

Chips of Sand

Be a Power Reader

Reading Technical Articles This article may contain some fairly difficult material. Because of this, you may find it hard to follow at times. Slow down and reread those parts you find difficult. As you read, make notes on any information you want to explore further.

Introduction

What does the word “chip” mean to you? A small piece of wood? A crack in a water glass? When computer people talk about **chips**, they are talking about **integrated circuits**, or **ICs**. Have you ever wondered how it is possible to make such tiny chips that can do so much work? It might surprise you to learn that it all starts with sand.

The next time you take a walk on the beach, look down at the sand under your feet. You could be walking over millions of future computer chips. Sand contains silicon, which is the second most common element found on Earth (oxygen is the most common). As you know, silicon is used to make glass. It also is used to make computer chips. Silicon is so important in the computer world that the area of California where the computer industry flourishes is called Silicon Valley.

Making the Chip

There are more than a hundred steps in making the average chip. To make these electronic miracles, engineers begin by designing the chip’s circuits on large wall-size diagrams. The circuits are the individual electrical paths within the chip. Once the chip is designed, the diagrams are reduced until they are about one square centimeter in size. Next these diagrams are copied onto glass squares. These glass

squares are called **photomasks**. These photomasks are then put aside to be used later in the chip-making process.

Silicon is made from raw sand. First, silicon is used to make cylindrical rods. These rods are more than 99.99 percent pure silicon. Each rod is sliced into circular pieces about as thick as a credit card. Each slice is about 6 to 8 inches in diameter. These slices are referred to as silicon wafers.

The wafers are heated so that they form a thin layer of silicon dioxide. Silicon dioxide is an important compound because electricity cannot flow through it. Without this property of silicon dioxide, integrated circuits would not be able to function.

Once the wafers are cooled, they are coated with a light-sensitive chemical called **photoresist**. The photomask that previously was designed by the engineers is placed over the wafer. Ultraviolet light shines through the photomask, and changes the photoresist. This process etches the circuit pattern onto the wafer. Each circuit is about 250 times smaller than a human hair.

Another layer of silicon dioxide is then added. Circuits are etched onto this new layer. This process is repeated many times to create a chip.

When all of the circuits have been created, tiny metal pathways are laid over the wafers. These pathways form electrical connections between the different electronic components.

A diamond saw or laser beam is then used to separate the wafer into chips. The chips are carefully tested to make certain that they work properly. Many are discarded because they can't pass the tests. Each chip is attached to a metal frame. The frame is surrounded by metal pins that are used to plug the chip into computers and other electronic devices.

These activities are performed in special "clean rooms." The air is carefully filtered to remove virtually all dust particles. Workers wear special "bunny suits." Even so, no human hands ever touch the wafers. Robots perform the operations.

Tiny Switches

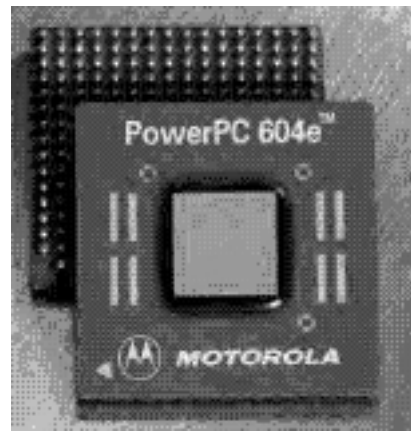
So, what exactly is on all these chips? Well, an important component is switches. Today's computers have about a billion switches. It's these switches that let the computer do so many different tasks.

A **transistor** can be thought of as a tiny switch that can turn itself "on" or "off." This switch has no moving parts. It is turned "on" or "off" by electric current. Turning on and off various transistors determines the path an electric current will travel through the chip. This allows the computer to perform different actions.

Microprocessors

A computer's "brain" is called its **central processing unit**, or **CPU**. This is where the computer manipulates data. A microcomputer's CPU is typically on a single chip, the **microprocessor**. If you ever get a chance to look inside a computer, see if you can spot its microprocessor. It is typically the largest chip in the computer. Today's microprocessors have about one-half million transistors. The most common type of processor used in PCs is an Intel Pentium. Macintosh computers use microprocessors made by Motorola, such as the PowerPC G4.

You may have heard people say, "I have a 3 gigahertz Pentium." You may be curious what this means. The speed of a microprocessor is typically measured in **gigahertz (GHz)**, or billions of cycles per second. This is referred to as the microprocessor's **clock speed**. A 3-GHz processor will perform 3 billion cycles each second. It is important to realize that other factors also affect how quickly a microprocessor processes data. However, clock speed is a good indicator of how fast a microprocessor can work.



Today's microprocessors can contain a half-million transistors.

Memory Chips

Computers also contain memory chips. **Memory** is used to store software, processing results, and other data that the computer uses while it works. There are two basic types of memory: **RAM (random access memory)** and **ROM (read-only memory)**.

RAM

When you enter data into a computer, it is stored in RAM. This is the type of memory we're usually talking about when someone asks us how much memory our computer has. RAM stores data temporarily while we're working with it. Let's say you are writing a letter to your grandmother. While

you are writing the letter, it is stored in RAM. If you want to permanently save the letter, you must copy it onto a storage medium such as a hard disk. If you turn off the computer without saving the letter, it is lost. The contents of memory are erased when the electricity is turned off.

The amount of RAM a computer has is usually measured in **megabytes (MB)**. A single **byte** of memory can store one character (such as the letters). So, a megabyte can store a million characters. Many of today's computers have 128 to 526 MB of memory.

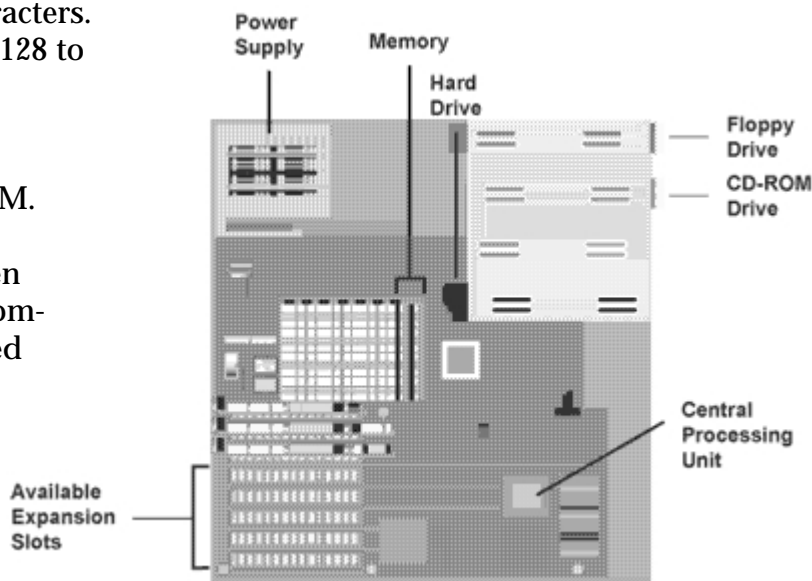
ROM

ROM chips are different from RAM. The contents of a ROM chip are permanent. They are not lost when the computer is turned off. The computer cannot change what is stored on ROM. ROM is used to store programming instructions and other data that does not need to change over time.

Circuit Cards

The main component of a computer is the **system unit**. Have you ever seen the inside of a system unit? You can learn a lot just by examining the different parts. System units typically contain several types of drives. There may be a hard drive, a floppy drive, and a CD-ROM (or DVD drive). In addition, there are one or more **circuit cards** (or circuit boards). These circuit cards contain electronic parts, including chips. Each circuit card can contain many chips.

The main circuit card is the **motherboard**. It typically lies on the bottom of the unit. Other circuit boards may be inserted into the motherboard. The cards are inserted into special **expansion slots**. For example, some computers have a separate graphics card. Graphics cards contain chips and other electronic parts that control the way graphics (images) are displayed on your monitor.



Conclusion

Not all chips are made of silicon. However, the majority are. Silicon is cheap and relatively easy to work with. These chips are used in all kinds of electronic devices—phones, CD players, dishwashers, you name it. The next time you look inside an electronic device, take a minute to examine these “chips of sand.”



Review Questions

1. Briefly explain, in your own words, how an integrated circuit is made.
2. What is the purpose of a circuit card?
3. List three things that you'll often find in a system unit.
4. How is the speed of a microprocessor measured?
5. How is RAM different from ROM?



What Do You Think?

1. Give an example of the kinds of data you think would be in a computer's ROM. Why would this data be in ROM rather than RAM?
2. Conduct research on the Internet to find out about the different types of microprocessors available today. What are some of their features? If you were buying a new computer, what kind of microprocessor would you want it to have? Why?

Glossary

byte The amount of memory required to store a single character, such as a letter, number, or special symbol.

central processing unit (CPU) The main control unit of a computer (its “brain”), which reads and performs program instructions and manages the tasks of input, output, and storage.

circuit card A board containing electronic parts such as integrated circuits. Also called a *circuit board*.

clock speed Used to measure how fast a microprocessor can work. Clock speed is usually measured in gigahertz (GHz).

expansion slot A special opening in a computer's motherboard that allows additional circuit cards to be inserted.

gigahertz (GHz) Billions of cycles per second. Used to measure the speed of microprocessors.

integrated circuit (IC) A complete electronic circuit contained on a small chip of silicon or similar substance. Also called a *chip*.

megabyte (MB) A million bytes.

memory Internal data storage areas, usually contained in integrated circuits placed

on the motherboard. Memory can be divided into RAM and ROM.

microprocessor A CPU that is on a single chip.

motherboard The main circuit board of the computer; it contains the microprocessor. Also called *system board*.

photomask A glass plate that determines the locations of electronic circuits being etched onto a silicon wafer.

photoresist A light-sensitive chemical used in manufacturing integrated circuits.

random access memory (RAM) Temporary memory that stores data and programs while they are being used.

read-only memory (ROM) Memory that stores instructions and data permanently in a computer. Data written onto a ROM chip can be read but cannot be removed or changed.

system unit The main part of a microcomputer. It contains many parts, including the motherboard and several disk drives.

transistor A tiny electronic component that can be turned “on” and “off” to control the flow of electricity.