Circuitos Integrados

Un circuito Integrado es una pieza sólida que contiene todo el circuito que se haya diseñado para cumplir una determinada función. Los componentes se hallan dispuestos de tal manera que no es posible realizar ningún cambio dentro del circuito una vez que éste ha sido armado. Dentro de la pieza sólida se encuentran todos los dispositivos que necesita el circuito diseñado (transistores, resistencias, condensadores, diodos, así como los conductores que los interconectan)

En la técnica de fabricación de circuitos integrados, la mas difundida es la tecnología de deposiciones planares sucesivas. En esta técnica se parte de una superficie plana, normalmente un sustrato semiconductor con ciertas impurezas (tipo n o tipo p), al cual se lo va tratando en una atmósfera controlada.

El tratamiento consiste en hacer una deposición de alguna sustancia metálica, semiconductora o aisladora en alguna región en particular de modo que en sucesivas deposiciones se construya ya sea hacia arriba o hacia los costados el dispositivo buscado,(por ejemplo si depositamos en la misma zona primero una capa de metal, luego un semiconductor tipo p y después otro tipo n y por último otra deposición metálica tendremos formado un diodo)

Si en un momento dado queremos depositar un material en una zona y al lado de la misma no queremos que aparezca éste material tendremos que apantallar la superficie expuesta. Esto se logra con las técnicas de fotolitografía ampliamente conocidas. Consisten en realizar un baño químico en el cual se deposita una resina fotosensible, luego utilizando una placa tipo negativo (transparente en regiones y opaca en oras) se hace incidir luz en la región que uno quiere fijar la resina. Luego se lava la resina no fijada y queda la máscara formada. En el paso siguiente se hace la deposición de la sustancia deseada y posteriormente se hace un lavado mas profundo para quitar la resina. En éste lavado la sustancia depositada sobre la resina es removida junto con ésta y sólo queda el material de interés en las regiones que hacía falta.

Así por deposiciones o erosiones planares iterativos se construye un edificio de varias plantas en el cual quedan en cada paso armados distintas componentes del circuito, ya sea conductores, transistores, resistensias, condensadores, etc.

Normalmente, para hacer un circuito integrado se parte de un monocristal de silicio y en una superficie normalmente comprendida entre 1 y 10 mm de lado, se van haciendo las deposiciones que contendrán los elementos activos y pasivos.

Los procesos empleados en la fabricación de tales circuitos son: preparación de la oblea, crecimiento epitaxial, difusión de impurezas, implantación de iones, crecimiento del óxido, fotolitografía, grabado químico y metalización.

Es también corriente el uso del proceso múltiple que ofrece una excelente identidad de resultados en la producción de un elevado número de circuitos integrados a bajo costo. Este proceso consiste en realizar sobre una oblea circular de 6 o 7 cm de diámetro, la deposición simultanea de decenas de CI

Descripción de los procesos de fabricación

Crecimiento de un lingote de silicio semiconductor en un horno tipo Czochralski: éste método nos permite obtener un lingote cilíndrico del monocristal

De éste lingote se obtendrán las obleas (discos de pocas décimas de milímetro de espesor), utilizando sierras especiales para el corte.

Luego se procede a preparar la oblea con sucesivos pulidos para dejar la superficie suficientemente plana, y luego diversos lavados ya sea con agua destilada y deionizada, detergentes y ácidos, para asegurar que la superficie de deposición se encuentre en las condiciones deseadas.

Deposición epitaxial con vapores controlados de $SiCl_4$ con agregados de vapores de PH_3 para dopado tipo *n* y B_2H_6 para sustencias tipo *p* : ésta técnica tiene por objeto agregar a la oblea, material semiconductor del mismo tipo que había anteriormente o de distinto tipo pero siguiendo el mismo ordenamiento cristalino que tiene el sustrato sobre el que se realiza la deposición.

Éste proceso se realiza en una atmósfera controlada, para lo que se debe construir hornos especiales que contienen tubos de cuarzo en los que se realiza vacío primero, luego se eleva la temperatura a la cual se desea realizar la operación y por último se inyectan o vaporizan las sustancias deseadas.

Oxidación: para lograr la capa de óxido necesaria en un transistor MOSFET se vaporiza SiO_2 y después se limpia las zonas en la que no debía aparecer el mismo usando HF (ácido fluorhidrico)

Enmascaramiento se tapa con resinas fotosensibles las zonas que se quiere evitar que se deposite algo (como se explicó anteriormente), luego se hace la deposición (por ejemplo epitaxial tipo *n* en los lugares de interés y luego se las limpia con otro tipo de solución para que quede la sustancia original visible.

Difusión: en un sustrato determinado se puede aumentar la densidad de impurezas de cualquier tipo regulando la atmósfera en forma adecuada dentro de un horno de difusión a temperaturas adecuadas. Para ello introducimos la oblea en el horno de cuarzo mencionado anteriormente. Hacemos vacío, elevamos la temperatura a la que se considera la adecuada para realizar la difusión y por último se vaporiza la impureza que se quiere difundir controlando en forma muy precisa el tiempo de la última operación pues de éste depende cuan profunda es la difusión de la impureza.

La implantación de iones es una técnica utilizada para introducir en lugares muy específicos una impureza determinada. Para ello se usa un cañón de impurezas que dispara un haz de las mismas en una dirección determinada.

Metalización: es un proceso en el cual se llena el horno con vapor de algún metal de interés habitualmente aluminio para depositar conductores dentro del chip. De ésta manera se realizan las conexiones entre dispositivos, se fabrican condensadores, se hacen los contactos de los dispositivos, etc.

Por último está el encapsulado del CI, que consiste en alojar el mismo en una sustancia que lo proteja mecánicamente del entorno (es común usar pastillas de sulfuro de plomo por su dureza) que además le provea los bornes para realiza las conexiones que necesita el circuito para formar parte de algún sistema más grande. Y que le permita disipar la potencia consumida

Incorporar las filminas del Scientific American

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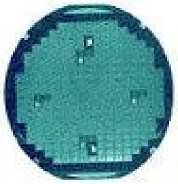
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The semiconductor industry has already advanced tremendously that there now exist so many distinct wafer fab processes, allowing the device designer to optimize his design by selecting the best fab process for his device. Nonetheless, all existing fab processes today simply consist of a series of steps to deposit special material layers on the wafers one at a time in precise amounts and patterns. Below is an example of what fabricating a simple CMOS integrated circuit on a wafer may entail.

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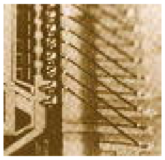

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Wafer Backgrind → Die Preparation → Die Attach → Wirebonding → Die Overcoat →
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Test Links:

Electrical Test → Burn-in → Marking → Tape and Reel → Dry Packing →
→ Boxing and Labeling

Silicon Valley Microelectronics, Inc. (SVM) is in its 14th year as a leading distributor of silicon wafers and provider of wafer services for the semiconductor industry. SVM supplies silicon wafers custom made to your requirement in a variety of diameters and grades.

SVM has a multi-million dollar inventory of prime, particle, lithography and test grade silicon wafers that can be shipped same-day or overnight to any location worldwide. In addition to same-day delivery, SVM provides a wafer stocking program with cost savings providing you with on time deliveries of high quality silicon wafers only as needed.

SVM divides its services into four main areas:

1. Silicon Wafers & Semiconductor Wafers
2. Thin Film Wafer Coating
3. Wafer Processing
4. Wafer Reclaim and Recycle

As a leader in each of these four areas, we offer the most cutting-edge technologies to fit your custom needs and provide expert customer service with competitive prices ensuring your satisfaction. In browsing through our site, you will find a wealth of information about silicon wafer manufacturing and processing and learn a great deal about SVM as a company.

We service accounts worldwide and are able to assist you in a variety of languages including French, Chinese, Cantonese, German, Spanish and English.

As your global semiconductor materials partner, it is our goal at SVM to offer consistent service, quality, delivery and pricing regardless of market conditions. With a pledge to achieve this goal through honesty, integrity, and sound business ethics, it is our ultimate aspiration to attain loyalty from our customers and suppliers, to develop and maintain mutually beneficial and lasting relationships, and to maximize the profitability of our customers, suppliers, employees and company. At SVM, we strive each and every day to be important and memorable to each and every customer. We succeed by providing high quality products and services, together with giving nothing less than extraordinary customer service.

More information on Silicon Wafers.

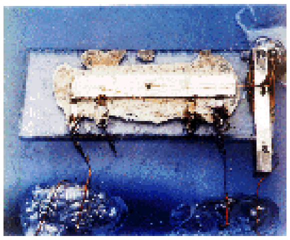
First Integrated Circuit (IC)

How Integrated Circuits Are Made Fact Sheet, August, 1993

Placing several million transistors on a piece of silicon the size of a fingertip is intricate and exacting. Precision associated with chip manufacturing is measured in microns and increasingly in fractions of microns. A micron is one-millionth of a meter, or about one one-hundredth of the diameter of a human hair. Maintaining this level of precision demands chip production environments that are 1,000 times cleaner than today's cleanest surgical operating rooms.

Texas Instruments, a leading semiconductor manufacturer, produces millions of integrated circuits (chips) every day in 17 worldwide chip fabrication centers.

The manufacture of chips involves various steps and recipes according to the type of chip being produced. However, there are common, basic steps involved after the wafer is sliced from an ingot of silicon and polished to a mirror-smooth finish. Each wafer, which is paper-thin and circular in dimension, undergoes eight main processing steps. Each step may be repeated many times.



* Deposition, or growing an insulating layer on the slice of silicon, is the first step. Its purpose is to install a layer on the wafer's silicon substrate that can be patterned using photolithography to form circuit elements.

* During diffusion, impurities are baked into the wafer in a diffusion furnace. Electrical characteristics are thereby altered to create separate regions with excess negative or positive charges.

* Metallization is a type of deposition process. Here, many interconnections are formed on each of hundreds of integrated circuits being formed on every wafer. Metallization is also used for bond pads that interconnect a chip to other components on a printed wiring board.

* During ion implantation, dopants or other impurities are introduced into a wafer's surface to create silicon crystals that conduct electricity.

* Photolithography/patterning refers to creating the actual circuitry. Masks expose a chemical coating called photoresist to ultraviolet light. In turn, the photoresist hardens in desired patterns when it is developed.

* During the etching process, wafers are moved to a plasma reactor where electrically excited gases etch the surface into the pattern defined by the photolithography process. After etching, wafers are cleaned thoroughly.

* Toward final wafer fabrication, each wafer is subjected to testing to determine defective components.

* Silicon nitride, a protective coating, is applied. Wafers are then ready for the final processing step, multiprobe testing. Each integrated circuit in the wafer is electrically tested to determine whether or not a chip is ready for final assembly, bonding and packaging.

World Impact of the Integrated Circuit

Fact Sheet, February, 1985

Most inventions, like the loom and the steam engine, are labor-saving devices. They free people from the limitations of their own strength. Other inventions, like the telescope, improve people's ability to comprehend their universe. They extend the senses. All great inventions revolutionize society, either by drastically altering human lifestyles or by changing the way people perceive themselves and their world.

By these standards, the integrated circuit is a great invention. It simply goes about its business in a different, less visible, way. The integrated circuit is at the heart of all electronic equipment today that has revolutionized the way we live: navigational systems, computers, pocket calculators, industrial monitoring and control systems, digital watches, digital sound systems, word processors, communications networks, and innumerable others. Few of these devices would exist, or could not work as reliably, without the integrated circuit.

The appearance of an integrated circuit, or IC, as it has come to be called, gives no hint of the considerable role it plays in modern technology. An IC chip is smaller and thinner than a baby's fingernail, yet, it is equivalent to thousands of electronic components all operating simultaneously. The properties that encourage the wide use of the IC are its small size, negligible weight, and reliable performance. Mass production and manufacturing experience have lowered the price of integrated circuits so that now they are used in all kinds of consumer products, from toys to home computers.

The IC was a logical, though dramatic, step in electronics development. In the century after the Industrial Revolution, people became increasingly aware of the need to store, organize, and synthesize massive amounts of information in a small space with low power requirements. Advancements in fields such as space exploration required ever-increasing computing power, precision, and speed. Many manufacturing processes became so complex and rapid that monitoring and control began to exceed human abilities.

The IC represents the first great invention that deals with the storing, processing and interpretation of information, rather than the manipulation of the physical environment. The success with which the IC performs these functions has given technology an entirely new dimension.

For example, the IC provides a practical means by which the electronic world of logic, reason, deduction, and system can be applied to the world we live in. Basically, an IC measures and controls the flow of electrical current or electronic signals. This enables ICs to control the performance of many different kinds of electronics equipment. A machine using ICs can marshal the work of other machines, the ultimate labor-saving device.

The IC allows people to live in environments where they otherwise could not survive. The miniaturization made possible by the IC allows people to navigate a spacecraft the half-million miles to the moon and back. People also can extend their senses into hostile environments through the use of computer-controlled remote devices.

The user can also learn from the computer. Computers are finding wide use in schools to teach reading, writing, spelling, geography, history, and foreign languages. In industry, computer simulators are used to provide specialized training in a number of areas, from shop training to computer design.

In the field of medicine, computers are used as diagnostic aids. Even a device like the glass thermometer has been replaced by a digital thermometer that is accurate to one-tenth of a degree, requires only one-tenth the time to take a patient's temperature, and eliminates the human error inherent in a technician's attempt to read a glass thermometer. Increasingly complex systems are being developed to aid all aspects of medical diagnosis and treatment. Microelectronics are making it possible for the mute to speak and the deaf to hear.

Spin-offs from the IC are also affecting our everyday lives. Computer chips have given the young, and not-so-young, video games and toys that seem uncanny to the previous generation. With present technology, appliances can be made to carry on simple conversations with consumers and carry out orders. A home owner can tell the television set to turn itself on, and it will ask, "Which channel?" Doors open on command, lights turn on when a person enters the room and off when he exits, and automobiles announce by voice that fuel is low.

It is clear that the IC constitutes an unprecedented revolution in today's society. But how has it changed people's concepts of themselves and their world? For the first time, we are evolving a technology that does not move earth, or speed through the sky, or put corks in bottles. Instead, we are developing a technology that supports and directs all other technologies, expanding exponentially people's capabilities. Through the integrated circuit, we will have powerful, versatile, reasoning devices to guide those technologies and our own lives more intelligently than ever before.

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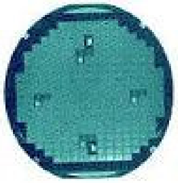

A silicon wafer

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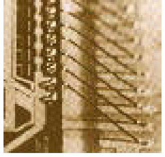

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Electrical Test → Burn-in → Marking → Tape and Reel → Dry Packing →
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Silicon Valley Microelectronics, Inc. (SVM) is in its 14th year as a leading distributor of silicon wafers and provider of wafer services for the semiconductor industry. SVM supplies silicon wafers custom made to your requirement in a variety of diameters and grades.

SVM has a multi-million dollar inventory of prime, particle, lithography and test grade silicon wafers that can be shipped same-day or overnight to any location worldwide. In addition to same-day delivery, SVM provides a wafer stocking program with cost savings providing you with on time deliveries of high quality silicon wafers only as needed.

SVM divides its services into four main areas:

1. Silicon Wafers & Semiconductor Wafers
2. Thin Film Wafer Coating
3. Wafer Processing
4. Wafer Reclaim and Recycle

As a leader in each of these four areas, we offer the most cutting-edge technologies to fit your custom needs and provide expert customer service with competitive prices ensuring your satisfaction. In browsing through our site, you will find a wealth of information about silicon wafer manufacturing and processing and learn a great deal about SVM as a company.

We service accounts worldwide and are able to assist you in a variety of languages including French, Chinese, Cantonese, German, Spanish and English.

As your global semiconductor materials partner, it is our goal at SVM to offer consistent service, quality, delivery and pricing regardless of market conditions. With a pledge to achieve this goal through honesty, integrity, and sound business ethics, it is our ultimate aspiration to attain loyalty from our customers and suppliers, to develop and maintain mutually beneficial and lasting relationships, and to maximize the profitability of our customers, suppliers, employees and company. At SVM, we strive each and every day to be important and memorable to each and every customer. We succeed by providing high quality products and services, together with giving nothing less than extraordinary customer service.

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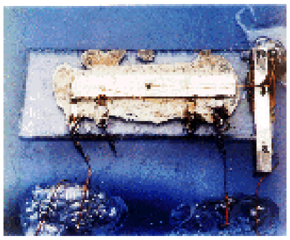

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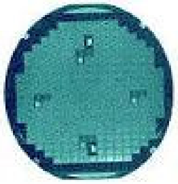
They're everywhere. From appliances to space ships, **semiconductors** have pervaded every fabric of our society. It has transformed the world so much that we've practically gone through hundreds of industrial revolutions during the last five decades. Indeed, we've gone a long way since 1948, when Bardeen and Brattain changed our lives forever with their transistor.

Nowadays, **semiconductor devices** allow machines to talk to us, and probably even understand us. They do our jobs, go where man has never gone before, and help us explore and utilize the universe around us. So overwhelming is the power of computing and signal processing today that it's difficult to believe that all of these came from sand.

Indeed, who would have guessed that mankind can reinvent the world simply by purifying sand, making it flat, and adding materials to it? This magical process of building integrated circuits from sand is now referred to as semiconductor manufacturing, and man has just about perfected it.


A silicon wafer

Semiconductor manufacturing consists of the following steps:

1) production of silicon wafers from very pure silicon ingots;
2) fabrication of integrated circuits onto these wafers;
3) assembly of every integrated circuit on the wafer into a finished product; and
4) testing and back-end processing of the finished products.

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Wafer Fabrication

Wafer fabrication generally refers to the process of building integrated circuits on silicon wafers. Prior to wafer fabrication, the raw silicon wafers to be used for this purpose are first produced from very pure silicon ingots, through either the Czochralski (CZ) or the Float Zone (FZ) method. The ingots are shaped then sliced into thin wafers through a process called wafering.

The semiconductor industry has already advanced tremendously that there now exist so many distinct wafer fab processes, allowing the device designer to optimize his design by selecting the best fab process for his device. Nonetheless, all existing fab processes today simply consist of a series of steps to deposit special material layers on the wafers one at a time in precise amounts and patterns. Below is an example of what fabricating a simple CMOS integrated circuit on a wafer may entail.

The first step might be to grow a p-type epitaxial layer on the silicon substrate through chemical vapor deposition. A nitride layer may then be deposited over the epi-layer, then masked and etched according to specific patterns, leaving behind exposed areas on the epi-layer, i.e., areas no longer covered by the nitride layer. These exposed areas may then be masked again in specific patterns before being subjected to diffusion or ion implantation to receive dopants such as phosphorus, forming n-wells.

Silicon dioxide may then be grown thermally to form field oxides that isolate the n-wells from other parts of the circuit. This may be followed by another masking/oxidation cycle to grow gate oxide layers over the n-wells intended for p-channel MOS transistors later on. This gate oxide layer will serve as isolation between the channel and the gate of each of these transistors. Another mask and diffusion/implant cycle may then follow to adjust threshold voltages on other parts of the epi, intended for n-channel transistors later on.

Deposition of a polysilicon layer over the wafer may then be done, to be followed by a masking/etching cycle to remove unwanted polysilicon areas, defining the polysilicon gates over the gate oxide of the p-channel transistors. At the same time, openings for the source and drain drive-ins are made on the n-wells by etching away oxide at the right locations.

Another round of mask/implant cycle may then follow, this time driving in boron dopants into new openings of the n-wells, forming the p-type sources and drains. This may then be followed by a mask/implant cycle to form the n-type sources and drains of the n-channel transistors in the p-type epi.

The wafer may then be covered with phospho-silica glass, which is then subjected to reactive ion etching in specific patterns to expose the contact areas for metallization. Aluminum is then sputtered on the wafer, after which it is subjected to reactive ion etching, also in specific patterns, forming connections between the various components of the circuit.

The wafer may then be covered with glassivation as its top protective layer, after which a mask/etch process removes the glass over the bond pads.

Such is the process of wafer fabrication, consisting of a long series of mask/etch and mask/deposition steps until the circuit is completed.

Wafer Fab Links:

Incoming Wafers → Epitaxy → Diffusion → Ion Implant → Polysilicon → Dielectric →
→ Lithography/Etch → Thin Films → Metallization → Glassivation → Probe/Trim

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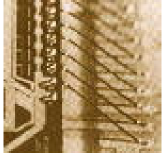
Assembly



The process of putting the integrated circuit inside a package to make it reliable and convenient to use is known as semiconductor package assembly, or simply 'assembly'. Over the years, the direction of assembly technology is to develop smaller, cheaper, more reliable, and more environment-friendly packages. Just like wafer fabrication technology, assembly technology has advanced tremendously that there are now a multitude of packages to choose from.

Despite glaring differences between the various packages available in the industry today, all packages share some things in common. To name a few, all of them: 1) provide the integrated circuit with a structure to operate in; 2) protect the integrated circuit from the environment; 3) connect the integrated circuit to the outside world; and 4) help optimize the operation of the device.

In general, an assembly process would consist of the following steps: 1) die preparation, which cuts the wafer into individual integrated circuits or dice; 2) die attach, which attaches the die to the support structure (e.g., the leadframe) of the package; 3) bonding, which connects the circuit to the electrical extremities of the package, thereby allowing the circuit to be connected to the outside world; and 4) encapsulation (usually by plastic molding), which provides 'body' to the package of the circuit for physical and chemical protection.

Subsequent steps that give the package its final form and appearance (e.g., DTFS) vary from package to package. Steps like marking and lead finish give the product its own identity, improve reliability, and add an extra shine at that.

Assembly Links:

Wafer Backgrind → Die Preparation → Die Attach → Wirebonding → Die Overcoat →
→ Molding → Sealing → Marking → DTFS → Leadfinish

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Test

Once assembled, the integrated circuit is ready to use. However, owing to the imperfection of this world, assembled devices don't always work. Many things can go wrong to make a device fail, e.g., the die has wafer fab-related defects, or the die cracked during assembly, or the bonds were poorly connected or not connected at all. Thus, prior to shipment to the customer, assembled devices must first be electrically tested.

Electrical testing of devices in big volumes must be done fast and inexpensively. Mass-production electrical testing therefore requires an automated system for doing the test. Equipment used to test devices are called, well, testers, and equipment used to handle the devices while undergoing testing are called, well, handlers. Tester/handler systems are also known as automatic test equipment (ATE).

Different products require different levels of sophistication in ATE requirements. Electrical testing of voltage reference circuits certainly don't require high-end ATE such as those used to test state-of-the-art microprocessors or digital signal processors. One area of electrical testing that continuously challenge engineers is building an ATE that can test the speed of new IC's that are much faster than what they can use in building their ATE's.

Software written for testing a device with an ATE is known as a test program. Test programs consist of a series of subroutines known as test blocks. Generally, each test block has a corresponding device parameter to test under specific conditions. This is accomplished by subjecting the device under test (DUT) to specific excitation and measuring the response of the device. The measurement is then compared to the pass/fail limits set in the test program. After the device is tested, the handler bins it out either as a reject or as a good unit.

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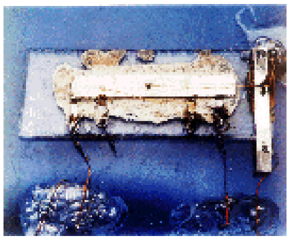

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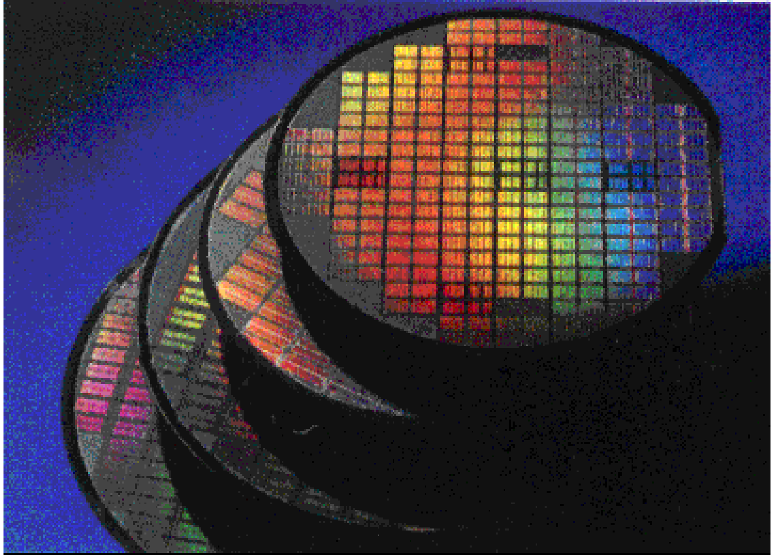

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Circuitos Integrados

Un circuito Integrado es una pieza sólida que contiene todo el circuito que se haya diseñado para cumplir una determinada función. Los componentes se hallan dispuestos de tal manera que no es posible realizar ningún cambio dentro del circuito una vez que éste ha sido armado. Dentro de la pieza sólida se encuentran todos los dispositivos que necesita el circuito diseñado (transistores, resistencias, condensadores, diodos, así como los conductores que los interconectan)

En la técnica de fabricación de circuitos integrados, la mas difundida es la tecnología de deposiciones planares sucesivas. En esta técnica se parte de una superficie plana, normalmente un sustrato semiconductor con ciertas impurezas (tipo n o tipo p), al cual se lo va tratando en una atmósfera controlada.

El tratamiento consiste en hacer una deposición de alguna sustancia metálica, semiconductora o aisladora en alguna región en particular de modo que en sucesivas deposiciones se construya ya sea hacia arriba o hacia los costados el dispositivo buscado,(por ejemplo si depositamos en la misma zona primero una capa de metal, luego un semiconductor tipo p y después otro tipo n y por último otra deposición metálica tendremos formado un diodo)

Si en un momento dado queremos depositar un material en una zona y al lado de la misma no queremos que aparezca éste material tendremos que apantallar la superficie expuesta. Esto se logra con las técnicas de fotolitografía ampliamente conocidas. Consisten en realizar un baño químico en el cual se deposita una resina fotosensible, luego utilizando una placa tipo negativo (transparente en regiones y opaca en oras) se hace incidir luz en la región que uno quiere fijar la resina. Luego se lava la resina no fijada y queda la máscara formada. En el paso siguiente se hace la deposición de la sustancia deseada y posteriormente se hace un lavado mas profundo para quitar la resina. En éste lavado la sustancia depositada sobre la resina es removida junto con ésta y sólo queda el material de interés en las regiones que hacía falta.

Así por deposiciones o erosiones planares iterativos se construye un edificio de varias plantas en el cual quedan en cada paso armados distintas componentes del circuito, ya sea conductores, transistores, resistensias, condensadores, etc.

Normalmente, para hacer un circuito integrado se parte de un monocristal de silicio y en una superficie normalmente comprendida entre 1 y 10 mm de lado, se van haciendo las deposiciones que contendrán los elementos activos y pasivos.

Los procesos empleados en la fabricación de tales circuitos son: preparación de la oblea, crecimiento epitaxial, difusión de impurezas, implantación de iones, crecimiento del óxido, fotolitografía, grabado químico y metalización.

Es también corriente el uso del proceso múltiple que ofrece una excelente identidad de resultados en la producción de un elevado número de circuitos integrados a bajo costo. Este proceso consiste en realizar sobre una oblea circular de 6 o 7 cm de diámetro, la deposición simultanea de decenas de CI

Descripción de los procesos de fabricación

Crecimiento de un lingote de silicio semiconductor en un horno tipo Czochralski: éste método nos permite obtener un lingote cilíndrico del monocristal

De éste lingote se obtendrán las obleas (discos de pocas décimas de milímetro de espesor), utilizando sierras especiales para el corte.

Luego se procede a preparar la oblea con sucesivos pulidos para dejar la superficie suficientemente plana, y luego diversos lavados ya sea con agua destilada y deionizada, detergentes y ácidos, para asegurar que la superficie de deposición se encuentre en las condiciones deseadas.

Deposición epitaxial con vapores controlados de $SiCl_4$ con agregados de vapores de PH_3 para dopado tipo *n* y B_2H_6 para sustencias tipo *p* : ésta técnica tiene por objeto agregar a la oblea, material semiconductor del mismo tipo que había anteriormente o de distinto tipo pero siguiendo el mismo ordenamiento cristalino que tiene el sustrato sobre el que se realiza la deposición.

Éste proceso se realiza en una atmósfera controlada, para lo que se debe construir hornos especiales que contienen tubos de cuarzo en los que se realiza vacío primero, luego se eleva la temperatura a la cual se desea realizar la operación y por último se inyectan o vaporizan las sustancias deseadas.

Oxidación: para lograr la capa de óxido necesaria en un transistor MOSFET se vaporiza SiO_2 y después se limpia las zonas en la que no debía aparecer el mismo usando HF (ácido fluorhidrico)

Enmascaramiento se tapa con resinas fotosensibles las zonas que se quiere evitar que se deposite algo (como se explicó anteriormente), luego se hace la deposición (por ejemplo epitaxial tipo *n* en los lugares de interés y luego se las limpia con otro tipo de solución para que quede la sustancia original visible.

Difusión: en un sustrato determinado se puede aumentar la densidad de impurezas de cualquier tipo regulando la atmósfera en forma adecuada dentro de un horno de difusión a temperaturas adecuadas. Para ello introducimos la oblea en el horno de cuarzo mencionado anteriormente. Hacemos vacío, elevamos la temperatura a la que se considera la adecuada para realizar la difusión y por último se vaporiza la impureza que se quiere difundir controlando en forma muy precisa el tiempo de la última operación pues de éste depende cuan profunda es la difusión de la impureza.

La implantación de iones es una técnica utilizada para introducir en lugares muy específicos una impureza determinada. Para ello se usa un cañón de impurezas que dispara un haz de las mismas en una dirección determinada.

Metalización: es un proceso en el cual se llena el horno con vapor de algún metal de interés habitualmente aluminio para depositar conductores dentro del chip. De ésta manera se realizan las conexiones entre dispositivos, se fabrican condensadores, se hacen los contactos de los dispositivos, etc.

Por último está el encapsulado del CI, que consiste en alojar el mismo en una sustancia que lo proteja mecánicamente del entorno (es común usar pastillas de sulfuro de plomo por su dureza) que además le provea los bornes para realiza las conexiones que necesita el circuito para formar parte de algún sistema más grande. Y que le permita disipar la potencia consumida

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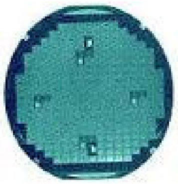
Nowadays, **semiconductor devices** allow machines to talk to us, and probably even understand us. They do our jobs, go where man has never gone before, and help us explore and utilize the universe around us. So overwhelming is the power of computing and signal processing today that it's difficult to believe that all of these came from sand.

Indeed, who would have guessed that mankind can reinvent the world simply by purifying sand, making it flat, and adding materials to it? This magical process of building integrated circuits from sand is now referred to as semiconductor manufacturing, and man



A silicon wafer

has just about perfected it.

Semiconductor manufacturing consists of the following steps:

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Wafer fabrication generally refers to the process of building integrated circuits on silicon wafers. Prior to wafer fabrication, the raw silicon wafers to be used for this purpose are first produced from very pure silicon ingots, through either the Czochralski (CZ) or the Float Zone (FZ) method. The ingots are shaped then sliced into thin wafers through a process called wafering.

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Silicon dioxide may then be grown thermally to form field oxides that isolate the n-wells from other parts of the circuit. This may be followed by another masking/oxidation cycle to grow gate oxide layers over the n-wells intended for p-channel MOS transistors later on. This gate oxide layer will serve as isolation between the channel and the gate of each of these transistors. Another mask and diffusion/implant cycle may then follow to adjust threshold voltages on other parts of the epi, intended for n-channel transistors later on.

Deposition of a polysilicon layer over the wafer may then be done, to be followed by a masking/etching cycle to remove unwanted polysilicon areas, defining the polysilicon gates over the gate oxide of the p-channel transistors. At the same time, openings for the source and drain drive-ins are made on the n-wells by etching away oxide at the right locations.

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Incoming Wafers → Epitaxy → Diffusion → Ion Implant → Polysilicon → Dielectric →
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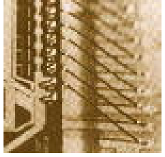

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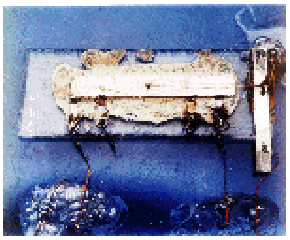

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It is clear that the IC constitutes an unprecedented revolution in today's society. But how has it changed people's concepts of themselves and their world? For the first time, we are evolving a technology that does not move earth, or speed through the sky, or put corks in bottles. Instead, we are developing a technology that supports and directs all other technologies, expanding exponentially people's capabilities. Through the integrated circuit, we will have powerful, versatile, reasoning devices to guide those technologies and our own lives more intelligently than ever before.

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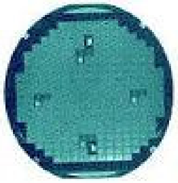

A silicon wafer

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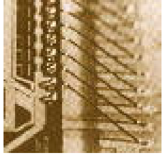

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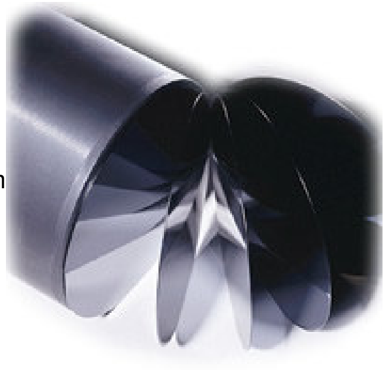

quality silicon wafers only as needed.

SVM divides its services into four main areas:

1. Silicon Wafers & Semiconductor Wafers
2. Thin Film Wafer Coating
3. Wafer Processing
4. Wafer Reclaim and Recycle

As a leader in each of these four areas, we offer the most cutting-edge technologies to fit your custom needs and provide expert customer service with competitive prices ensuring your satisfaction. In browsing through our site, you will find a wealth of information about silicon wafer manufacturing and processing and learn a great deal about SVM as a company.

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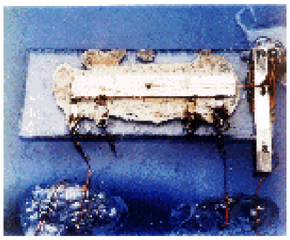

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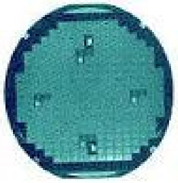
It is clear that the IC constitutes an unprecedented revolution in today's society. But how has it changed people's concepts of themselves and their world? For the first time, we are evolving a technology that does not move earth, or speed through the sky, or put corks in bottles. Instead, we are developing a technology that supports and directs all other technologies, expanding exponentially people's capabilities. Through the integrated circuit, we will have powerful, versatile, reasoning devices to guide those technologies and our own lives more intelligently than ever before.

They're everywhere. From appliances to space ships, **semiconductors** have pervaded every fabric of our society. It has transformed the world so much that we've practically gone through hundreds of industrial revolutions during the last five decades. Indeed, we've gone a long way since 1948, when Bardeen and Brattain changed our lives forever with their transistor.

Nowadays, **semiconductor devices** allow machines to talk to us, and probably even understand us. They do our jobs, go where man has never gone before, and help us explore and utilize the universe around us. So overwhelming is the power of computing and signal processing today that it's difficult to believe that all of these came from sand.

Indeed, who would have guessed that mankind can reinvent the world simply by purifying sand, making it flat, and adding materials to it? This magical process of building integrated circuits from sand is now referred to as semiconductor manufacturing, and man has just about perfected it.


A silicon wafer

Semiconductor manufacturing consists of the following steps:

1) production of silicon wafers from very pure silicon ingots;
2) fabrication of integrated circuits onto these wafers;
3) assembly of every integrated circuit on the wafer into a finished product; and
4) testing and back-end processing of the finished products.

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Wafer Fabrication

Wafer fabrication generally refers to the process of building integrated circuits on silicon wafers. Prior to wafer fabrication, the raw silicon wafers to be used for this purpose are first produced from very pure silicon ingots, through either the Czochralski (CZ) or the Float Zone (FZ) method. The ingots are shaped then sliced into thin wafers through a process called wafering.

The semiconductor industry has already advanced tremendously that there now exist so many distinct wafer fab processes, allowing the device designer to optimize his design by selecting the best fab process for his device. Nonetheless, all existing fab processes today simply consist of a series of steps to deposit special material layers on the wafers one at a time in precise amounts and patterns. Below is an example of what fabricating a simple CMOS integrated circuit on a wafer may entail.

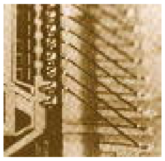
The first step might be to grow a p-type epitaxial layer on the silicon substrate through chemical vapor deposition. A nitride layer may then be deposited over the epi-layer, then masked and etched according to specific patterns, leaving behind exposed areas on the epi-layer, i.e., areas no longer covered by the nitride layer. These exposed areas may then be masked again in specific patterns before being subjected to diffusion or ion implantation to receive dopants such as phosphorus, forming n-wells.

Silicon dioxide may then be grown thermally to form field oxides that isolate the n-wells from other parts of the circuit. This may be followed by another masking/oxidation cycle to grow gate oxide layers over the n-wells intended for p-channel MOS transistors later on. This gate oxide layer will serve as isolation between the channel and the gate of each of these transistors. Another mask and diffusion/implant cycle may then follow to adjust threshold voltages on other parts of the epi, intended for n-channel transistors later on.

Deposition of a polysilicon layer over the wafer may then be done, to be followed by a masking/etching cycle to remove unwanted polysilicon areas, defining the polysilicon gates over the gate oxide of the p-channel transistors. At the same time, openings for the source and drain drive-ins are made on the n-wells by etching away oxide at the right locations.

Another round of mask/implant cycle may then follow, this time driving in boron dopants into new openings of the n-wells, forming the p-type sources and drains. This may then be followed by a mask/implant cycle to form the n-type sources and drains of the n-channel transistors in the p-type epi.

The wafer may then be covered with phospho-silica glass, which is then subjected to reactive ion etching in specific patterns to expose the contact areas for metallization. Aluminum is then sputtered on the wafer, after which it is subjected to reactive ion etching, also in specific patterns, forming connections between the various components of the circuit.



The wafer may then be covered with glassivation as its top protective layer, after which a mask/etch process removes the glass over the bond pads.

Such is the process of wafer fabrication, consisting of a long series of mask/etch and mask/deposition steps until the circuit is completed.

Wafer Fab Links:

Incoming Wafers → Epitaxy → Diffusion → Ion Implant → Polysilicon → Dielectric →
→ Lithography/Etch → Thin Films → Metallization → Glassivation → Probe/Trim

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Assembly

The process of putting the integrated circuit inside a package to make it reliable and convenient to use is known as semiconductor package assembly, or simply 'assembly'. Over the years, the direction of assembly technology is to develop smaller, cheaper, more reliable, and more environment-friendly packages. Just like wafer fabrication technology, assembly technology has advanced tremendously that there are now a multitude of packages to choose from.

Despite glaring differences between the various packages available in the industry today, all packages share some things in common. To name a few, all of them: 1) provide the integrated circuit with a structure to operate in; 2) protect the integrated circuit from the environment; 3) connect the integrated circuit to the outside world; and 4) help optimize the operation of the device.

In general, an assembly process would consist of the following steps: 1) die preparation, which cuts the wafer into individual integrated circuits or dice; 2) die attach, which attaches the die to the support structure (e.g., the leadframe) of the package; 3) bonding, which connects the circuit to the electrical extremities of the package, thereby allowing the circuit to be connected to the outside world; and 4) encapsulation (usually by plastic molding), which provides 'body' to the package of the circuit for physical and chemical protection.

Subsequent steps that give the package its final form and appearance (e.g., DTFS) vary from package to package. Steps like marking and lead finish give the product its own identity, improve reliability, and add an extra shine at that.

Assembly Links:

Wafer Backgrind → Die Preparation → Die Attach → Wirebonding → Die Overcoat →
→ Molding → Sealing → Marking → DTFS → Leadfinish

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Test

Once assembled, the integrated circuit is ready to use. However, owing to the imperfection of this world, assembled devices don't always work. Many things can go wrong to make a device fail, e.g., the die has wafer fab-related defects, or the die cracked during assembly, or the bonds were poorly connected or not connected at all. Thus, prior to shipment to the customer, assembled devices must first be electrically tested.

Electrical testing of devices in big volumes must be done fast and inexpensively. Mass-production electrical testing therefore requires an automated system for doing the test. Equipment used to test devices are called, well, testers, and equipment used to handle the devices while undergoing testing are called, well, handlers. Tester/handler systems are also known as automatic test equipment (ATE).

Different products require different levels of sophistication in ATE requirements. Electrical testing of voltage reference circuits certainly don't require high-end ATE such as those used to test state-of-the-art microprocessors or digital signal processors. One area of electrical testing that continuously challenge engineers is building an ATE that can test the speed of new IC's that are much faster than what they can use in building their ATE's.

Software written for testing a device with an ATE is known as a test program. Test programs consist of a series of subroutines known as test blocks. Generally, each test block has a corresponding device parameter to test under specific conditions. This is accomplished by subjecting the device under test (DUT) to specific excitation and measuring the response of the device. The measurement is then compared to the pass/fail limits set in the test program. After the device is tested, the handler bins it out either as a reject or as a good unit.

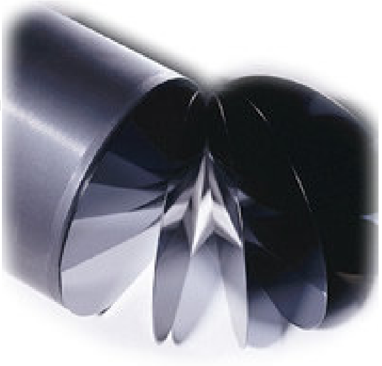
After a lot is tested, it is subjected to other back-end processes prior to shipment to the customer. Tape and reel is the process of packing surface mount devices in tapes with pockets while this tape is being wound around a reel. Boxing and labeling is the process of putting the reels or tubes in shipment boxes, and labeling these shipment boxes in accordance with customer requirements.

Test Links:

Electrical Test → Burn-in → Marking → Tape and Reel → Dry Packing →
→ Boxing and Labeling

Silicon Valley Microelectronics, Inc. (SVM) is in its 14th year as a leading distributor of silicon wafers and provider of wafer services for the semiconductor industry. SVM supplies silicon wafers custom made to your requirement in a variety of diameters and grades.

SVM has a multi-million dollar inventory of prime, particle, lithography and test grade silicon wafers that can be shipped same-day or overnight to any location worldwide. In addition to same-day delivery, SVM provides a wafer stocking program with cost savings providing you with on time deliveries of high quality silicon wafers only as needed.



SVM divides its services into four main areas:

1. Silicon Wafers & Semiconductor Wafers
2. Thin Film Wafer Coating
3. Wafer Processing
4. Wafer Reclaim and Recycle

As a leader in each of these four areas, we offer the most cutting-edge technologies to fit your custom needs and provide expert customer service with competitive prices ensuring your satisfaction. In browsing through our site, you will find a wealth of information about silicon wafer manufacturing and processing and learn a great deal about SVM as a company.

We service accounts worldwide and are able to assist you in a variety of languages including French, Chinese, Cantonese, German, Spanish and English.

As your global semiconductor materials partner, it is our goal at SVM to offer consistent service, quality, delivery and pricing regardless of market conditions. With a pledge to achieve this goal through honesty, integrity, and sound business ethics, it is our ultimate aspiration to attain loyalty from our customers and suppliers, to develop and maintain mutually beneficial and lasting relationships, and to maximize the profitability of our customers, suppliers, employees and company. At SVM, we strive each and every day to be important and memorable to each and every customer. We succeed by providing high quality products and services, together with giving nothing less than extraordinary customer service.

More information on Silicon Wafers.

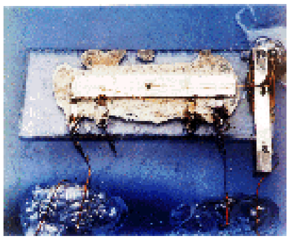
First Integrated Circuit (IC)

How Integrated Circuits Are Made Fact Sheet, August, 1993

Placing several million transistors on a piece of silicon the size of a fingertip is intricate and exacting. Precision associated with chip manufacturing is measured in microns and increasingly in fractions of microns. A micron is one-millionth of a meter, or about one one-hundredth of the diameter of a human hair. Maintaining this level of precision demands chip production environments that are 1,000 times cleaner than today's cleanest surgical operating rooms.

Texas Instruments, a leading semiconductor manufacturer, produces millions of integrated circuits (chips) every day in 17 worldwide chip fabrication centers.

The manufacture of chips involves various steps and recipes according to the type of chip being produced. However, there are common, basic steps involved after the wafer is sliced from an ingot of silicon and polished to a mirror-smooth finish. Each wafer, which is paper-thin and circular in dimension, undergoes eight main processing steps. Each step may be repeated many times.



* Deposition, or growing an insulating layer on the slice of silicon, is the first step. Its purpose is to install a layer on the wafer's silicon substrate that can be patterned using photolithography to form circuit elements.

* During diffusion, impurities are baked into the wafer in a diffusion furnace. Electrical characteristics are thereby altered to create separate regions with excess negative or positive charges.

* Metallization is a type of deposition process. Here, many interconnections are formed on each of hundreds of integrated circuits being formed on every wafer. Metallization is also used for bond pads that interconnect a chip to other components on a printed wiring board.

* During ion implantation, dopants or other impurities are introduced into a wafer's surface to create silicon crystals that conduct electricity.

* Photolithography/patterning refers to creating the actual circuitry. Masks expose a chemical coating called photoresist to ultraviolet light. In turn, the photoresist hardens in desired patterns when it is developed.

* During the etching process, wafers are moved to a plasma reactor where electrically excited gases etch the surface into the pattern defined by the photolithography process. After etching, wafers are cleaned thoroughly.

* Toward final wafer fabrication, each wafer is subjected to testing to determine defective components.

* Silicon nitride, a protective coating, is applied. Wafers are then ready for the final processing step, multiprobe testing. Each integrated circuit in the wafer is electrically tested to determine whether or not a chip is ready for final assembly, bonding and packaging.

World Impact of the Integrated Circuit

Fact Sheet, February, 1985

Most inventions, like the loom and the steam engine, are labor-saving devices. They free people from the limitations of their own strength. Other inventions, like the telescope, improve people's ability to comprehend their universe. They extend the senses. All great inventions revolutionize society, either by drastically altering human lifestyles or by changing the way people perceive themselves and their world.

By these standards, the integrated circuit is a great invention. It simply goes about its business in a different, less visible, way. The integrated circuit is at the heart of all electronic equipment today that has revolutionized the way we live: navigational systems, computers, pocket calculators, industrial monitoring and control systems, digital watches, digital sound systems, word processors, communications networks, and innumerable others. Few of these devices would exist, or could not work as reliably, without the integrated circuit.

The appearance of an integrated circuit, or IC, as it has come to be called, gives no hint of the considerable role it plays in modern technology. An IC chip is smaller and thinner than a baby's fingernail, yet, it is equivalent to thousands of electronic components all operating simultaneously. The properties that encourage the wide use of the IC are its small size, negligible weight, and reliable performance. Mass production and manufacturing experience have lowered the price of integrated circuits so that now they are used in all kinds of consumer products, from toys to home computers.

The IC was a logical, though dramatic, step in electronics development. In the century after the Industrial Revolution, people became increasingly aware of the need to store, organize, and synthesize massive amounts of information in a small space with low power requirements. Advancements in fields such as space exploration required ever-increasing computing power, precision, and speed. Many manufacturing processes became so complex and rapid that monitoring and control began to exceed human abilities.

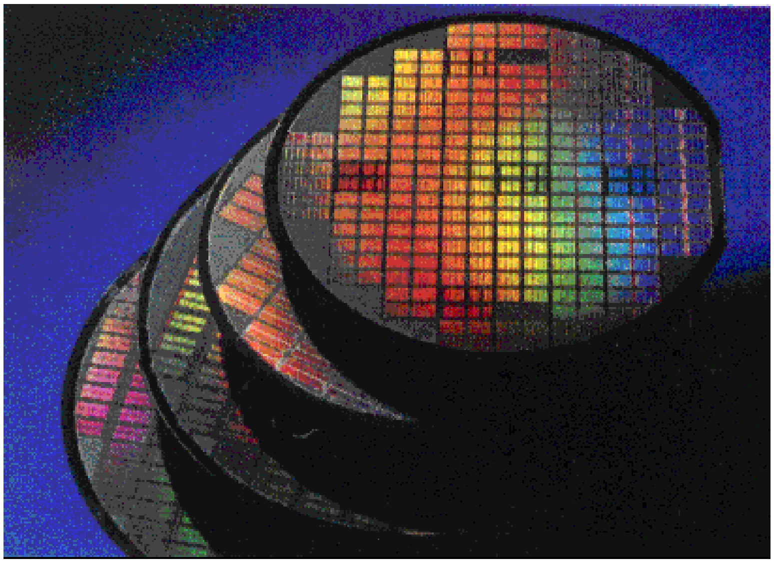
The IC represents the first great invention that deals with the storing, processing and interpretation of information, rather than the manipulation of the physical environment. The success with which the IC performs these functions has given technology an entirely new dimension.

For example, the IC provides a practical means by which the electronic world of logic, reason, deduction, and system can be applied to the world we live in. Basically, an IC measures and controls the flow of electrical current or electronic signals. This enables ICs to control the performance of many different kinds of electronics equipment. A machine using ICs can marshal the work of other machines, the ultimate labor-saving device.

The IC allows people to live in environments where they otherwise could not survive. The miniaturization made possible by the IC allows people to navigate a spacecraft the half-million miles to the moon and back. People also can extend their senses into hostile environments through the use of computer-controlled remote devices.

The user can also learn from the computer. Computers are finding wide use in schools to teach reading, writing, spelling, geography, history, and foreign languages. In industry, computer simulators are used to provide specialized training in a number of areas, from shop training to computer design.

In the field of medicine, computers are used as diagnostic aids. Even a device like the glass thermometer has been replaced by a digital thermometer that is accurate to one-tenth of a degree, requires only one-tenth the time to take a patient's temperature, and eliminates the human error inherent in a technician's attempt to read a glass thermometer. Increasingly complex systems are being developed to aid all aspects of medical diagnosis and treatment. Microelectronics are making it possible for the mute to speak and the deaf to hear.



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