacuum tubes were apparent for many *applications*; it was only necessary to make transistors *reliable* and cheap.

固体
利点
応用
信頼性

Gordon E. Moore

But Shockley changed his original goal, turning his focus to another semiconductor device he had invented while at Bell Labs—a four-layer diode possibly useful in telephone switches but not much else. A group of us (the Fairchild 8) went off to found a new company, Fairchild Semiconductor, to continue to pursue the silicon transistor.

Fortunately we at Fairchild were on the right track technologically when Jack Kilby of Texas Instruments demonstrated a complete circuit made of semiconductor materials. My colleague Bob Noyce saw how the Fairchild technology could be extended to make it practical to manufacture a complete circuit, rather than just individual transistors. Shortly after Bob's inventions he was promoted to general manager and I was left to oversee development of the technology extensions that ultimately led to the computer chips we are all familiar with today.

Gordon E. Moore

The new integrated devices did not find a ready market. Users were concerned because the individual transistors, resistors, and other electronic circuit components could not be tested individually to ensure their reliability. Also, early integrated circuits were expensive, and they *impinged on* the turf that traditionally belonged to the circuit designers at the customer's company. 衝突する

Again, Bob Noyce made a seminal contribution. He offered to sell the complete circuits for less than the customer could purchase individual components to build them. (It was also significantly less than it was costing us to build them!) This step opened the market and helped develop the manufacturing volumes necessary to reduce *manufacturing costs* to competitive levels. 製造原価

To this day the *cost reductions* resulting from *economies of scale* and newer high-density technology are passed on to the user—often before they are actually realized by the circuit manufacturer. 原価低減 規模の経済

As a result, we all know that the high-performance electronic gadget of today will be replaced with one of higher performance and lower cost tomorrow.

Moore‘s Law(ムーアの法則)

By 1965 integrated circuits—chips as they were called—*embraced* as many as 50 elements. That year a physical chemist named Gordon Moore, *cofounder* of the Intel Corporation with Robert Noyce, wrote in a magazine article: "The future of integrated electronics is the future of electronics itself." He *predicted* that the number of components on a chip would continue to double every year, an *estimate* that, in the *amended* form of a doubling every year and a half or so, would become known in the industry as Moore's Law. While the *forecast* was regarded as wild-eyed in some quarters, it proved remarkably *accurate*. The *densest* chips of 1970 held about 1,000 components. Chips of the mid-1980s contained as many as several hundred thousand. By the mid-1990s some chips the size of a baby's fingernail embraced 20 million components.

包含する
共同創立者
予想した
推定する　修正の
予想
正確な　高密度な

CPU (Central Processing Unit)

ALU=Arithmetic Logic Unit 算術演算論理回路

The computing part of the computer. Also called the “processor,” it is made up of the control unit and *ALU*. Today, the CPUs of almost all computers are contained on a single chip.

The CPU, clock and main memory make up a computer. A complete computer system requires the addition of control units, input, output and *storage* devices and an operating system.

記憶装置

CPUs Come in Different Sizes Depending on which end of the field you are in, a CPU can mean the processor, memory and everything inside the cabinet, or just the microprocessor itself.

Microprocessor

A central processing unit (CPU) contained within a single chip. Today, all computer CPUs are microprocessors. The term originated in the 1970s when CPUs up until that time were all comprised of several chips.

Thus, when the entire CPU (processor) was *miniaturized* onto a single chip, the *term* "micro" processor was *coined*. Since the turn of the century, the semiconductor manufacturing process has become so *sophisticated* that not only one, but two or more CPUs, are built on a single chip (see dual core and multicore).

Microprocessor is often *abbreviated* MPU for "microprocessor unit" or just MP, the latter also spelled with the Greek µ symbol for micro or the letter "u" as an alternate (µP or uP).

微細化する　用語
造語
洗練された
省略する

Microprocessors

The first microprocessor was produced by Intel in 1971. Dubbed the 4004, it cost about $1,000 and was as powerful as ENIAC, the vacuum tube monster of the 1940s.

Faster versions soon followed from Intel, and other companies came out with competing microprocessors, with prices dropping rapidly toward $100. The *flexibility* of the offerings had enormous appeal. If, for instance, the maker of a washing machine or camera wanted to put a chip in the product, it wasn't necessary to *commission* a special circuit design, await its development, and shoulder the expense of *custom* manufacturing.

柔軟性

委任する

特注品

An inexpensive, *off-the-shelf* microprocessor, guided in its work by appropriate software, would often suffice. These devices, popularly known as a computer on a chip, quickly spread far and wide.

日用品

Microprocessor

They Started as 8-Bit
The first microprocessors were created by Texas Instruments, Intel and a Scottish electronics company. Who was really first has been debated. First-generation 8-bit families were Intel's 8080, Zilog's Z80, Motorola's 6800.

Today's Microprocessors Are 32 and 64-Bit
The 32-bit and 64-bit microprocessors found in most of today's workstations and servers are the x86, PowerPC and SPARC lines. More than 200 million of these chips ship inside general-purpose computers each year.

Eight-Bit Lives On
For *embedded systems*, newer versions of 8- and 16-bit, first-generation microprocessor families are widely used and *exceed* the desktop computer and server market in volume. Each year, millions of microprocessors and billions of microcontrollers are built into toys, appliances and vehicles. A microcontroller contains a microprocessor, memory, clock and I/O control on a single chip .

組み込みシステム
超過する

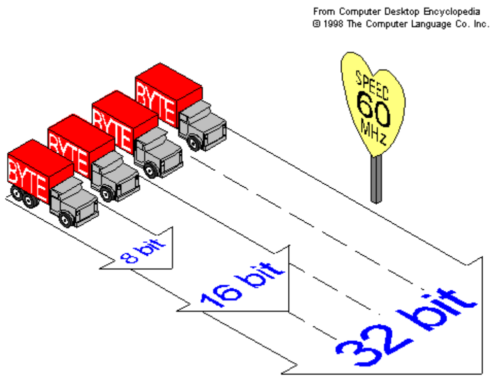
The Speed Limit

*Mega*hertz and *giga*hertz are *analogous* to a highway speed limit. The higher the speed, the faster the *traffic moves*. In a CPU, the higher the clock rate, the quicker data gets *processed*.

10^6 10^9 類似
交通
処理される

The 8-, 16- and 32 bit *designation* is the CPU's word size and can be thought of as the number of lanes on the highway. The more lanes, the more traffic. The combination of speed and number of paths determines the total processing speed or channel *bandwidth*.

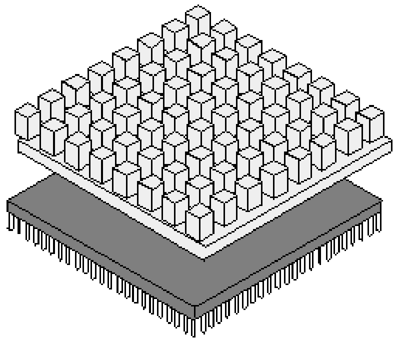
呼称
バンド幅



CPU cooler

A device that draws heat away from a CPU chip and other hot-running chips such as a graphics processor (GPU). The simplest type of cooler is a heat sink, which is a metal cover *glued* to the chip that provides a larger surface area for heat *dissipation*.

接着する
消費，消散



Even more effective is a CPU fan because it forces the hot air away from the chip. It is often used *in conjunction with* a heat sink. *Water-cooled* systems and heat pipe coolers provide more *esoteric solutions*. *Refrigeration* systems have also been built to cool down the CPU.

一緒に
水冷
秘伝，奥義　解決　冷却

Pentium D

One of Intel's first dual-core 64-bit Pentium CPUs. Introduced in 2005 along with the Pentium Processor Extreme Edition 840, they both share the EM64T 64-bit technology, but the Pentium D does not include Hyper-Threading. The Pentium D's two *execution* cores provide two completely parallel processing streams.

命令実行

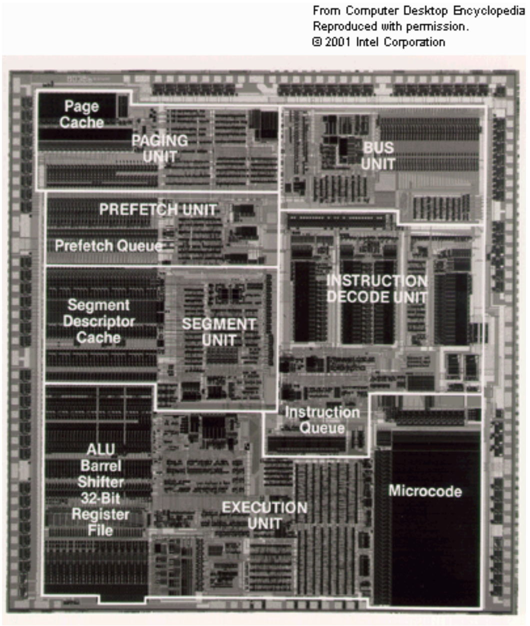
Microprocessors

The creation of today's chips is a *prodigious* challenge. The design stage alone, mapping out the pathways for a forest of *interconnected* switches, may take months or even years and can be accomplished only with the help of powerful computers. Manufacturing is done in multibillion dollar plants of unearthly *cleanliness*, because a single particle of dust, *boulderlike* in the microworld of transistors, would ruin the circuitry. The tiny electronic *creations* wrought by all this engineering effort are now everywhere, operating behind the scenes in every household device and every mode of *communication*, *transportation*, recreation, and commerce. Most extraordinary of all, the rate of advance shows no signs of *slackening*. Engineers and scientists are *exploring three-dimensional* architectures for circuits, seeking *organic molecules* that may be able to *spontaneously assemble* themselves into transistors and, on the misty edge of possibility, experimenting with mysterious *quantum effects* that might be *harnessed* for computation. Whether we are ready or not, computing power will continue its incredible expansion and change our future in ways yet unimagined.

巨大な
相互配線
清浄度　巨石
作られた
通信　輸送
緩める
探索する　3次元　有機分子
自発的に　組み立てる
量子効果　利用する

The 386 Microprocessor

No technology is more incredible than the microprocessor. Every second, trillions of switch openings and closings occur all within a thousandth of an inch below the surface. The older 386 chip is shown here because it contains a mere 275,000 transistors, and you can see some slight detail. Contemporary chips contain hundreds of millions of transistors, which at this magnification would show up only as a sea of gray. (Image courtesy of Intel Corporation.)



Gordon E. Moore

The integrated circuit completely changed the *economics* of electronics. Initially we looked forward to the time when an individual transistor might sell for a dollar. Today that dollar can buy tens of millions of transistors as part of a complex circuit. This *cost reduction* has made the technology *ubiquitous*—nearly any application that processes information today can be done most economically electronically.

No other technology that I can identify has undergone such a dramatic decrease in cost, let alone the improved performance that comes from making things smaller and smaller. The technology has advanced so fast that I am amazed we can design and manufacture the products in common use today.

It is a classic case of lifting ourselves up by our *bootstraps*—only with today's increasingly powerful computers can we design tomorrow's chips.

経済

原価低減

偏在する

加速装置

Microprocessors

Price dropped with size. In the early 1950s a transistor about as big as an *eraser* cost several dollars. By the mid-1970s, when transistors were approaching the size of a bacterium, they cost mere *hundredths of a cent* apiece. By the late 1990s the price of a single transistor was less than a *hundred-thousandth of* a cent - sometimes far less, mere billionths of a cent, depending on the type of chip.

消しゴム
1/100 セント
1/1000

Today's transistors come in a variety of designs and materials and are arrayed in circuits of many degrees of *complexity*. Some chips provide electronic memory, *storing* and *retrieving* binary data. Others are designed to execute particular tasks with maximum efficiency—*manipulating* audio signals or graphic images, for instance. Still others are *general-purpose* devices called microprocessors. Instead of being *tailored* for one job, they do whatever computational work is assigned to them by software instructions.

複雑性 蓄積 取り出し
操作する
汎用
誂える

Memo

フォローアップURL

http://mikami.a.la9.jp/meiji/MEIJI.HTM

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