

Semiconductor Introduction

Here, I have a circuit with a battery, a light bulb, and gap.

If I fill this gap with a metal, the light comes on.

If I fill this gap with glass, the light stays off.

You probably already know this, because the metal is an electric conductor, and glass is an insulator.

But what happens when I fill this gap with a silicon wafer*?

The light stays off, so you might think that silicon's an insulator.

But what if I heat it up? It lights up.

The silicon is insulating at room temperature, but conducts electricity when it's very hot. It's a semiconductor, whose conductivity changes based on the environment.

This special ability makes semiconductors the perfect brains for electronic devices.

Circuits of small semiconductor switches, called transistors, are the heart of computer chips, and enable them to do math and run programs.

Semiconductors have enabled electronics to become smaller, faster, and more reliable.

But what is it exactly about semiconductors that allow them to either conduct or insulate?

In a single atom, electrons can occupy specific energy levels.

When multiple atoms bond, the electrons are shared between them.

But because the atoms are now interacting, the energy levels shift around.

As I've said, computers are made up of semiconductors, switches or transistors, that switch between conducting and insulating.

Computers use electric fields because heat is slow and would burn too much energy.

We can turn this wafer into a computer chip by printing a circuit of transistors on it, using a process called photolithography*.

Here, in the photo room, we cover the wafer with a light sensitive material and expose it to light that we shine through a patterned mask.

Then, we develop the wafer, like film in photography, which leaves behind a pattern that becomes the circuit.

In a solid, trillions and trillions of atoms interact with each other.

Their individual energy levels smear into energy bands.

For a material to conduct, the electrons must be able to jump from lower energy states to higher ones.

The spacing of these energy levels and how they're filled with electrons determines if the material is a conductor, insulator, or semiconductor.

If there's a huge gap between the lower energy levels and the higher ones, it's hard for electrons to jump to the higher ones, so a current can't flow, and it's an insulator like this glass.

Metals have no gap at all. Electrons can move to the higher energy levels with no problem. Current can flow.

Semiconductors fall somewhere in the middle. They have a medium-sized band gap.

So technically, I could make this glass conduct electricity. If I added enough energy through heat to push the electrons into a higher band. But that amount of heat would either melt or break the glass before it actually conducts. This is true of most insulators. The amount of energy needed to make them conduct is just too high.

But in a semiconductor, the band gap is small enough that electrons can jump into the higher energy band so that current can flow.

The amount of heat we apply determines how many electrons jump into the higher band, and how much current flows.

And heat isn't the only way to change the conductivity in a semiconductor.

We can also use light, electric currents, and in a computer, electric fields.

Printing the transistors at once lets you make circuits that are smaller and cheaper than if you built them from individual parts.

Transistors make up the logic elements, the memory components, and the communication modules that let computers talk to each other.

With semiconductors, you can cheaply add transistors to almost any device you can think of, from spaceships, to servers, to maybe even your toaster.

Semiconductors have enabled the technological revolution, the internet, the computer, and the cellphone.

No semiconductors, no information age

_____	1. a device that produces electricity to provide power for radios, cars, etc.
_____	2. a rounded glass container that produces light when an electric current goes through it
_____	3. the power to conduct electricity or heat
_____	4. a small device that controls and turns on or off an electric current
_____	5. to stop heat, sound, or electricity from escaping or entering something
_____	6. a close connection joining two or more things or persons
_____	7. to spread a liquid over a surface
_____	8. an empty space in the middle of something or between two things
_____	9. to turn from something solid into something soft or liquid
_____	10.the area surrounding an object with an electrical charge where positive and negative particles are reacting with each other
_____	11.a small electrical device containing a semiconductor, used to control or increase an electric current
_____	12.to be hurt, damaged, or destroyed by fire or extreme heat, or to cause this to happen
_____	13.a very small piece of semiconductor, especially in a computer, that contains extremely small electronic circuits and devices
_____	14.to send out or reflect light
_____	15.a length of dark plastic-like material that can record images
_____	16.costing little money or less than is usual or expected
_____	17.a vehicle used for travel in space