Introduction to Semiconductor Devices
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Lecture – 3.8
Semiconductor Device Fabrication

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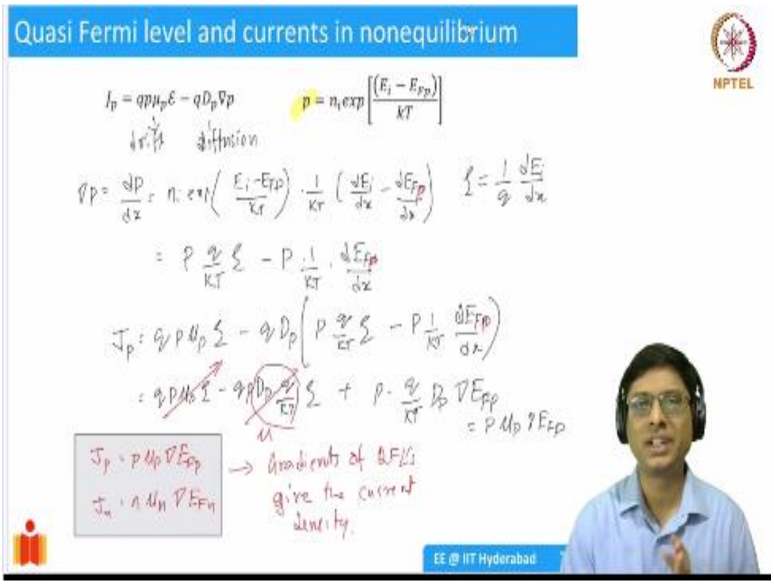

This essentially, you know, finishes the basic fundamentals that I want to cover. But I just wanted to take a few minutes to introduce the fabrication aspects of it.

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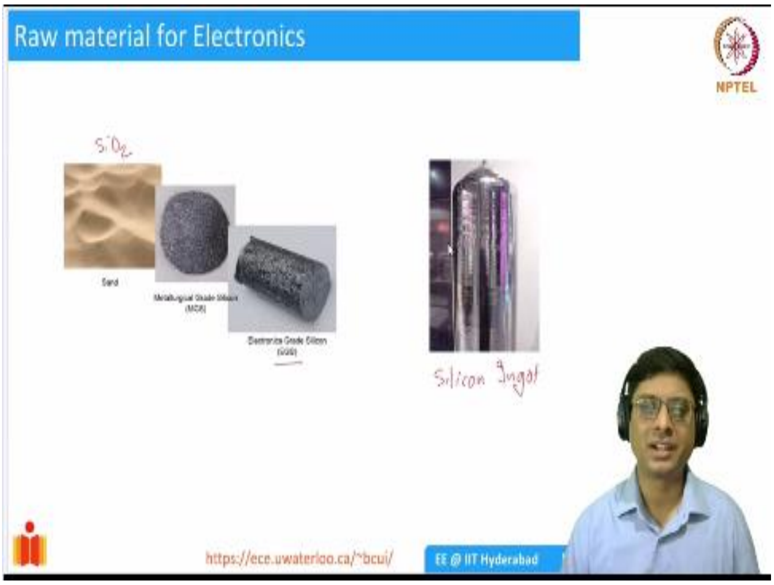

So far, we only focus on the physical and the, you know, understanding part of it, the theoretical aspects of it, we are not talking about practical aspects of semiconductors. So, I just thought I would take a few minutes to talk about that. So, if you look at semiconductors, we talk about silicon. But if you wonder, I do not know if you wonder, but it actually is made from glass sorry, silica sand.

So, if you go to beaches, you see lots of sand. It has huge amounts of silicon in it; it is a SiO_2. Sand is simply silica, which is a SiO_2. So, you add some carbon and then you do some chemical reactions and purify it. So, it can be you know, purified to a level of 2 parts per billion or even more. So, essentially, what we do is: we start with sand, we can actually purify it and get what is known as metallurgical grade silicon and then purified further to get electronic grade and so on.

And then this sort of electronic grade silicon, EGS is taken and then it is heated up on the chamber; you melt it and then put a small seed crystal. And then there are multiple processes to actually make pure silicon. And eventually you melt it and then you draw that so that a perfect single crystal of silicon forms. And that is what is shown here, you know, this is called as a silicon ingot, ingot essentially means.

It is like a cylindrical cylinder silicon, pure crystalline silicon, I do not know if some of you have studied this in your high school. If you want to perfect crystals, you can take a solution of a sample of whatever chemical and then put a single small piece of that and then tie it to a thread and then you pull it up. As you pull it up very, very, very slowly, you will see that crystal forms around it.

Something similar is done in this case, a silicon. So, you make the silicon like this and then the fabrication facilities you dice it, you cut it into thin, thin wafers. We start with the circular ingot and then you cut it and then you form wafers. So, these pictures are taken from this website of a professor in Waterloo. You can go and look at that he has a course on nanofabrication.

So, there are 2 dimensions, you know, what we are going to do in this course, is essentially talk about the physics and theoretical aspects of it. But there is a huge number of innovations done to actually make these things practical. So, these are captured in, you know, these are taught in a VLSI technology kind of a course. So, that will not be required in the undergraduate level. But suppose if you are more interested, you can actually look at that.

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So, the entire process of actually making semiconductor devices is a very fascinating thing. You know, I just mentioned that you would make it from sand. So, I would urge you to go and look at YouTube, there is a video, I do not want to play it now, but chip manufacturing how microchips are made. So, there is a video from Infineon, take a look at this video. And it will show; it is about 10 minute video; it will show. So, these things are actually done in very, very known sophisticated environments called clean rooms.

And these clean rooms are extremely expensive places. So, they have, if you want to set up a clean room right now at the state of the art, we require about 5 to 8 billion dollars. It is a huge amount of money. You know, it is so expensive that you know, very, very few companies are there in the world that can actually make it; one of the companies is Intel, which is the one that makes processors Core 2 duo and Zeon and all that is made by Intel.

There are a few other companies which are called as contract manufacturers, which are like TSMC and Globalfoundries and so on, Samsung, all of these companies make these devices. So, they make things like Nvidia and Qualcomm chips. The Nvidia graphics cards like we have those and the Qualcomm chips that go into your mobile phones and all are made by this foundries, contract manufacturers. So, this industry is a very, very fascinating story.

I mean, how technologically, we are able to make devices on it. On a single chip, we are having billions of transistors,. That is one of the greatest fascinating stories of technological innovation. So, we will get a glimpse of it. When you see this video, you will get a glimpse of this. So, I do not want to really know, I cannot possibly tell you all the details in a course like this. So, it requires a course on its own VLSI technology.

So, I would urge you to go and look at the video. You will see that these chips are made in very clean rooms and these clean rooms are so pure, I mean, they are like, you know, really 1000 times cleaner than your hospital, you know, the best hospitals, though generally, when we have hospitals, we talk very, very, they are supposed to have less contamination. So, that the patients do not catch any infections.

But if you look at the clean rooms, they will be like to 1000 times cleaner than a hospital, the best operating theatre. The reason is, even a tiny amount of impurity in the semiconductors can actually kill the performance of the device. So, we spend a lot of money to actually run a wafers in a clean room. So, any contamination is going to kill it. So, you actually see that, you know, you will see people are actually covered in complete hoods.

You know, like a clean room dressing gown, which covers every aspect of it, except the eyes, you know, you have extreme precautions which are taken to make sure that the environment is very clean, so much, so that actually at the cutting edge, you know, the process, there is a huge amount of automation, you will see in the video that a lot of these wafers are being moved around automatically.

Everything is automated, so that there is minimum amount of human intervention, because human beings are essentially contaminating the semiconductor manufacturing process. So, please take a look. I am going to finish a little earlier today. But you know, I urge you to just, you know, go and take a look at all this video especially and we will be ready to talk about p-n junctions in the next class. So, thank you very much. I will stop here and we will continue in next week.