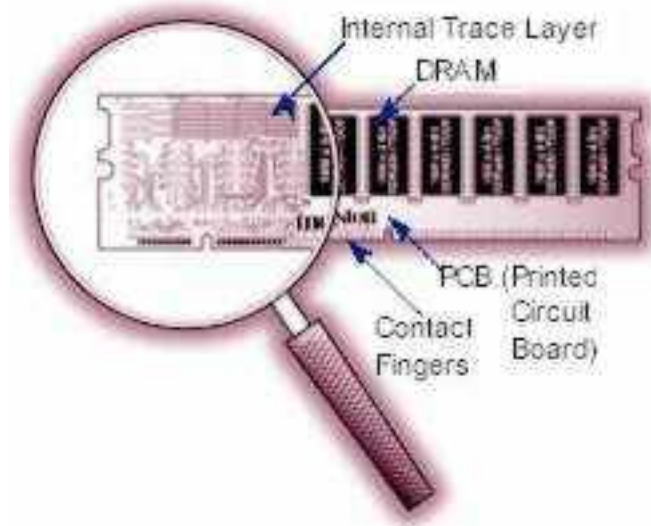


A CLOSER LOOK

Memory comes in a variety of sizes and shapes. In general, it looks like a flat green stick with little black cubes on it. Obviously, there's a lot more to memory than that. The illustration below shows a typical memory module and points out some of its most important features.

WHAT MEMORY LOOKS LIKE



A closer look at a 168-pin SDRAM DIMM.

PCB (PRINTED CIRCUIT BOARD)

The green board that all the memory chips sit on is actually made up of several layers. Each layer contains traces and circuitry, which facilitate the movement of data. In general, higher quality memory modules use PCBs with more layers. The more layers a PCB has, the more space there is between traces. The more space there is between traces, the lesser the chance of noise interference. This makes the module much more reliable.

DRAM (DYNAMIC RANDOM ACCESS MEMORY)

DRAM is the most common form of RAM. It's called "dynamic" RAM because it can only hold data for a short period of time and must be refreshed periodically. Most memory chips have black or chrome coating, or **packaging**, to protect their circuitry. The following section titled "Chip Packaging" shows pictures of chips housed in different types of chip packages.

CONTACT FINGERS

The contact fingers, sometimes referred to as "connectors" or "leads," plug into the memory socket on the system board, enabling information to travel from the system board to the memory module and back. On some memory modules, these leads are plated with tin while on others, the leads are made of gold.

INTERNAL TRACE LAYER

The magnifying glass shows a layer of the PCB stripped away to reveal the traces etched in the board. Traces are like roads the data travels on. The width and curvature of these traces as well as the distance between them affect both the speed and the reliability of the overall module. Experienced designers arrange, or "lay out", the traces to maximize speed and reliability and minimize interference.

CHIP PACKAGING

The term "chip packaging" refers to the material coating around the actual silicon. Today's most common packaging is called TSOP (Thin Small Outline Package). Some earlier chip designs used DIP (Dual In-line Package) packaging and SOJ (Small Outline J-lead). Newer chips, such as RDRAM use CSP (Chip Scale Package). Take a look at the different chip packages below, so you can see how



DIP (DUAL IN-LINE PACKAGE)

When it was common for memory to be installed directly on the computer's system board, the DIP-style DRAM package was extremely popular. DIPs are through-hole components, which means they install in holes extending into the surface of the PCB. They can be soldered in place or installed in sockets.

SOJ (SMALL OUTLINE J-LEAD)

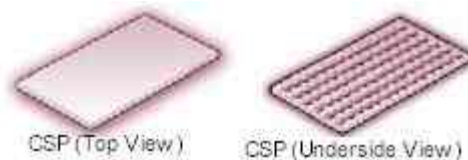
SOJ packages got their name because the pins coming out of the chip are shaped like the letter "J". SOJs are surface-mount components - that is, they mount directly onto the surface of the PCB.

TSOP (THIN SMALL OUTLINE PACKAGE)

TSOP packaging, another surface-mount design, got its name because the package was much thinner than the SOJ design. TSOPs were first used to make thin credit card modules for notebook computers.

CSP (CHIP SCALE PACKAGE)

Unlike DIP, SOJ, and TSOP packaging, CSP packaging doesn't use pins to connect the chip to the board. Instead, electrical connections to the board are through a BGA (Ball Grid Array) on the underside of the package. RDRAM (Rambus DRAM) chips utilize this type of packaging.



CHIP STACKING

For some higher capacity modules, it is necessary to stack chips on top of one another to fit them all on the PCB. Chips can be "stacked" either internally or externally. "Externally" stacked chip arrangements are visible, whereas "internally" stacked chip arrangements are not.

Example of externally stacked chips.

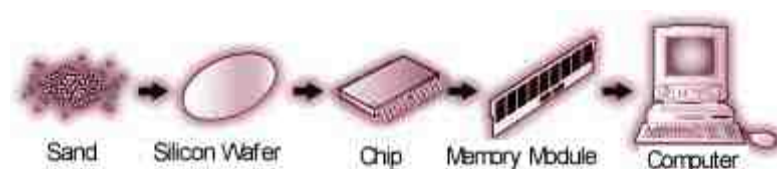
WHERE MEMORY COMES FROM

MAKING THE CHIP

Amazing but true: memory starts out as common beach sand. Sand contains silicon, which is the primary component in the manufacture of semiconductors, or "chips." Silicon is extracted from sand, melted, pulled, cut, ground, and polished into silicon wafers. During the chip-making process, intricate circuit patterns are imprinted on the chips through a variety of techniques. Once this is complete, the chips are tested and die-cut. The good chips are separated out and proceed through a stage called "bonding": this process establishes connections between the chip and the gold or tin leads, or pins. Once the chips are bonded, they're packaged in hermetically sealed plastic or ceramic casings. After inspection, they're ready for sale.

MAKING THE MEMORY MODULE

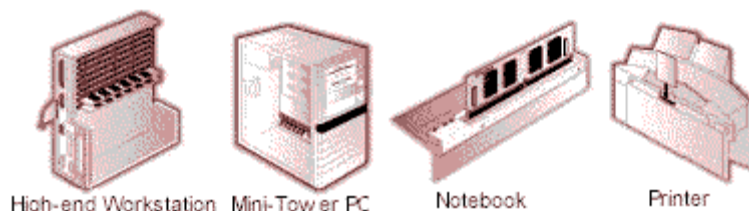
This is where memory module manufacturers enter the picture. There are three major components that make up a memory module: the memory chips, PCB, and other "on-board" elements such as resistors and capacitors. Design engineers use CAD (computer aided design) programs to design the PCB. Building a high-quality board requires careful consideration of the placement and the trace length of every signal line. The basic process of PCB manufacture is very similar to that of the memory chips. Masking, layering, and etching techniques create copper traces on the surface of the board. After the PCB is produced, the module is ready for assembly. Automated systems perform surface-mount and through-hole assembly of the components onto the PCB. The attachment is made with solder paste, which is then heated and cooled to form a permanent bond. Modules that pass inspection are packaged and shipped for installation into a computer.



WHERE MEMORY GOES IN THE COMPUTER

Originally, memory chips were connected directly to the computer's motherboard or system board. But then space on the board became an issue. The solution was to solder memory chips to a small modular circuit board - that is, a removable module that inserts into a socket on the motherboard. This module design was called a SIMM (single in-line memory module), and it saved a lot of space on the motherboard. For example, a set of four SIMMs might contain a total of 80 memory chips and take up about 9 square inches of surface area on the motherboard. Those same 80 chips installed flat on the motherboard would take up more than 21 square inches on the motherboard.

These days, almost all memory comes in the form of memory modules and is installed in sockets located on the system motherboard. Memory sockets are easy to spot because they are normally the only sockets of their size on the board. Because it's critical to a computer's performance for information to travel quickly between memory and the processor(s), the sockets for memory are typically located near the CPU.



Examples of where memory can be installed.

MEMORY BANKS AND BANK SCHEMAS

Memory in a computer is usually designed and arranged in memory banks. A memory bank is a group of sockets or modules that make up one logical unit. So, memory sockets that are physically arranged

in rows may be part of one bank or divided into different banks. Most computer systems have two or more memory banks - usually called bank A, bank B, and so on. And each system has rules or conventions on how memory banks should be filled. For example, some computer systems require all the sockets in one bank to be filled with the same capacity module. Some computers require the first bank to house the highest capacity modules. If the configuration rules aren't followed, the computer may not start up or it may not recognize all the memory in the system.

You can usually find the memory configuration rules specific to your computer system in the computer's system manual. You can also use what's called a memory configurator. Most third-party memory manufacturers offer free memory configurators available in printed form, or accessible electronically via the Web. Memory configurators allow you to look up your computer and find the part numbers and special memory configuration rules that apply to your system.