Siemens played an important role in reconstructing West Germany after the war, finally merging all its constituents to form Siemens AG in 1966. In the 1980s, Siemens entered the **minicomputer** and PC market with the acquisition of the German company Nixdorf, which became Siemens-Nixdorf. Siemens later sold the division, which is now the Wincor company. Over the years, Siemens became the only European computer maker to have success outside its own country, but the important U.S. market has eluded it. In 1999, it set up a new U.S. company, Unisphere Solutions, which intends to concentrate on high-speed data networking equipment and operate independent of the German parent. Back in Europe, Siemens had become the fifth-largest supplier of mobile phones, making it well positioned to take advantage of the **wireless networks** market.

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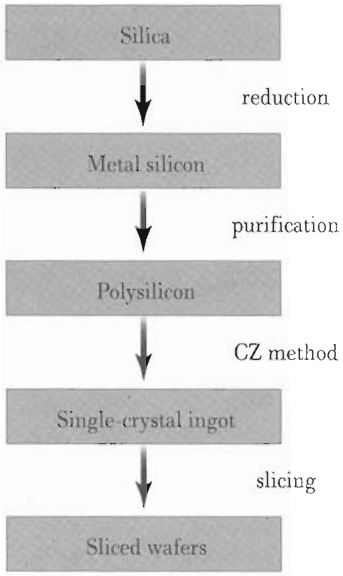
—Andy Dornan

Silicon

Silicon is semiconducting material, and it has also become an icon of the computer era. The word is used in conjunction with many others—almost as a synonym of computer chips. **Silicon Valley**, Silicon Alley, silicon foundry, and Silicon Glen are just some of the neologisms of our time.

Computer chips are built using **semiconductor** materials and metallic interconnections. Semiconductors do not conduct electricity as easily as metals, and neither are they good insulators. When they are combined with other elements in a process called *doping*, they can be made to conduct electricity in a controlled manner. **Transistors**, which are simple logic switches, can then be built.



Process of making silicon.

Silicon is the most abundant element in nature and also in computer chips. In fact, it is used as the substrate for the entire chip. First, it is extracted from silica using a metal that reacts with silicon; then the metallic silicon is purified using a chemical process. The next step is growing silicon ingots (large rods of silicon) from a single crystal. A silicon ingot is, in principle, a single giant crystal with few imperfections and great purity. It is grown using the *Czochralski* (CZ) or *float zone technique*. The first method consists in molting the silicon in a closed furnace containing an inert atmosphere. A single crystal is used to pull out the material slowly. As the silicon solidifies, it adopts the same orientation as the seed crystal.

When the ingot is complete, thin slices are cut and are used as *wafers* for the chips. The diameter of the ingots used was 20 centimeters (cm) until 1999, then the semiconductor industry started the transition towards 30-cm wafers, which will be the standard for several years until 45-cm wafers arrive. The larger the wafer, the more chips that can be built on them, and the cheaper they become. The figure summarizes the steps of the production process from silica to the wafers. Computer chips are sculpted on the silicon wafer using several layers of materials which are deposited using chemical etching and photolithography. The process demands a high degree of purity and exactitude, and it requires extremely expensive equipment, and therefore chip factories have become unaffordable for small companies. In the last years, the cost of a semiconductor facility has been duplicating every two years. Since chip production is becoming increasingly expensive, it makes sense to separate production from design, at least in the case of low-volume chips. *Silicon foundries* are companies specialized in manufacturing all kinds of chips for clients who do their own design but cannot own a fabric.

The term *silicon cycle*, refers to the periodic ups and downs of the semiconductor industry. Since this sector produces the raw material for the rest of the electronic industry, it is the first affected in the production chain. The silicon cycle goes from growth to recession in four years. It has been empirically "observed" that the peak usually coincides with an Olympic year.

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—*Raúl Rojas*

Silicon Graphics, Inc.

Based in Mountain View, California, in the heart of **Silicon Valley**, for two decades Silicon Graphics, Inc. (SGI) has been a world leader in high-performance computing technology, especially for three-dimensional **graphics** applications. It has also been instrumental in the development of the **Virtual Reality Modeling Language** (VRML). The company's systems have ranged from desktop workstations and servers to **supercomputers** in the world, delivering computing and three-dimensional visualization facilities for scientific, engineering, and entertainment applications. In particular, Pixar has used the platform for computer animation in the film industry. Disney films and other blockbuster films such as *Jurassic Park*, have benefited from SGI technology.

SGI was founded by James H. Clark (1944–) in 1982 with seven cofounders. They were Kurt Akeley, David J. Brown, Tom David, Mark Grossman, Marc Hannah, Charles "Herb" Kuta, and Charles "Rocky" Rhodes. All of them were members of Jim Clark's research group in the Computer Systems Laboratory at Stanford University.

The company was born from Clark's Geometry Engine, a special-purpose **very large scale integration** (VLSI) computer graphics processor, especially good for fast transformations necessary in real-time three-dimensional graphics. Marc Hannah undertook the original VLSI design. The U.S. Department of Defense Advanced Research Projects Agency (DARPA) supported the foundational research. **Hewlett-Packard** fabricated the first copy of the initial data path design, and **Xerox Palo Alto Research Center** (PARC) fabricated the first fully functioning version of the entire Geometry Engine chip.

The original full system was an adapted version of the Stanford University Network (SUN) terminal, designed and licensed by **Andreas Bechtolsheim** (1955–), a Ph.D. student at Stanford. Bechtolsheim later used this technology to cofound **Sun Microsystems**, a rival workstation manufacturer. The Silicon Graphics version replaced the SUN frame buffer board (one of three in the SUN terminal) with three new boards. These included frame buffer controller and bit plane boards, and also a Geometry Engine and pipe adapter board to enable fast three-dimensional graphics.

Like the original SUN system, the first Silicon Graphics IRIS system was a terminal (available in 1983). Later versions, such as Sun, became **Unix** workstations (available from 1984), but they used the AT&T System V version of Unix rather than the Berkeley Unix of **Bill Joy** (1955–), also cofounder of Sun. This was largely due to the employment by Silicon Graphics of a number of **Bell Labs** engineers, including Steve Bourne, who wrote the original Bourne **shell** for user interaction with Unix.

The early SGI technology was based on the **Motorola** 68000 series of **microprocessors**. The first Geometry System used the original 68000 16-bit processor with 256 kilobytes of random access memory (**RAM**; expandable up to 2 megabytes) running at a clock speed of 8 megahertz. The geometry subsystem included from 10 to 12 copies of the Geometry Engine itself. The color raster subsystem provided 1024 x 1024