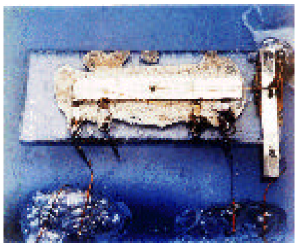

How Integrated Circuits Are Made

World Impact of Integrated Circuit

Jack Kilby, Inventor of the Integrated Circuit

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.