Experimental Physics - III
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Lecture – 13
Magneto resistance for Semiconductor

Now, I will demonstrate Magneto resistance measurement experiment in our solid state physics laboratory.

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this is the experimental setup or magneto resistance measurement. we need electromagnet, this is the electromagnet we have seen earlier. these two are coils and these are pole piece tapered pole piece ok.

there is an air gap between these pole pieces. this air gap we have kept for putting our sample. one can change these distance between these pole pieces using this just rotating these two heads that arrangement is there. we have kept this air gap fixed for our experiment.

Now, what you should do first you should measure this air gap because, by chance if it changes ok. Or today you have you have calibrated the electromagnet and then next day when you are coming for doing the experiment if someone changes this one that calibration curve will not be valid. that is why one should measure this air gap and keep note of the air gap.

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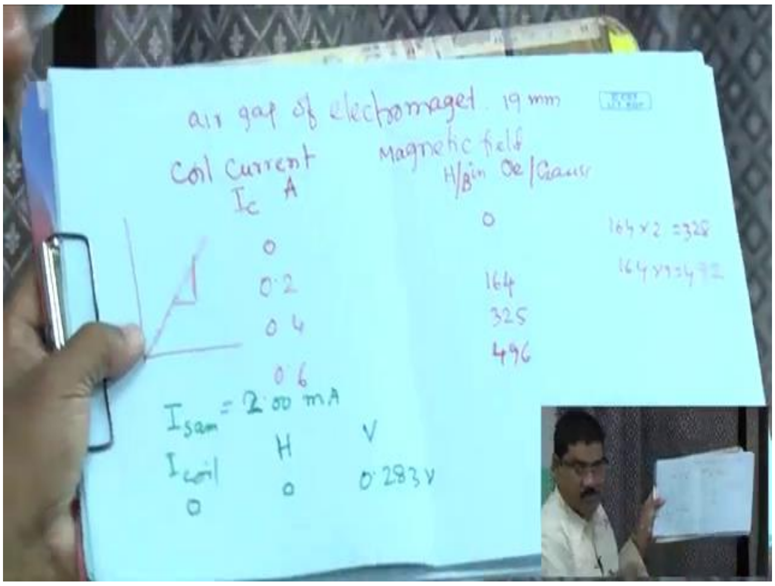

first task is that you should electromagnet you should note down in your note book that air gap; air gap of electromagnet. I have measured that one it is a generally in our cases it is around 19 I think millimetres or no can be is 19 millimetre around 2 centimeter.

we have to keep note that this is the for safety if any changes are there you can again make it 19 millimeter because, your calibration curve we have made for 19 millimeter. now this electromagnet how to connect you know that we need this constant current power supply for coil currents. this is the constant current power supply ok.

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now we will pass current through this coils this electromagnetic coils. these two connection one can make it ok. this is; this is coming from this electromagnet ok. If you connect these two here how it is connected electromagnetic these two coils how it is connected. current should be flow in same direction. that way it is connected interconnected these two electromagnet and other two end of the electromagnetic is these. these we have connected with the constant current power supply ok.

Now, if I switch on this constant current power supply. Now, here for different coil currents what is the magnetic field between these two pole pieces. at the middle of this pole pieces where we will put our sample that there we will put this gauss meters hall probe of these gauss meters this is the gauss meters this is the gauss meter. just switch on these gauss meter switch on these gauss meters, it is just fluctuating. this it is I should put in middle between two pole pieces ok, where we will put our sample.

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Hall probe how it gives the this reading of the magnetic field that I have discussed. I am not repeat that one. here now fill should be current is 0 fill should be zero, but there are some reading it is showing. there is a 0 adjustment I can make it 0. it is more or less 0. 0 current 0 magnetic field ok.

Now, what I have to do? I have to I have to make a calibration curve, current coil current. this should be coil current; coil current I can write I c in unities I think you can write in ampere current in ampere or milli ampere whatever. Current in ampere and corresponding magnetic field; magnetic field H in o state or if you write b then we write gauss ok. in o state or gauss or gauss. if you write gauss then we write B, B in ok.

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0 curren,t 0 magnetic field. Now, I will change current; I will change current say I will change current say 0.2 ampere 0.2 ampere 0.2 ampere. what is the magnetic field it is showing? it is a showing negative.

if you change the polarity it will show the positive or just it also depends on this I think it may depend on if you rotate the I do not know let me check it. if I rotate this probe no I cannot rotate anyway let me keep it without disturbing it is in middle more or less. anyway you write this is 0.64. here polarity does the matter just one polarity we are taking 164. all reading will be minus, if necessary you can include this minus sign later on.

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this way 0.2, 0.4, 0.6 just vary, then I will go to point now it is 0.3 let me go to 0.4 ok. It is a 0.4 corresponding reading is 3 2 5 corresponding reading is 0.4 3 2 5 ok. this one 164 into 28 2 3 you see one thing you can check that is generally this field we if we will expect that it will be linear curve you know. It will be linear curve for smaller current smaller field and you can it is a linear you see, it’s a 164 it is a 2 328, it just doubled current is double magnetic field is double. It is a double is 328 here we are getting 325 ok.

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Next you go to the 0.6; go to 0.6. Now, field is 0.6 your field is 496. now, current is 3 times let me check 164 into 3 3 times. 2 9 3 4 you see 492, but I am getting 496. current is 3 times magnetic field is 3 times it is the linear.

I am taking my reading is this way you see you have to apply your you have to be when you are taking data you have to be cautious you know. just you are taking data next one you know that curve should be linear. whether it is following or not just taking 3 data I can see it is the it is going towards the linear and higher current it will deviate slightly deviate from the linearity ok.

if you now from the slope of this curve if it is linear. now, whatever the slope you will get that slope you will be using this slope that is the calibration constant. if we you to if you know the current using the slope you can find out the corresponding magnetic field. then I do not need the Hall probe to place the sample place. now, this way you should continue and do the calibration. (Refer Slide Time 13:14)

Next, what I will do? First I should reduce the current; I should reduce the current coil current make it 0 and gauss meter also showing 0.

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then will just shift I will take away the Hall probe ok. this I do not need basically; this I do not need I will switch off that one ok. Now, next is I have to take data for resistance measurement in magnetic field of our sample.

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Now, we will use sample this is the sample you see this is the sample germanium a piece of germanium; a piece of germanium ok. this sample we want to study the magnetic resistance of this sample, this is n type germanium sample ok.

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this sample I need four connections, four probe method four connection. I will use; I will use this type of arrangement you see this type of arrangement I can open it and show you.

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here spring is there. I will place; I will place that circle here; I will place the sample here I have to place sample here and then I will then I have to there is a spin here I will show you. I have to just I have not place the sample, but just I am showing I will just both equally I have to; I have to ok. Both equally I have to I have to tighten you see the probe is touching this you see. Now, this probe is touching this one ok.

I can open it and show you that probe that alI can do, but I will use another because sample already is there. I will open it and show you what is there. it is the there is a spring I should hold it: I should hold it, yes you see you see this four probes are there here this.

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that contact that probe we will get four contact we will get four contact they are equidistance. outer two we will use for the current and middle two we will use for the for the voltage ok. it is a spring arrangement you can see this spring is there spring is there, here also spring is there here also spring is there. it is a nice arrangement or four probe linear four probe measurement.

I will use the same similar probe, let me just slightly tighten it later on we will work on it. this is the four probe arrangement now there we have put sample that the same sample. this is the it is already now this I will use for our measurement you can just notice there is a sample ok. There is a sample this side this four probe and this there is a that piece is there that sample ok.

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now this wires this four probe if through this; through this ok. You cannot see that one four wires are connected with that one ok. This four connection this four connections four wires are connected with this four probe, there ok. two for current and two for the voltage we that you have to identify just you take a volt meter and sorry you take a multimeter then check which two are connected to with the outer wall and which two are connected with the middle one that way you can identify.

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that we have done and now, I will place; I will place this probe; I will place this probe ok. I can do from opposite side then you can I think which is better I can place this way here I will keep. you can see it I have to place the sample at the middle where I placed the probe for measuring the, for calibrating the magnetic field I have placed it ok.

now our sample is in the air gap of the electromagnet. precaution you have to take the place we have use the middle point of this air gap for measuring the magnetic field using the Hall probe. when I will place this four probe with samples sample should be at the middle place. that way I have I have put it.

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Now, this two here you can see as I told four wires are there; two are for constant current and two for the measuring the voltage. these two; these two red and black this is the constant current source. Here it is written magnet resistance setup here there is an option for applying current and corresponding what is the voltage also you can you can get from the same display ok.

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But here we will use only for as a for current and for measuring the voltage we will use this one digital microvoltmeter ok. that is why these two connection we have made with this meters voltmeter. these two connected with this voltmeter and other two are connected with this constant current source ok.

now, let me switch on this current I will apply experiment you can as a told for a particular current for a particular sample current and that is coil current ok. For a particular sample current say let me take 2 this is in milli here milliampere. let me take 2 milliampere say slowly I should change.

two milliampere I have put two milliampere current it is a 2 milliampere current. Now, this current constant current is passing through the through the sample through these outer probe outer these two probe ah passing through the sample.

Now, what is the corresponding voltage drop; what is the corresponding voltage drop? That reading I will get from this voltmeter micro voltmeter. I have kept it at 2 volt range it is showing 0.284 volt and magnetic field current coil current corresponding magnetic field 0.

what I will note down? Next I will note down the constant sample current for sample current I sample, this is 2.00 it is the milliampere ok. For this current we will keep fixed for this current now, magnetic field current coil current corresponding magnetic field and voltage reading ok. coil current now it is 0, corresponding magnetic field will be 0 and voltage we are getting 0.283 volt ok.

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now what I will do? I will apply magnetic field; I will apply magnetic field. let me apply 0.2 say 0.2 ampere coil current and now there is no significant change. Here its it is a fluctuated fluctuation sample is becoming or resistance slightly changing some fluctuation or this meter itself fluctuating.

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I in this case there is no change 0.2 coil current corresponding magnetic field you will get from this curve and that is also 0.283. it becomes slightly we can adjust it, but this is not the good way to do it ok. this become 0.2 current decrease that why it is a 0.7 0.287. that way I will vary magnetic field in step by step; step by step and see the change ok. it's the 0.4; 0.4 ok.

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current I should keep constant current it should remain constant, but somehow my it is not. it should not vary it should not vary current should remain constant; current remain constant current should it's an ok. it is a 2.84, it is remains same it is fluctuating it is fluctuating. it should not happen it is a 2.86. there is no much variation you should increase. I think I can take in 0.5 step ok.

in small field there is no significant change; there is no significant change. this way you just go ahead let me show you at higher I will go up to 4. Say, 2 ampere I will go to 2 ampere coil current ok, 2 ampere coil current. Something wrong looks to me; something wrong there is no change, something wrong there is no change this is not remaining constant.

I should go more or I do not know, but it is out of range ok. There is no change I think I have to find out what is the; what is the possible reason there is no variation of magnetic field. we have to check it something it may happen that air gap is no air gap should be fine because I was getting fields sufficient change of field. But let me check field just at the same place with us it is ok, yes it is ok. It is a magnetic field is there magnetic field is there, but this is not this is not remaining constant it’s a changing.

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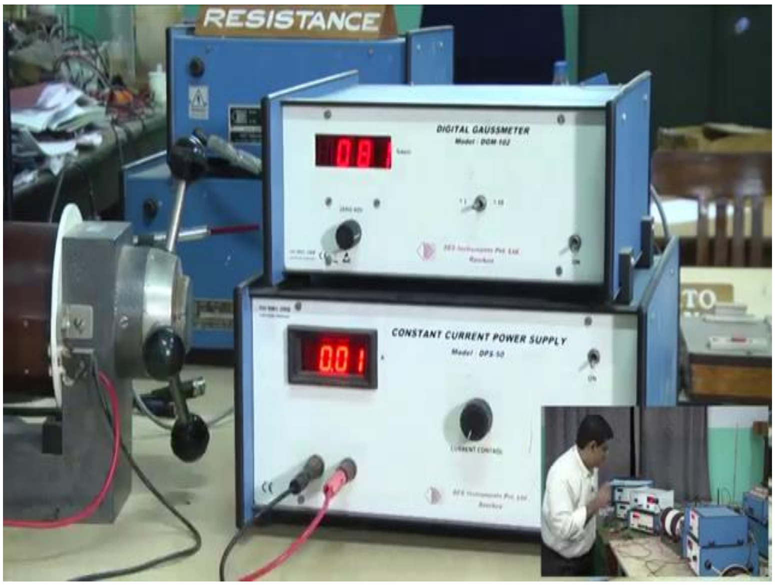

But even if I put yeah there is no change of magnetic field I think. we are facing problem then what I have done I have change the sample with another probe ok.

I have placed it and then I found this problem with this connection that I have rectified. Now, we can see since this is another probe. it is a current is change for 0 field one has to note down 308 ok. This is for 2 milliampere sample current now, I will apply magnetic field; I will apply magnetic field and there is no change. apply magnetic field and see this 308 to 309 for 1.8. this is for maximum field what is the change let me see for 4.24 this is 316. 308 to 316 millivolt ok, this is the change.

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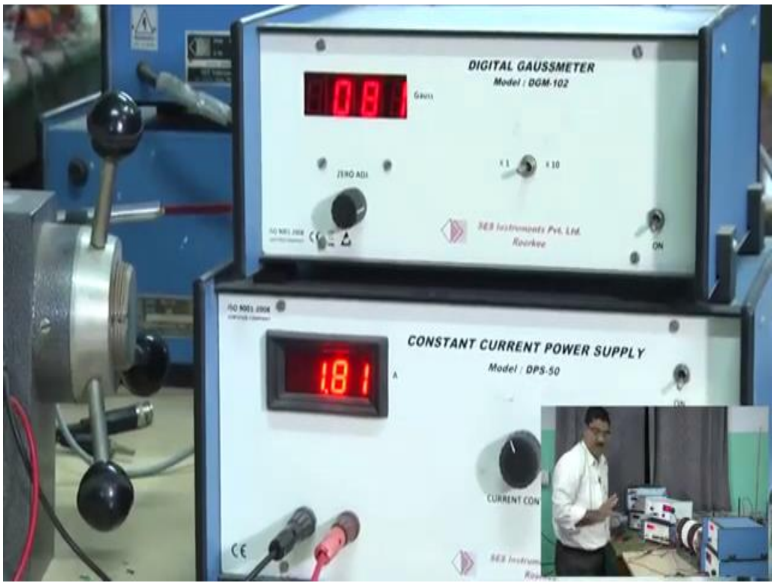

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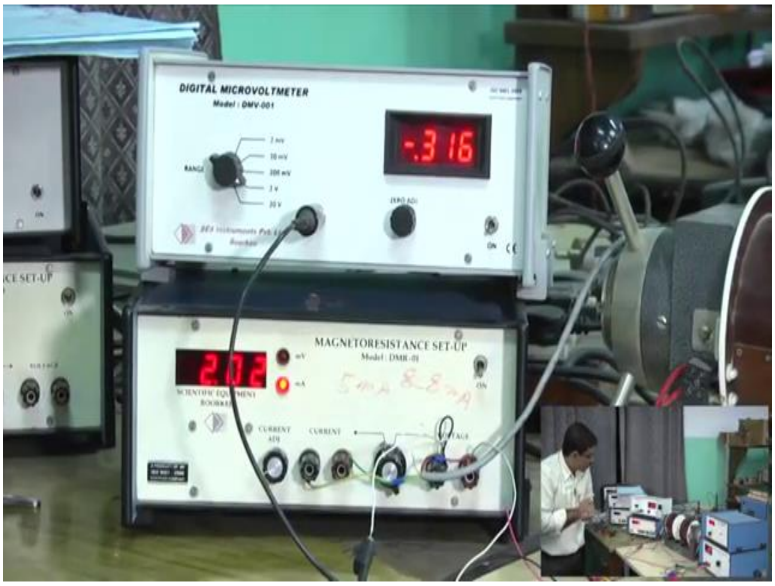

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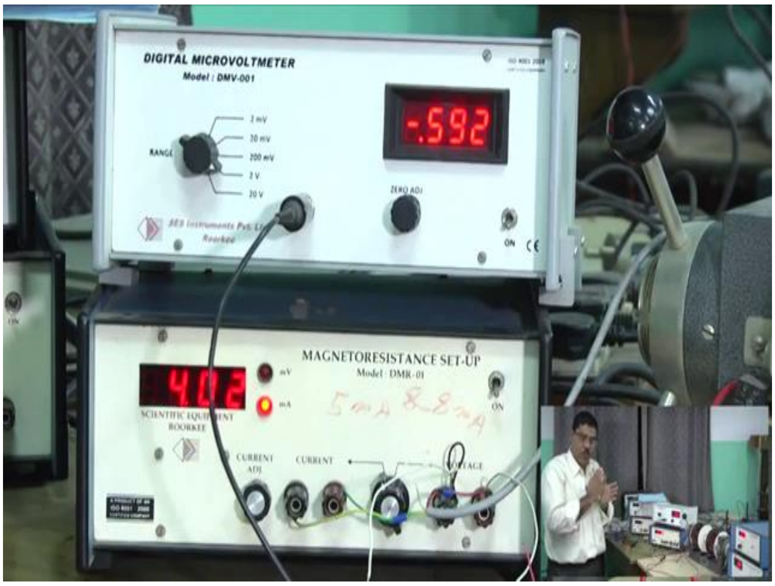

Now, I will go for the let me reduce the field let me reduce the field to 0. Now, I will I will go to the second current say 3 ampere; 3 ampere milliampere and then forth current 4 milliampere. let me just show you 4 milliampere. there variation will be higher ok.

now it is 593 for 0 magnetic field, this is another set ok. 3 set data we will take for 2 milliampere sample current, for 3 milliampere sample current, for 4 milliampere sample current. for 4 milliampere sample current this is for 0 magnetic field, this voltage is 590 milli volt now I will change the magnetic field ok.

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you have to do step by step for 1 ampere current this is 592. this is just you vary and see what is the effect of magnetic field for maximum magnetic field I have applied its now 509 or 508 ok.

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for from 592 93 it is the 5 change you see this that voltage change is very small; that means, resistance change is very small, magneto resistance is very small ok. that is why resistance change is very small these two probe this very small change you need very sensitive measurement. that is why if you use two probe you will not see any change ok.

that is why we are using four probe method that this sensible this sensitive change means very small change can be measured. here whatever change of magnetic field we have change of volt as a function of magnetic field we are seeing. that is that is that is because of the very small change of the resistance of the sample with magnetic field ok.

now we you have data you can calculate magneto resistance for different magnetic field. Because you know voltage you know current you know the resistance at different magnetic field as well as 0 field. you will be able to calculate magneto resistance ok. you plot it magneto resistance versus magnetic field and then you should get; you should get; you should get this type of curve. Yes, this type of data you should get and that MR and this is H.

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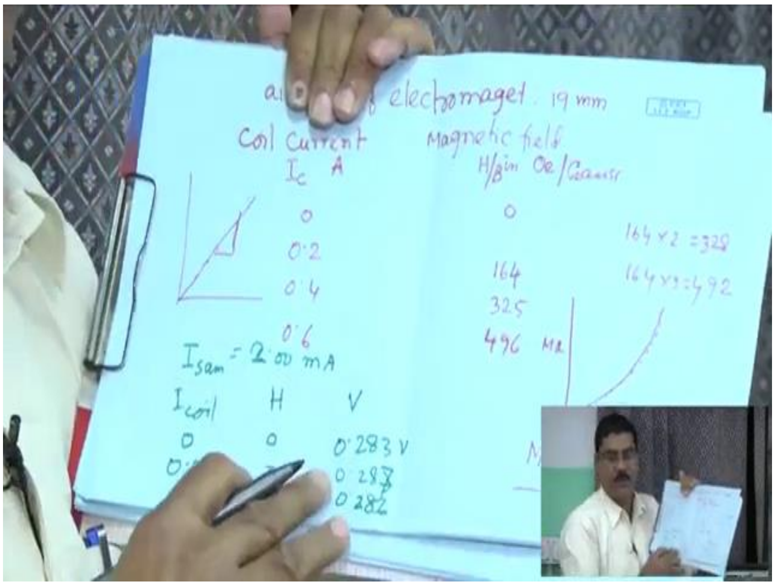

this if you fit it will follow this equation MR is proportional to A square or B square ok. And it comes this is the experiment and nice experiment you can demonstrate that how magneto resistance depends on the magnetic field for metal, for semiconductor; for metal dependence is different ok.

I think there are many things in this magnetic field, Hall probe then four probe method lot of things are involved in this experiment. And in earlier I discussed about the magnetic how magnetic field would produce; how measure the magnetic field. Now, I explained four probe method and how four probe is used for measuring the small change of resistance. the that in terms of magneto resistance we showed you the use of the four probe method this very important method. I will stop here ah.

Thank you.