[MUSIC PLAYING]

PROFESSOR: Hello everyone, today we're going to learn how a Solar Cell is able to turn light generated mobile charges into electricity. Today's lesson will use everything we've learned in the past videos to understand this effect. So, make sure you understand the material from the previous videos before watching.

First, let's go over the structure of a Solar Cell. Here's a cell that I made. And we can see that a metal ribbon is connected to the top metal contacts, which form a grid. The spaces between the grid lines allow light to enter the cell. If we flip over the cell we see the entire back surface is coated with metal, which allows easy extraction of charge from the back surface. Additionally, we have another metal ribbon that's connected to the backside.

Now, let's hook up our Solar Cell to an ammeter to measure the current. So, here we have an ammeter connected to our Solar Cell and our light source which will simulate the sun. And we can see that if we turn on our light source we start to read a current flowing out of our Solar Cell. In this case about 0.12 amps or 120 milliamps. Now, if we turn off the light the output of the cell drops to zero and we no longer read any current.

We know from our last demo the light generates mobile charges and silicon. But how do these mobile charges become a electric current coming out of our Solar Cell? The secret has to do with doping.

The top layer is doped with phosphorus, shown in blue. Well the bottom layer is doped in boron, shown in red. The different dopants interact in a way, which we'll describe shortly, to create an electric field in our device where the Boron-doped and Phosphorous-doped regions meet. It is this electric field that acts as a one way valve in our Solar Cell for electrons and holes.

An electric field is created when positive and negative charges are separated. As you know, opposite charges attract and like charges repel. We'll exploit this property by creating a sheet of positive charges on the left and negative charges on the right, thus producing an electric field, which we denote with the Greek letter z. If you were to insert a negatively charged particle, such as an electron, into this field it would move toward the positive charges. Alternatively, if you put a positively charged particle it would move toward the negative charges.

We're able to create an electric field inside our Solar Cell by using different dopants on either side of the device. Here we have our silicon lattice, which is un-doped. We'll start by replacing some of the silicon atoms with phosphorus atoms on one side. On the opposite side we'll put in boron atoms.

To focus on our dopant atoms and the mobile charges they introduce we'll fade out the silicon lattice. Recall that phosphorus atoms introduce static positive charges in mobile negative charges. While boron atoms introduce static negative charges in mobile positive charges.

All the mobile charges are free to move around at random. A process known as diffusion. Here we see a single electron moving around on its random walk. During this random motion if an electron and hole encounter each other they neutralize and effectively vanish.

As this process of holes and electrons randomly defusing and neutralizing as the interface continues, the total number of mobile charges in the device decreases. This leaves a region at the interface of immobile static charges where the net charge is negative on one side and positive on the other.

These opposing sheets of charge create an electric field of the interface, which at this point is very weak. As charges continue to diffuse, they're still able to move across this weak electric field and neutralize. As this happens, the sheets of net positive and net negative static charges widen and the electric field grows in strength. Now that the electric field is stronger, as other mobile charges continue to move and diffuse around the lattice, they're now repelled by the field and electrons to the left and holes stay to the right. It is this electric field that separates light generated mobile charges and pushes them to the extreme ends of the device.

The image we see now is our Solar Cell in the dark. However, recall that our silicon atoms are still present. And if light strikes our silicon atom, a mobile hole and electron is generated. As these mobile charges move around randomly there's a chance that they will randomly encounter the electric field. The mobile electron will get repelled by the electric field. However, the mobile hole will get swept to the other side by the electric field.

Now, let's zoom out. We can see that after the electric field has pushed our light excited electron and hole to the left and right respectively, we now have an extra negative charge on the left and extra positive charge on the right. If we connect a wire to short the two opposite sides together the excess electrons are attracted to the excess holes on the opposite side. This attraction is what drives electricity through our wire. As light continually shines on the Solar Cell charges are constantly being pushed out of the device and driving the electric current.

Now hopefully you understand the basics of how these amazing, but rather simple, devices work. We hope that this knowledge will provide the basic foundation while tackling more difficult and abstract concepts while you learn the material in this course. I'm Joe Sullivan, thanks for watching.