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# Lecture-19
## Materials Characterization
## Fundamentals of Scanning Electron Microscopy

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Hello every one welcome to this material characterization course in the last class we looked at the details of the image contrast in the scanning electron microscopy and then and we also looked at some of the parameters which significantly influence the image contrast and typically the topographic and atomic number contrast is primarily controlled by the secondary electron and electron singles.

And I also maintained that there are some more special contrast mechanism possible in an SEM and today we will look at some of them very briefly if not detail for the fake of completion of all the contrast mechanism possible under SEM so what I will do is I will just write in on the black board.

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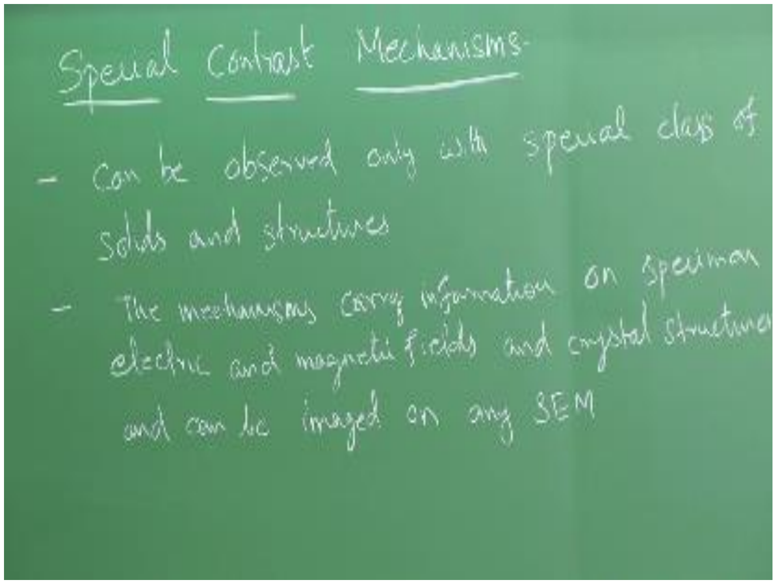


So when we say that is a special contrast mechanism this can be observed only with the special class of materials or solid and structures and typically these mechanism carry the information on the specimen electric and magnetic fields and these two structures and this can be imaged in any of the scanning electron microscope first we will look thorough the electric fields how it can be imaged and what is the idea behind it and then we will move on to the magnetic fields so first is electric field.

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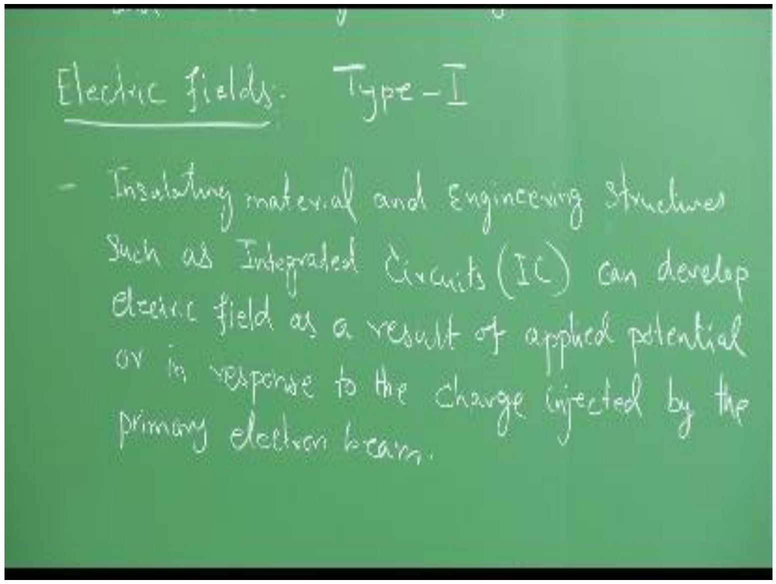


So we will first look at the how to image this electric fields there are two types what we now going to look at it is type 1 where you have the insulating material and engineering structure such as integrated circuits can develop electric field as a result of applied potential or in response to the charge injected by the primary election beam so what is that causes the image that we will see now.

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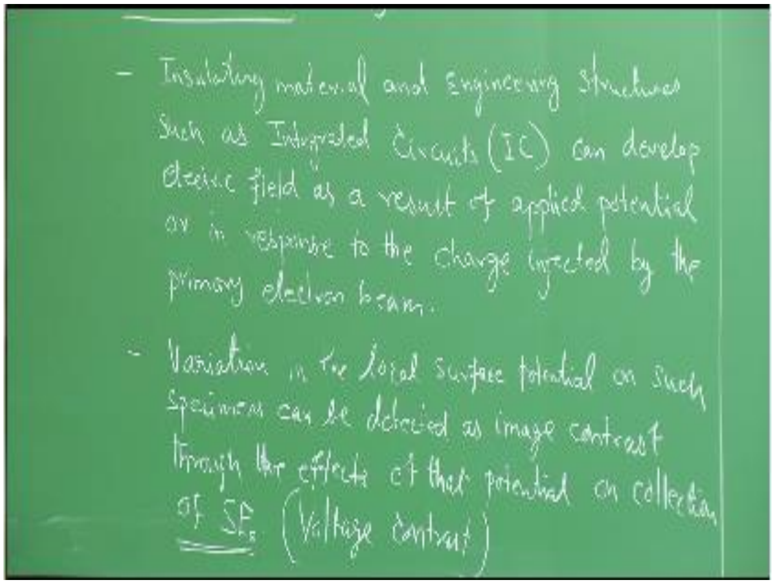


You see when this electron beam interacts with this any inculcating theory or the IC circuits the variation in the local surface potential on such specimens can be deducted as the image contrast through the effects of the potential on collection of SEc collection of secondary electrons through the ET detector like we have seen in the other mechanism see this potential ages in collecting the secondary electron which is come out of this structures could be IC circuits are any insulating material because of the variations in the local surface potential it can be imaged as voltage contrast.

So this is 1 type we will look at the other type.

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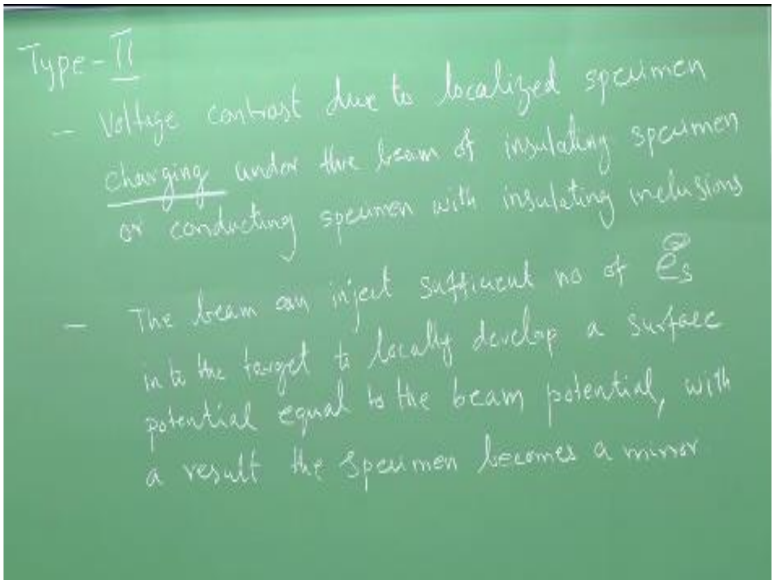


You see this is another very important aspect of resume operation itself some of you would have seen or may see that sometimes your specimen is getting charged whether you operate till this or if you are operating the machine you itself will observe it that is a voltage contrast you to localize the specimen charging under the beam of insulating specimen or a conducting specimen with insulating inclusions.

So non-conducting inclusion we also cause charging effect and that is because of, so what happens is in the insulation material the beam can inject sufficient number of electrons into the target to develop a surface potential local equal to the beam potential, so with the result to the specimen becomes a mirror actually you are just looking at the beam you can say that, so that is why you get the images of a charging effect.

You can see that in a grey micrograph from parts some portions wherever you have this insulation material or insulation insulating inclusions you will see that very white bright spots which may not be actual feature of your material or of a microstructure so this is the another type of imaging using this voltage contrast in a base CM, now we will look at the magnetic fields.

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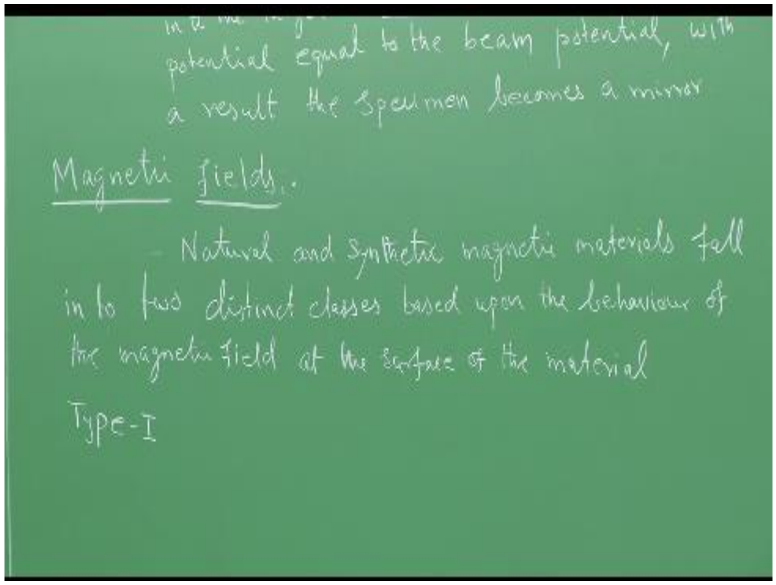


So in the case of magnetic fields imaging where you have the natural and synthetic magnetic materials fall into two distinct classes based upon the behavior of the magnetic field at the surface of the material, there are two types first we will see type 1 imaging so that is based on.

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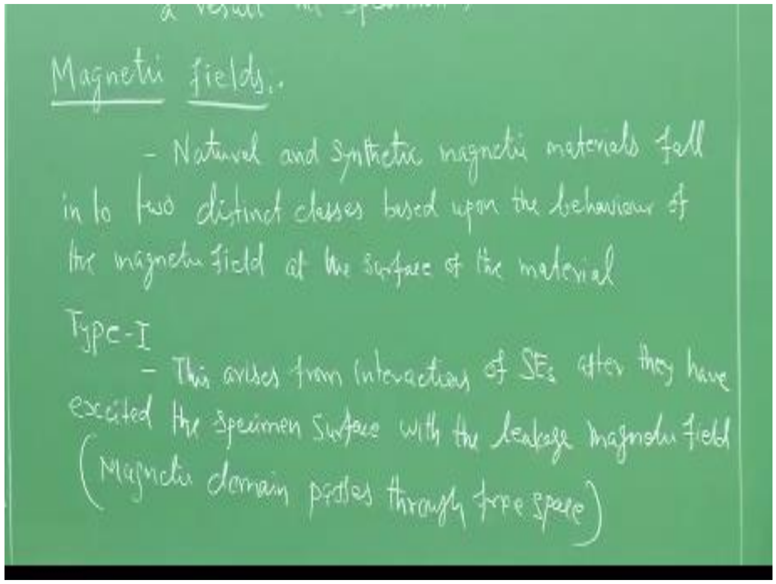


So the first type of the magnetic field imaging fall into the this category where this contrast arises because from the interaction of secondary electrons after they have excited this specimens surface with the leakage magnetic field of the magnetic specimen so what is leakage magnetic field.

So you see in a magnetic material you have all the spins oriented in same direction for the magnetic domain and then when the magnetic domain reaches the surface a free space there it is called magnetic leakage you can write in the bracket. Magnetic domain a magnetic domain passes through free space where it is called a magnetic field leakage. So the interaction between those fields with the secondary electrons gives the net contrast. So I will just need to draw a schematic for that.

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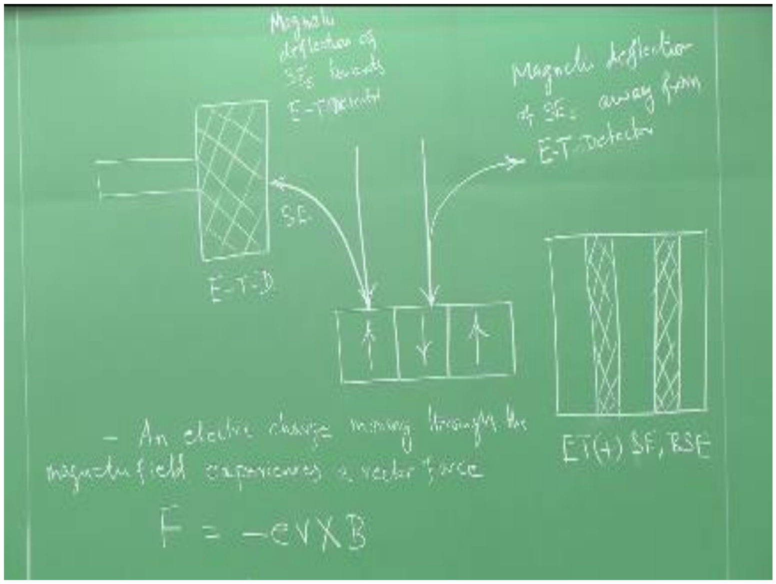


So you see a schematic representation I have drawn here is this is an ET detector and this is the specimen we talked about. And there are two distinct events happen here. Because of this an electric charge moving through the magnetic fields expresses a vector force. F = -EV x B V is the velocity of vector, vector of secondary electron, B is the magnetic field, E is the electronic charge. So what happens is and this field the job of this field is to accelerate the secondary electron it is not just the acceleration of the secondary electron.

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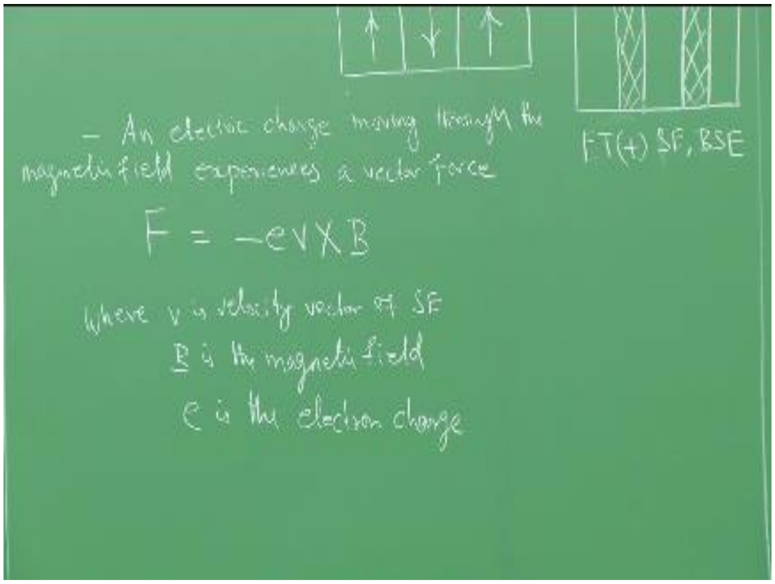


But also the making directional component of the secondary electrons directionality is also controlled by this force. So in that process what happens is you have this as IM of particular orientation at the magnetic deflection of see towards Ed detector. And where you have the opposite domain where the magnetic deflection of SC is away from the ED detector. So you know now very well when you do this then you are making a secondary electron yield very high. And when it is moving away from the secondary electron the yield is reduced. So in that sense you have you develop a dark and a bright band in the specimen image.

So that is how the, the image contrast is produced we will write it down so that we would miss the point.

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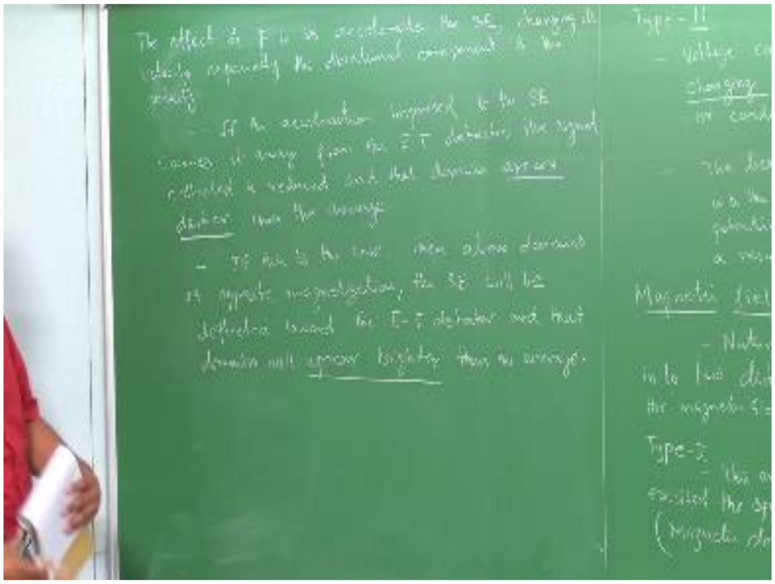

The effect of force is F is to. So whatever is shown in the schematic we have put them in the form of couple of sentences. To the effect of this force is F is to accelerate the secondary electron, changing it is velocity. Especially the directional component of the velocity. So when you have the control long directions then you have both the options. If the acceleration imported by the secondary electrons carries it away from ET detector. Then the signal collected is reduced and the domain appear darker than the average so we are talking about suppose if you have the. This is an image so we are talking about this parker domain. Suppose if you suppose if this is the case then the above domains of opposite magnetization.

The secondary electron will be deflected towards the ET detector and that domain will appear brighter than the average. So you will have bands of a dark bright, dark bright, dark bright kind of animation. Which actually you are imaging the magnetic domains of particular orientation. So this is about type 1 of magnetic field imaging then we will look at the type 2.

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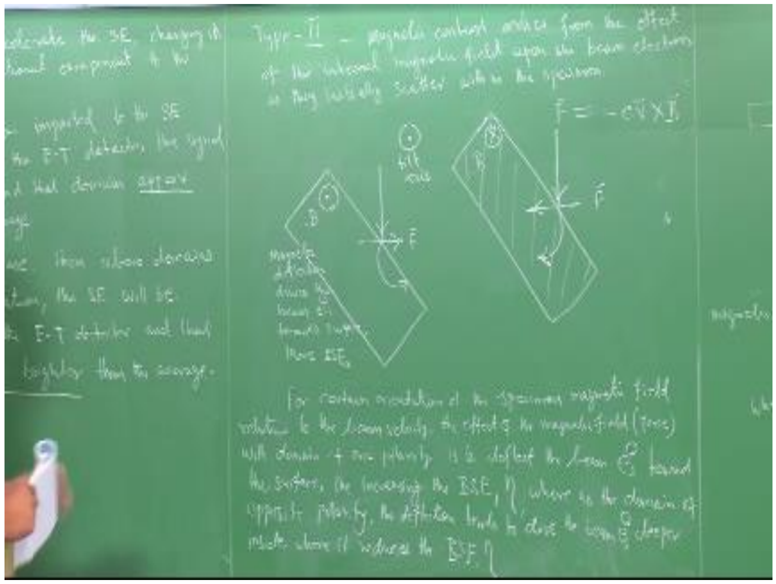

So this type 2 contrast or magnetic contrast arises from the effect of internal magnetic field up on the beam electrons as the initial scatter within the specimen so it is the interaction, between the internal magnetic, field at the beam of electrons after they initially scatter within this specimen. I need to draw one schematic again based we will use the same equation here also F=-vxB so you have.

See what we have drawn here as a schematic once second a micro schematic specimen and this is a till taxes of this so it is kept in this one direction and then operate tills and it is in another direction.

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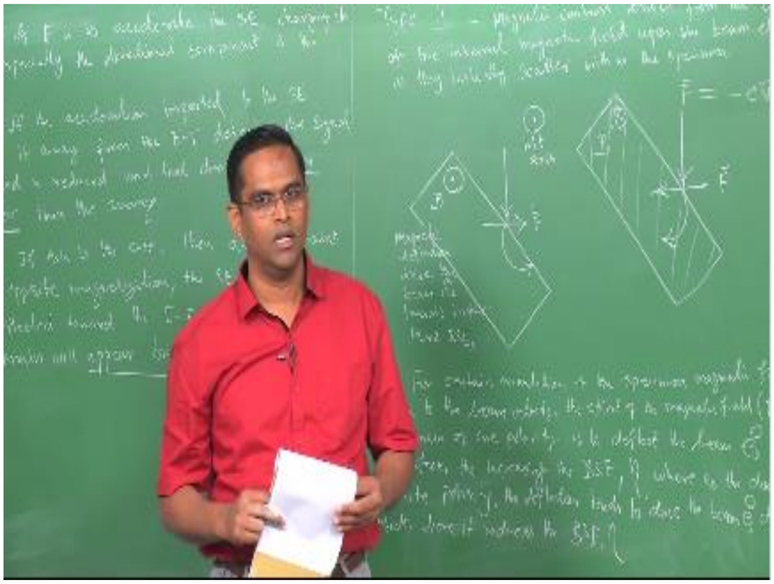

So what is shown in this schematic is for certain orientation of the specimen magnetic field relative to the deem velocity the effect of magnetic field that is force with the domain of 1 polarity to deflect the beam of electrons towards the surface that is this case for this polarity the magnetic deflection pushes the beam of electrons towards surface that means I get more backscattered electrons here because of this force then that increase the backscattered electron it whereas the domain of opposite polarity for example if I this is an opposite polarity.

The deflection times to drag the beam electrons much more deeper inside the specimen where it reduces the BSC field low backscattered electron yield in this case in this case it is a more backscattered electron yield so that produces again a similar cantor strop a bright and a dark bands in the image of the respective specimens so this is a type two a magnetic contrast which one can appreciated the scanning electron microscopy and to more contrast mechanisms I would like to discuss.

Namely the electron channeling and as well as electron backscattered live fraction EBSD these two I will briefly discuss in the next class and I will also show some of the laboratory demonstrations how we are going to acquire this EDST maps using ACM thank you.

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