What are semiconductors?

Semiconductors work tirelessly behind the scenes to power the world around us – from the technology in your house to the labs curing deadly diseases. They are the foundation of modern technology. Without them, billions of devices across the planet would not function. But what exactly is a semiconductor? And how are they made? Let's get right to it.

The term semiconductor refers to a material that can be altered to conduct electrical current or block its passage. However, it more commonly refers to an integrated circuit (IC), or computer chip. The most common semiconductor material is silicon. Not surprisingly, silicon is also the main ingredient in computer chips.

How chips are made in the fab



As small as a fingernail, semiconductors are arguably the most complex products ever manufactured. A common chip is only about 1 millimeter thick and contains roughly 30 different layers of components and wires called interconnects that make up its complex circuitry. Billions of microscopic switches called transistors make semiconductors work.

1. Mask operations

Engineers take digital blueprints and convert them into glass templates, called masks. They are used in fabrication photolithography, or "printing with light." As the mask engineers finish each mask, they send them to fabrication factories — or fabs — to begin manufacturing.

What are masks?

Masks are templates used to print circuitry onto a silicon wafer. Mask engineers use computerized drawings from chip designers as blueprints. Those drawings are fed into machines that convert the data into an electronic beam that replicates the circuitry pattern onto 6-by-6- inch pieces of quartz just a quarter-inch thick. These quartz squares are called masks. It can take more than 50 masks to make all the layers of a chip.





2. Fabrication

Technicians wear bunny suits and use high-tech equipment in clean rooms to create layers of circuits and devices on silicon wafers. Each wafer will contain hundreds of chips. From here, the fab sends the finished wafers to die/sort prep facilities.

What is photolithography?

Silicon wafers are made from the silicon extracted from sand. Techs use photolithography machines to shine light through the masks to re-create patterns. A lens reduces the image and directs it onto a wafer's surface. This is done repeatedly using a different mask for each layer of transistors and wire connections. Eventually the wafer will be imprinted with hundreds, or even thousands, of tiny individual chips.

3. Die/sort prep

In these facilities, diamond saws cut the wafers into thousands of fingernail-size individual rectangles, each called a die or computer chip. Die and sort prep machines cherry-pick the working chips and hand them off to another machine that places them onto reels. These are sent to assembly and test plants.





4. Assembly and test

Here, technicians take each die and test them one last time to make sure they're healthy and good to go. If they pass, they're mounted between a heat spreader and a substrate to form a sleek, enclosed package. The exterior package protects die from damage, heat and contaminants. Inside a computer, the package forms electrical connections between the chip and the circuit board.

5. Finished goods warehouses/hubs

From here, logistics professionals may send chips directly to some customers, such as system manufacturers. Or they ship them to global distribution hubs. From these hubs, chips might be sent to original equipment manufacturers in trays or be boxed for retail sale.



Major processor architectures

There are many different kinds of semiconductors – each with its own specialty (and its own acronym). Familiarize yourself with various kinds of semiconductors and learn more about what they do.



FPGA

Field-programmable gate array; software-configurable circuits

What they do: Often used in applications that



GPU

Graphics processing unit

What they do: Make images; accelerate



CPU

Central processing unit (the brain of the computer)

What they do: Run the computer and all



ASIC

Application-specific integrated circuit

What they do: One thing very quickly,

including deep learning, encryption and network processing.

Semiconductors are everywhere

The average American adult spends more than 12 hours a day using electronics, such as computers, mobile devices, TVs and cars. Those devices are all powered by semiconductors, which improve our lives, increase productivity and drive economic growth.



Ultrasound modules Wireless patient monitors

Advanced driverassistance systems Diagnostic equipment Mapping/Sensing Navigation systems Scanners Smartphones Televisions Watches/clocks

Intel's global manufacturing footprint

Semiconductors are a worldwide business

\$10-15B

The approximate cost to build a new semiconductor factory or "fab"

Global semiconductor industry sales in 2022

12K

The number of construction, high-tech and support jobs a semiconductor fab typically creates

The equivalent clean room area in one typical semiconductor fab

Summary

- Semiconductors are the foundation of modern technology. They improve our lives, increase
 productivity and drive economic growth.
- There are many different kinds of semiconductors, each with its own specialty (and acronym).
- Semiconductors are probably the most complex products manufactured in the world. A common chip is only about 1 millimeter thick and contains roughly 30 different layers of components and wires called interconnects that make up its complex circuitry. Billions of microscopic switches called transistors make them work.

→ Ready to discover more?

The Intel Tech 101 series mixes visuals and descriptions to break down complex subjects and demystify the technology we use every day.