Experimental Physics – III
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Lecture – 38
Topic: P-N Junction (Contd)

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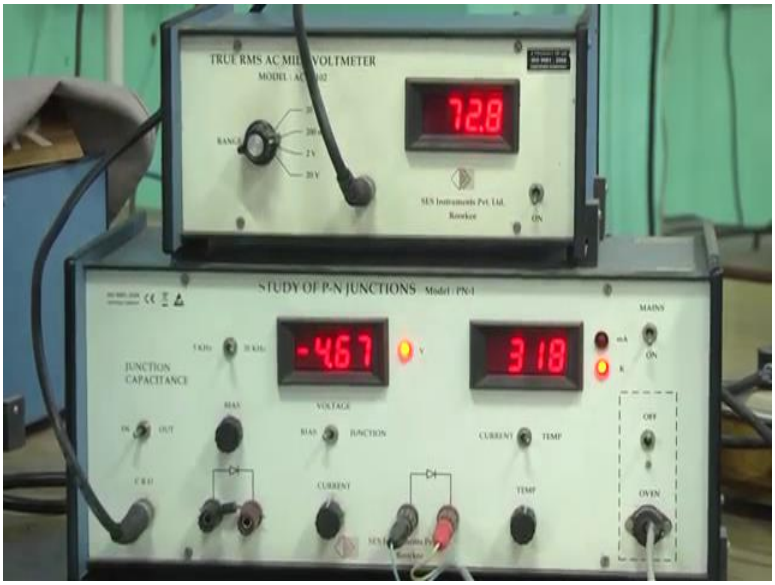

This is the simplest experiment of P-N Junction. as I discussed in theory that will perform three experiment. Experiment 1 is will find out the saturation current as well as material constant eta.

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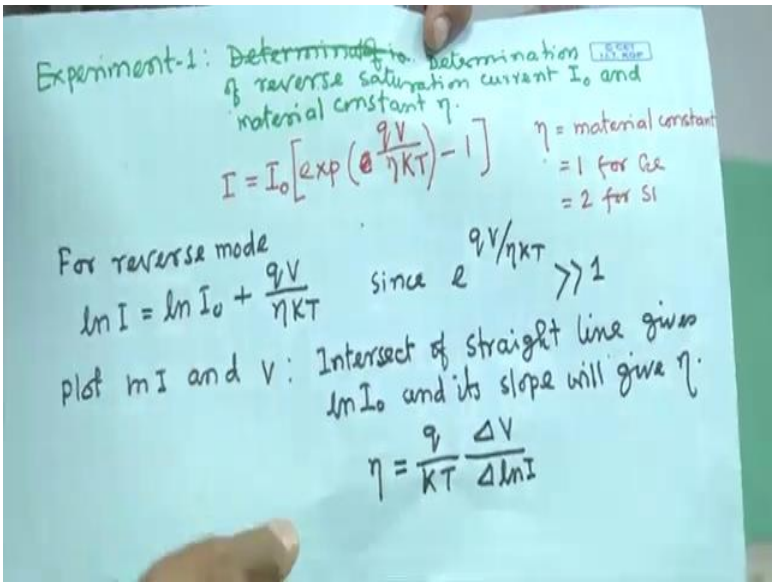

For that, what we have to do? We have to as I showed you we have to do the experiment that current versus the voltage junction voltage ok. Then we will plot and then find out the all thing. current versus the junction voltage.

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I need diode. here you see here there is a diode. Is the we have? this diode connection to junction connection it has come here you can just in picture you can see diode ok.

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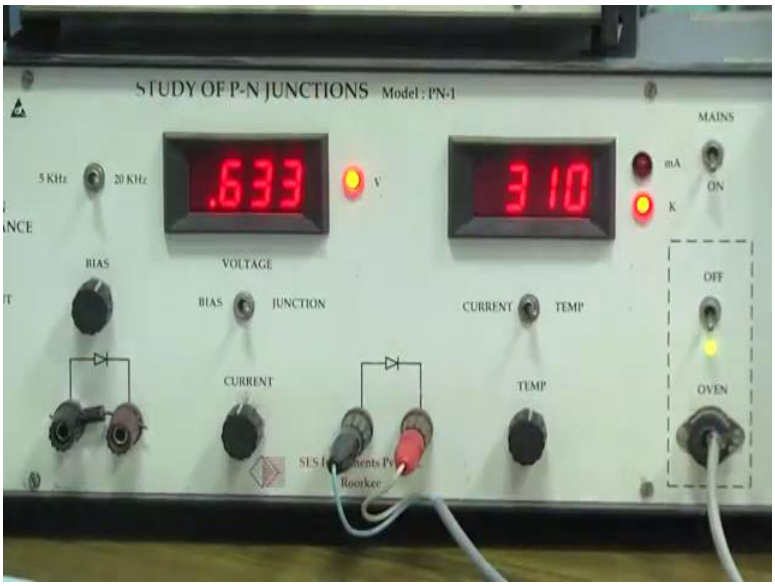

This connected with this electronics. this we are keeping here.

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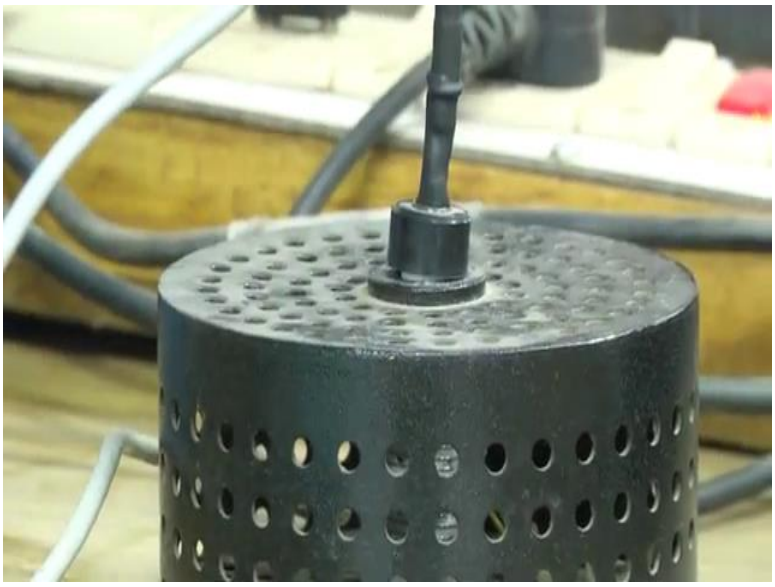

We are keeping here because the second experiment also will do using this diode this junction as a function of temperature. This is the temperature oven.

Now this junction diode junction is a diode junction it is the is connected here. here you see the voltage. Here two options are there bias and junction. one can choose bias; bias means I am this bias voltage I am applying and junction means what is the voltage drop across the junction, so that it will display that value. In this case, we will vary the current

and measure the voltage drop across the junction. That is why we have to put this one towards junction and here the reading whatever we are we will see that we have note down. that is the junction voltage drop across the junction.

In addition, current here temperature and current these two options are there. In this meter, we want to read the current. I have to put towards current. Now, here it will give current and it will give the voltage drop across the junction ok. Now just what I have to do this is the diode now we are we are changing the current. Let me start with the 0 current. This is the 0 current. At 0 current what is the reading junction; that we have to we have to note down.

Now I am varying I am varying current you see initially we have to. just say it is the 0.1 0.1 what is the voltage 0.622, this is the in volt here in volt and this is the in milliampere ok. 0.1 milliampere, this is the 0.622 volt that is the junction voltage. we have to note down current versus this voltage junction voltage. Then you go to the next step say 0.2 0.2 0.2 note down this junction. this way just vary current and note down the junction voltage. Then take log of take log of this current ln I and ln I versus magnetic field magnetic field.

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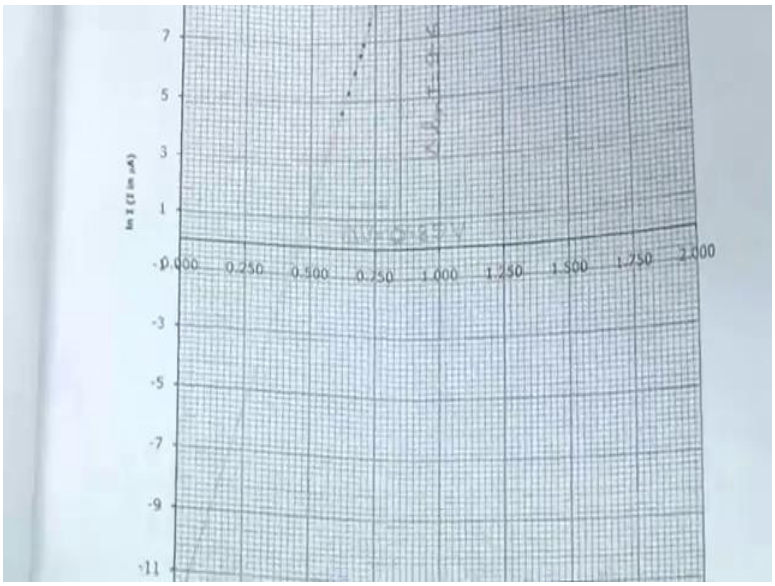

Here you can see this in manual this is the ln I; I in in micro million microampere here is sheeted and this is the voltage junction voltage ok. Plot the data; you will get a straight line. Now, you find out the slope and find out the intersection with this y-axis ln I ok.

From here from this intersection you will be able to calculate I 0 and this from this from this slope from this slope one can calculate the; one can calculate the calculate the eta.

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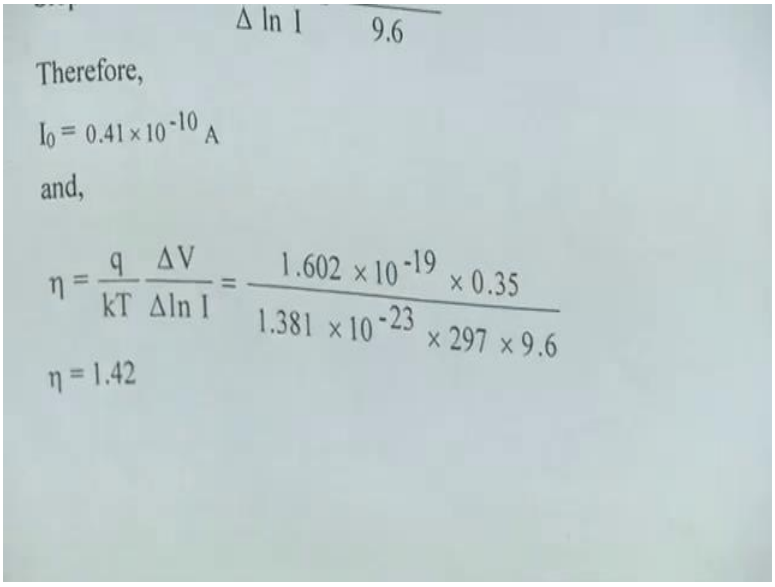

As I described in manual this data is nicely this data is nicely showed and calculation also given.

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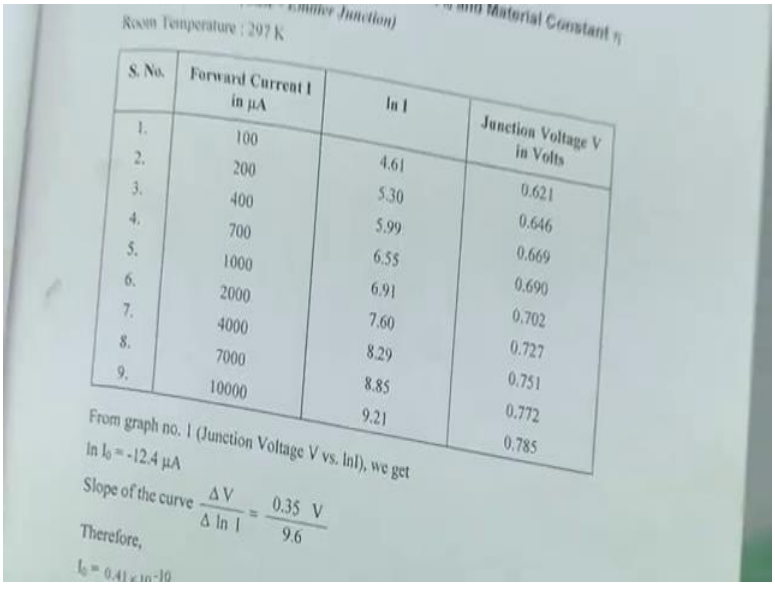

As just this is the simplest experiment and eta value eta equal to 1.42 you got an I 0 is this. One has to be put this one.

Second experiment was as I told you that we have to we want to do the measurement as a function of temperature.

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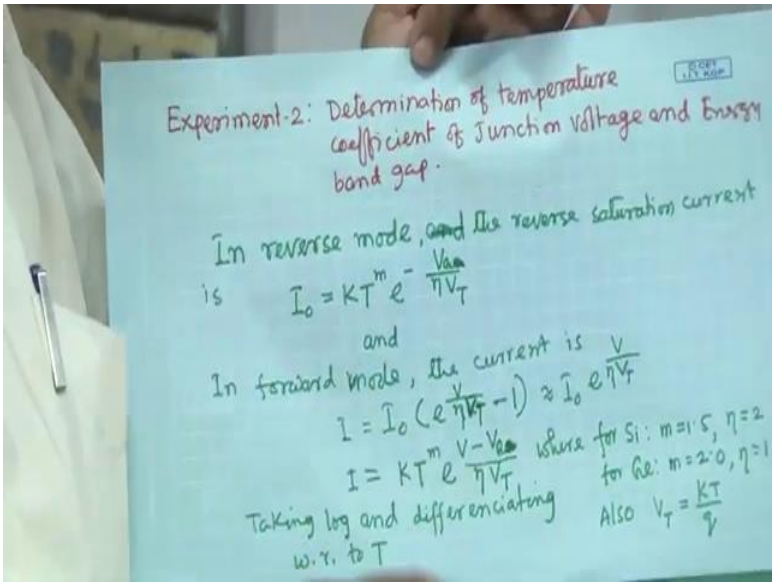

Determination of temperature coefficient of junction voltage and energy band gap. we want to find out the energy band gap and we want to find out the temperature coefficient of junction voltage. What is junction voltage? Already I told you junction voltage junction how junction voltage is changed with temperatures. Now, an experiment we have to earlier experiment was junction voltage versus the; this what is the current in the circuit ok.

Now we have to do experiment these junction voltage how junction voltage changes with the temperature. we have to take this temperature ok. Now, there is oven here there is oven here it is now switch OFF, now I put ON ok. This oven; now, an oven temperature you can change you can change this temperature ok. you see it is the now it is the light you can see. After sometime what will happen? This light will go off when it will attain the temperature.

Now, it is 302 now at this 302 what is the is the voltage what is the junction voltage. For a now, we are not change in for a particular current some current already I put so you can change at a particular current and after that you should not change. keeping this current constant now this we have to take data of junction voltage as a function of temperature ok.

Now just change the temperature next one just wait to reach this temperature to that value. it is going 305 still it will increase 306 it is a 307, 308, 309. It is a 310 ok. now, it is OFF. Now, you take it is OFF means now this temperature is stable ok. at that temperature what is this value? Junction voltage just note down. This way we generally up to 370. Around from room temperature it is 70 it is around 100 degree centigrade ok. we do the experiment we do not go behind that because it is the semiconductors.

it cannot it cannot do this experiment this semiconductor means is the I think I do not exactly do not know, it is the silicon or germanium looks germanium diode from eta value probably it is showing what I showed for silicon eta value 2 see it is 1. 5. It is in middle. difficult to say whether it is silicon or germanium anyway. Just vary the temperatures and do the experiment; do the experiment.

Now after get after getting this data taking the data this theory is simple taking data also simple, now just one has to analyze this data. In addition, for an experiment 2 it is the we have to plot; we have to plot a junction voltage you can see; this is the junction voltage it is the junction voltage as a function of temperature.

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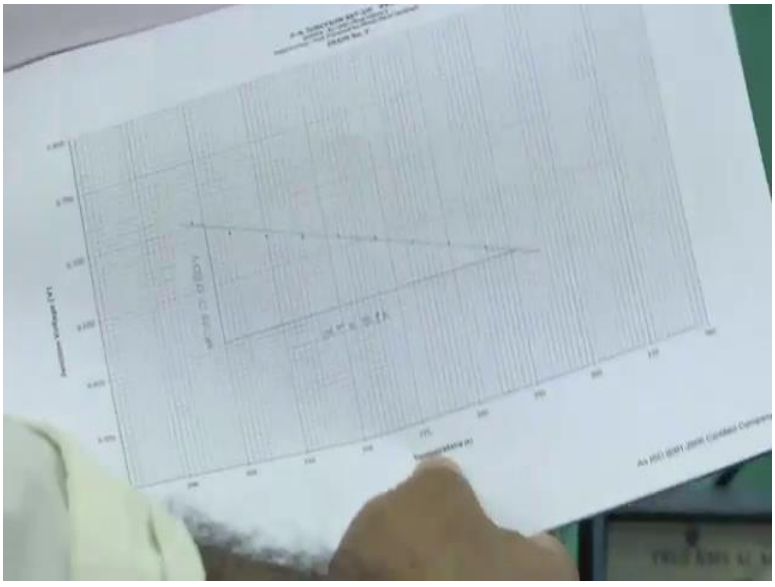

Now you will you will get a straight line; you will get a straight line with negative slope. from there you can find out the slope.

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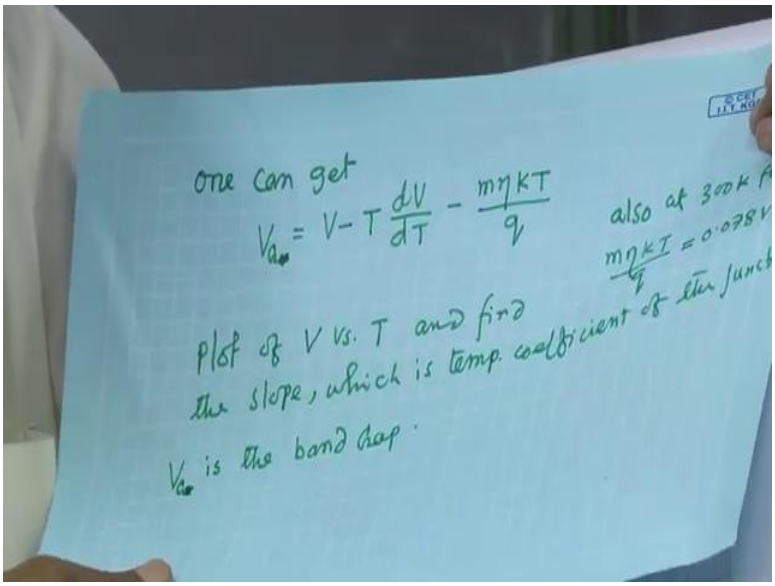

And, the slope is nothing, but dV by dT and from dV by dT as I showed you the experiment 2 plot V versus T find the slope, which is the energy coefficient of the junction, and V G is the band gap that we have to calculate. find out the slope and from slope you used from slope that. This is the slope at which temperatures that T we need.

Now, V junction voltage, this slope and this that at which T is in the middle we have to take whatever the slope we are finding out the temperature at which this you are finding out the slope. Minus this term is a one this is for silicon this this is silicon diode. from there if you know the slope, then you can find out the V G at that temperature ok; generally V G does not change much with the temperature one can check also a different temperature one can calculate V G.

However, it is the. This as well as now you see this this dV by dT actually you got this is the straight line we are getting know this we are getting straight line. at different temperature slope is constant; slope is constant at different temperature more or less slope is constant know. This slope is dV by dT is constant ok.

At all temperature these dV by dT are same. This here now question is your band gap whether it varies with the temperature or not. This temperature t have some role ok. one can find out one can find out whether this V G is changing with temperature or not from this from this from this equation after calculating this one at different temperature

calculating this one at different temperature at different temperature this looks constant because it is the linear these also constant.

V at different temperatures T V will be different V will be different. In that case, so the way V T T is increasing V is decreasing. this way these two will be there will not be much change in V G. there may be there may be changes with temperature, but there will not much change because when T increasing from here, you can see T increasing, then V decreasing ok. This term will increase this term will be increased and V will decrease ok.

That way it will be compensating not fully, but this value will final value will not be much difference but there may be slide different. That one can study also but I think it is almost this remain constant. that is why we just we can we can just report for one temperature one voltage where we have taking this slope. If slope varies with this with a temperature then this, this will effect drastically.

Anyway, so this is the second experiment from where you can find out the band gap as well as you can find out the band gap and to find out the band gap we need this temperature coefficient of junction voltage as from the graph one can find out.

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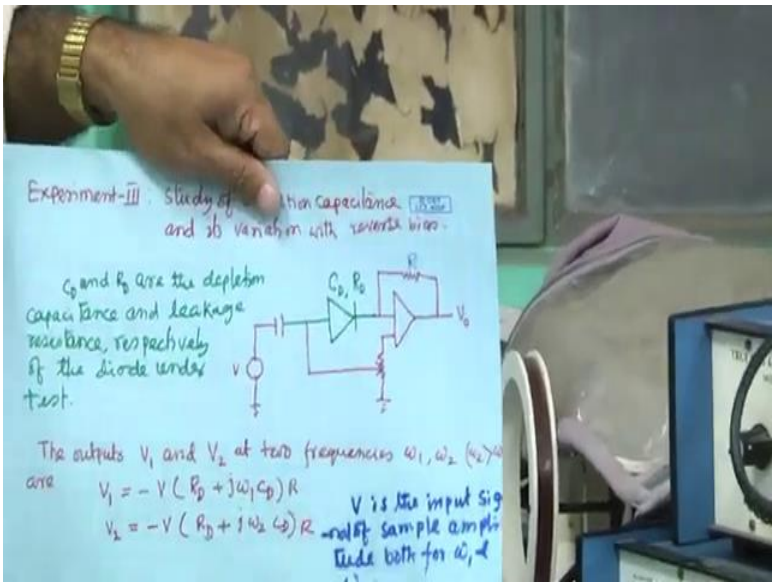

Now, third experiment as I told that we want to we want we can study the depletion capacitance and its variation with reverse bias and for that the circuit diagram as I mentioned this circuit diagram will be used this circuit diagram will be used. Now, for

experiment 1 and experiment 2 this part where this diode we have used now for this experiment. This another diodes this this part we will use ok.

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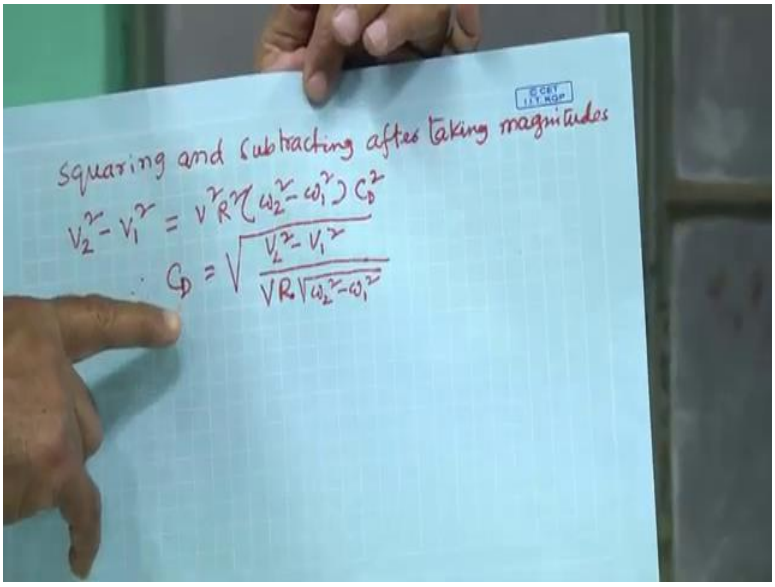

In this case, what we need we need to calculate C D? We need to calculate C D. for the C D what here V is there and V V whatever voltage we are applying here you can see bias we are applying. for this part this is the bias, now this not junction voltage we are measuring what bias we are applying bias voltage we are applying that that I have selected that I have selected bias ok.

Hear whatever reading we are seeing now whatever reading we are seeing. I will put off this oven I will put off this oven now this voltage whatever it is not junction voltage whatever bias voltage we are applying so that here you can see this I can change the bias voltage I can change the bias voltage here. Now bias voltage here we are applying in the circuit in the circuit. The circuit diagram, this is the diode and this circuit diagram is inbuilt inside a box I cannot show you.

Now, according to this relation we will do the experiment. We want to calculate C D for that I need V, bias voltage. that is the bias voltage we need this R value. That is supplied that is supplied by the R is taken it is there that will be supplied ok. Now, I have to find out V 1 and V 2 at omega 1 and omega 2. This V 1 V 2 actually from C R we are not using C R what we are using a one this is milli voltmeter ok.

This output so this output V out here input whatever is it was it was showing here. output out V 1 and V 2 I will this reading I will get from here and it is in in 200 millivolt range means this 31.4 whatever I am getting this is this is millivolt ok. At this bias at this bias now what is V 1 and V 2 for two frequencies I have to do. here option is there 5 kilohertz and 20 kilohertz ok. 5 kilohertz that is say V 1 I will note down for 5 it was this is V 1 for this bias; now, for V 2 now for V 2 and this frequency is 20 kilohertz what is the value that I will record I will note down.

Then, everything is known and I will calculate C D. Now, this C D for this bias now I will change this bias I will change this bias to next value and negative sign you can see this is the reverse bias reverse bias we are applying. Now, now at 5 kilohertz at this bias 5 kilohertz what is the V 1 this I have to note down and what V 2 that we have to note down. Then we will calculate the C D.

Now, that C D will be plotted for different value of bias voltage. There how C D varies with the bias voltage reverse bias voltage ok.

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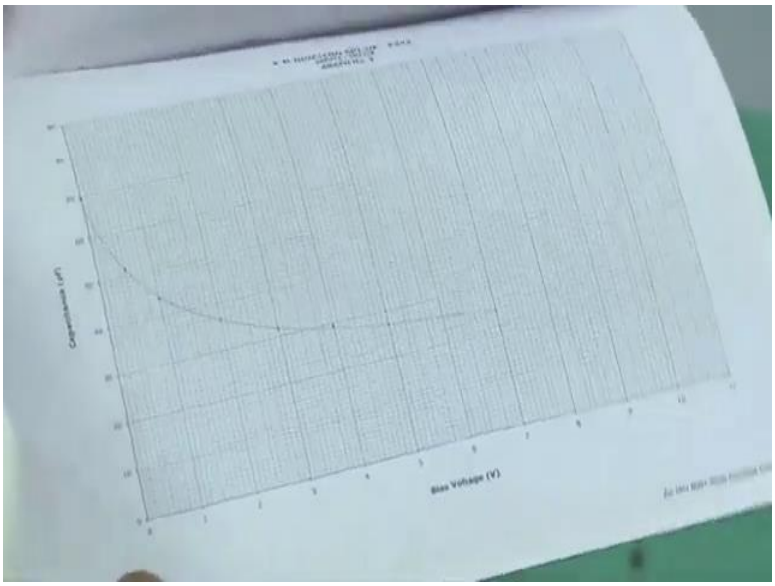

Here this capacitance C D in Pico farad and this is bias voltage. it Is if you plot, then you will see this kind of vary.

This is very simple experiment, theory also is simple. But, it gives so important parameters this is band gap energy of a semiconductor how to measure the band gap of a

of a of a semiconductor using a diode P-N junction junctions how the capacitor, how the junction capacitance varies, how the junction voltage varies with temperature ok, what is the material constant, what is the saturation current of the of the junction. All-important parameter one can find out using this very simple set up what I discuss in in in theory class ok.

I think this is the experiment nice experiment V g experiment, but it is a full of one can one can really just one can really measure or monitor the different parameters of semiconductor in this experiment. I will stop here.

Thank you.