Indian Institute of technology Madras
Presents

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Lecture - 5
Materials Characterization
Fundamentals of Optical microscopy

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Welcome back in the last class we just reviewed the concept of filters, illumination filters and interference filters and we also looked at the definition of optical path length and so on. And before we started the optical microscopy topic, and we also extensively looked at the different kinds of lengths defects. So I just introducing you the equipment, the light optical microscope, I would like to continue to do that.

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So let us look at what I just showed in the last class. The first one I introduce is the metallurgical microscope which is an inverted type. And I just want to have a feel of how this equipment look like, then we will slowly get into the details of the quartz details as well as the operation details as we go along. So I think we have just seen that let me sped up this, I also told that this is attached within CCTV camera and also with some polarizer's and analyzers and so on.

These attachments we will take it up as and when we deal with the variation of the microscope. So what you now see is an illumination stage where the sample is kept and this is a simple type in metallurgical microscope which I introduced in this last class. So just have a look at it again this is specimen stage and these are all different objectives and this is you ocular.

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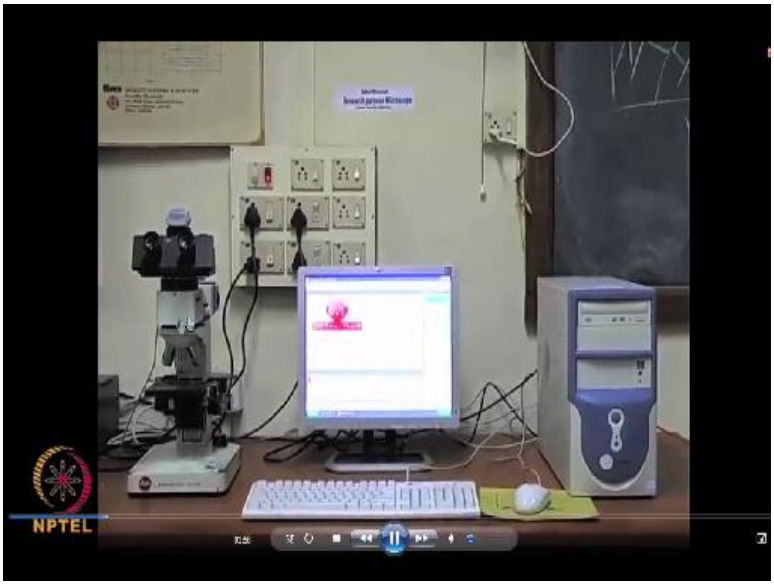

And the another one is which is the image analysis system, that also I just introduced just to recap. You can see that objective lens again system stage. So these objectives will have three or four depending upon the microscope ranging from 5x to 50x to 100x. And you can see that al the objectives are marked with their specification of their magnification, refractive index details. And depending upon our interest we can choose any one of this objectives to view the micro structure.

So this is again a leveling press to keep this system flat or the microscope and this is what we have seen already a metallic polish specimen is being pressed with the plast sizer to make it even if it is placed so that your reflection can be from the flat surface. Now this is how the specimen is placed out of the objective and then you choose the lowest one to examine the microscopic details through the light rays.

And you can directly light rays as well as you can look at the monitor computer monitor because it is being interfaced with the CCTV camera. So either you can look through the ocular directly or you can look at the computer monitor because it is attached with the CCTV camera. Now this microscope is the, this is where I just left in the last class. So this is the optical transmission microscope which has got two illuminating system one is halogen lamp and this one is iodine vapour lamp.

So it is being shown closely for the clarity halogen lamp, iodine vapour lamp, these two are just used for the specific application, I will just mention whenever it is applicable. So have a look at it how this the structure, the architecture is very different from the simple vertical microscope, what you have seen is the polarizer which is being engaged and then your normal white field illumination which disengage this, so that this is kept for the light to pass through.

And what you are now seeing is below the a set of a condenser and filters and approaches belong to different modes of operation, you can see that t is being numbered 1, 2 and 3 and 4 and 5 so on. So depending upon the operation mode you will turn this condenser and approaches to the particular slot which is given as a white dot here. So that you will be able to perform that particular operation.

So in this set of condenser approaches the 1 and 2 is for phase contrast mode and 3 is for DIC mode, there is differential interference contrast mode we will see in much more detail when we deal with the particular variant of the microscopic technique and 4 and 5 approaches are meant for bright field illumination. So you have this condenser of the set of approaches here and then appropriate approaches are being chosen depending upon the mode of operation.

So this is for your clarity which is more closer view of this condenser approaches being rotated 1, 2, for phase contrast mode. So 3 DIC mode, I will let you know the details of what kind of approaches and condenser details as and when I just talk about the theory of this mode of operation. I just think and I want to introduce the kind of hardware you should know, you should not think that every microscope variant will have a different, different microscope as a whole.

It is just that approach and then condenser set of filters which makes the variants of the microscope. So now again this is an polarizer being engaged and disengaged. And this is the specimen stage remember this is a transmission optical microscope so you have the transparent window where you can keep your very thin transparent sample on this glass slide. And then you can start doing it.

So this is the specimen stage which can be adjusted in X and Y moment for this knot you cn clearly see that X and Y moment. So you should have an idea this is done just to give you feel of as if your actually in the monitory to operate this microscope I will also do give you the actually experiment so that you will have a complete understanding of operation of this equipment so again this is the whole specimen stages being adjusted you can see that this is an another assess movement now you see that all your objectives are kept in the vertical position compare to the normal vertical metal screw microscope it is put in a inverted positions but you can see that you have about 6 slots one these 2 slots are empty.

But other 4 slots are filled with different kinds of congested opaque you can also see that the details of the objectives are written in this letters where the magnification details that is 4 x and this is something reflective index details and then typically this has got 4x and then 10x and then 20 x and this is 40 x or 50x so depending upon the kind of microscopes you can have whether it is a 4 objectives or 5 up to 6 so this is what about possibility of keeping 6 objectives but you have right now you have it is only 4 objectives.

So if you have up to 50 and 100x eventually you will have the magnification up to 1000x because IP’s will have 10x magnification what is that now you have seen is this a part called

analyzer the operator is just inserting the analyzer this analyzer is being used when we operate that microscope in a differential interface contrast mode DLC mode and you can do this a constructive destructive interface preference using this nope turning this nope you can make the preference of constructive and destructive interface we will see in a appropriate time how it is useful to use this parts.

So now we will see a another set of condenser aperture just below this shutter, this shutter is meant for operating this the bottom elimination which is mercury lamp most in this microscope it I being used only for florescence mode when you want to operate perform a florescence microscope then this is keep on this is in on mercury lamp will be on and when you put it back then it is in a halogen lamp mode. So here again you have a another set of condenser apertures similar to what we have see in the top of or above this objective apertures 1 and 2 for phase contrast.

And 3 for VIC and 4 and 5 for bright fill eliminations so you should keep both the condenser and aperture and filters are above and below the objectives on a same position to perform a particular mode of operation. For example if it is a you are going to operate a bright field elimination either you choose a condenser window her 4 or 5 similarly you have to rotate this of the top of or above the objective condenser lens also 4 or 5 then only your mode of operation will be correct it is just for your clarity this rotation is being found once again.

So the next detail we would like to see focusing of this is a the bigger one is the course focus and the smaller one is the fine focus it will basically move the stage towards the objective or either way you will start focusing the specimen and this a coarser this coarser fine the smaller one is fine and the next detail is the IP's elimination magnification either you have 1x, this is not out then it is 1x and if you push it inside sorry if you pull it is 1.66 if you push it inside it is 1x for a IPC so this facilities possible.

And this is your brightness control this is more intensity to the lower intensity so this an alular piece which is not about which has got some variable I mean 1x to 15 x so now you have some idea about parts of optical transmission microscope and as well as the simple vertical or inverted

microscope what are the kinds of parts you have in a system you have stage you have objective you have IP's and so ion and if it is integrated with the a computer or CCT camera then you will have those also will be part of the optical microscope.

So now I would like to show a bright field elimination in this optical microscope in actual experiments beefier I do that I would like to do some board work in a bright field elimination the primary thing is the reflectivity is the key factor in s bright field elimination so for the when you say reflectivity what happens when the light falls on the specimen then the light which is being reflected which are getting entering into the objective then that pace will appear bright so the more the reflectivity from the object the more the image quantity and so on for that the objective also should be completely eliminated.

So for that we will see some of the some of the basics of condensers and eliminators especially for an opaque specimens like a metallurgical system or material systems.

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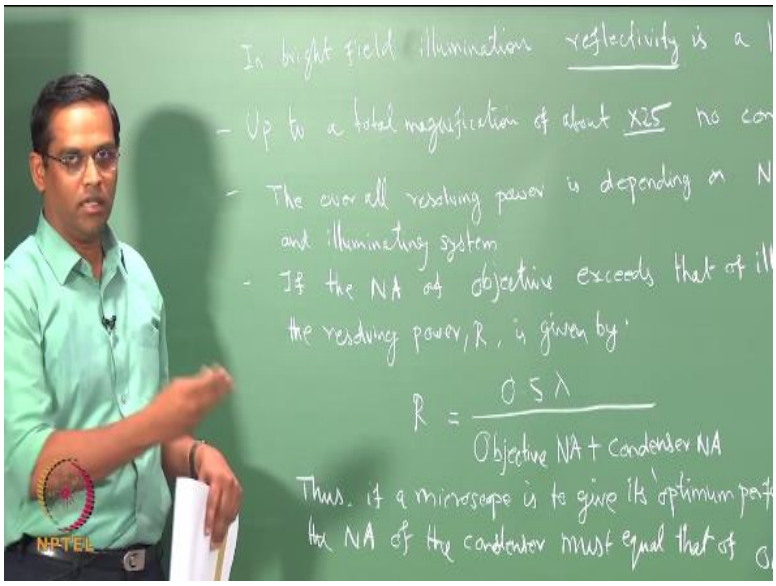

Bright field illumination reflecting t is a key factor, so this is your key point and before we will just exploit this concept we will look at the condensers and illuminators we will talk about

illuminators so you see up to 25 times of magnifications you do not require a condenser to illuminator objective but beyond that otherwise the objective which is having a higher magnification you need a condenser so let us write no condenser is necessary up to the magnificent 25x this is another point.

So the overall resolving power is depending on numerical apertures of both objective, and illuminating system so we know that already just to give a connect to the concept of reflection illumination of objectives also equally important concept so for that we are looking at the some of the basics and so we can write if the numerical aperture of the objective exceeds of illuminating system then that is all being powered we can write is given by R=0.5 times γ divided by objective numerical aperture plus condenser numerical aperture so this clears that thus if a microscope is to be given it is optimum performance the numerical aperture of the condenser must equal that of objective so let me we repeat again.

We are talking about illuminating the objective at higher magnification that is more than 25x the overall resolving power is depending on the numerical apertures of both objective and illuminating system if the numerical aperture of objective exceeds that of illuminating system then the resolving power R is given by 0.5 times γ divided by objective of D micro aperture and then condenser numerical aperture if a microscope is 2 give it is optimum performance can put it in the code the numerical aperture of the condenser must equal to the tough objective so that takes care of them.

Illumination of the objective then what we talk about this reflectivity also will be optimum so in normal microscope if you talk about the illuminating system and if you there two things we will confine our discussion only to be a metallurgical microscope primarily we will see what are the other variations in the other variants.

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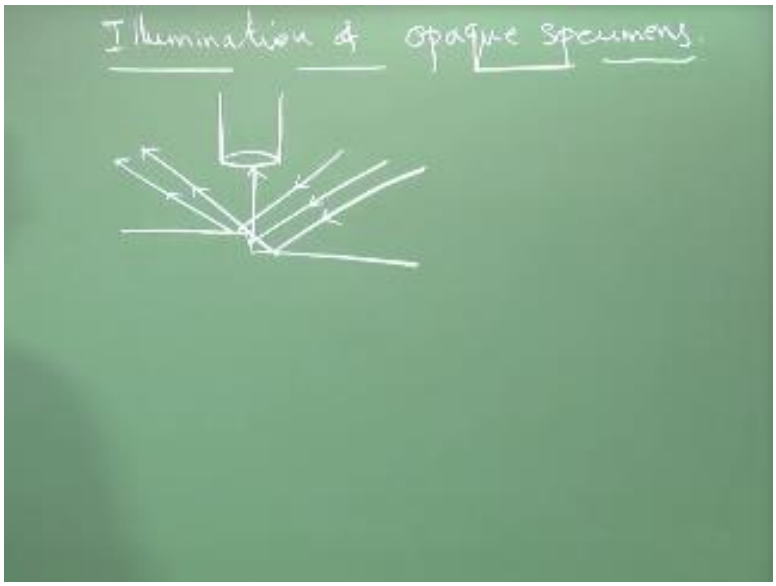

First let us take our illumination of opaque specimen see if you look at the working distance of any metallurgical microscope which we going to see I will show you it is very, very small so illuminating the specimen between the objective and the specimen surface is rarely possible so oblique illumination can be employed so what happens if you employ and oblique in elimination suppose if you have the surface like this suppose we are now illuminating like this will go and this and suppose you will have the objective here, so if it is in a oblique elimination by a surface like this if it is not a even surface the reflected rays not primary reflected rays which will not enter the objective but only the reflection which is from the step or a can uneven surface only will get into the objective only those features will appear bright in future.

So see the best is the normal elimination through the normal direction we will see just what are the eliminations which are primarily employed in the methodological microscope and then we will proceed through the bright fill elimination.

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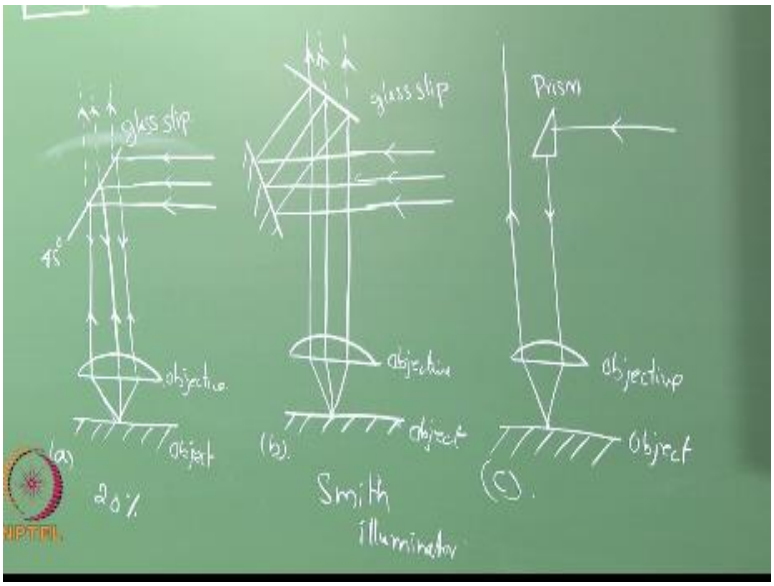

let me draw the schematic suppose this is the this is the light saying which is coming from the source so normally it is passes through a glass slit and then they are all reflected then you have the objective and then you have specimen of face this is object let as be A.

Object this is objective lens and then it goes and then it reflected back it goes to eye piece this is a an inclined slip limit eliminator inclined slit eliminator for a in a normal conventional methodological microscope the other type of elimination is this, here the glass slit is kept at 45^0 and you have this glass slip and then this comes down and you have the objective and you have the object.

This is P and then this goes to eye piece and this is called smith eliminator and the third and final one is simple one the light source comes and then it enters the a prism and then that goes free objective and the sample, this is C so you have this three kind of a elimination possible in the termination methodological microscope and this is called intentional I mean the inclined glass slip elimination and you see that with this only 20% of the light is being used for the edge formation.

And this set of base because if you use a polarized light and in this case if you use a polarized light the pain of propagation get rotated by this glass slit which is over come by this design that is for smith eliminator, the more intense elimination is possible by introducing a prism in the optical tube but then it also abstracts the rate part in the tube but these are the primary elimination parts are being considered for the conventional methodological microscope.

So now we will look at some of the example of bright field elimination I will take you to the microscope lab again and then we will see so what you are now seeing is.

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I am going to juts show you the bright field elimination and the identifying the micro structure there are three samples.

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One is steel specimen another is stacker Styron another is aluminum specimen we will seed how this bright field elimination gives them.

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What kind of information we will use again the vertical the type microscope and I will take up this sample preparation techniques in a separate class and this is just I am introducing a specific mode of operation so we are talking about a bright field elimination now so even you should have some idea about how this bright field is looking like, so we will keep this so now the sample is being kept the polish sample being kept on inverted microscope and what you now see is this is another I mean this is crush sample.

And you can even use this slipped to be station the specimen and then you use the appropriate objective lens to start with that will be the lowest probably the 5x objective you use and you can rotate the tour and what you now see is selecting the appropriate objective and then and viewing it on this specimen and this is for aluminums sample so all these three micro structures we are going to look at it that is why it is just shown how the sample are being kept and then just it is just showing then operational mode how you look at it.

Since it is reflection microscope and I say as I said it is some opaque samples so we will see how the right field micro structure appears. So you see the microstructure is graphed by the CDD camera and now you are seeing it in the monitor this is the a cast iron microstructure where you

see the people who have some materials background will understand what I am saying otherwise the people who do not have the materials and we do not have worry what it is.

All that you have to appreciate is you are able to see this microstructure because of the reflection the region which is appearing very bright or getting the lights are getting into the objective the one which is appearing dark they are escaping the objective that is something go back. See so here the for the people who understand the material the information and this is white cast serine and then you have so now you see that you are increasing the magnification you are able to see the third phase details.

So you have basically a two phase in this case it is for eight and semantide the white is semantide and the black is paralite sorry, paralite and semantide sorry and then you increase the magnification to 500X so you start seeing much more detail of this specimen, see you see that there is a magnification increases your you can see that the depth of focus is also having some issue because the specimen flatness is questioned here and you can see that at the end of the corner you are not able to focus as good as in the center region of the specimen.

So now you go to the 500X or even more 1000X you will see that much more detail, I think it is getting blood beyond this we will look at the next okay, this is better 1000X and this is for the medium carbon sties specimen as a lowest magnification on 100X you see that frighten white is frighten black is paralite as I mentioned the people do not have the back ground and materials you do not have to worry it is just that the phase which is appearing bright that means the reflectivity of that phases very high you can say that.

That means the ray which is coming from this white surface are entering into objective the one which is appearing dark escape the objective that is all you have to remember and then appreciate. For ant specimen which is having this kind of a surface undulation you will have this kind of a contrast. Again this is a 200X magnification and you see the details of the microstructure is getting better and better,.

So now you go to 500X you see the much more detail inside the white region all close boundaries are being reveled so clearly and this is 1000X magnification you can even see that you are able to resolve this the black position which is paralite and you are able to see much more details of the sample. So you just see okay, this is a better 1000X you can see much more clear with details of the black phase and so we will now move on to the next sample this is the aluminum sample this is an as-cast structure you are able to see that it is a cast structure.

The people who do not have this background for this material I would say them it is a solidified form of aluminum microstructure you see that we call it these things are called in metallurgical terms are dendrites and then you can see that the details much more details of this specimen that as you go from lower magnification to higher magnification much more clear details are visible. You can see that inside this the other black phase you will be able to see much more details of the microstructure information.

So with that I would like to move on to the next technique what we have now seen is a bright field elimination in a conventional metallurgical microscope the kind of information you get what I have just demonstrated and in the next class I will start with the first another variant of optical microscope and then I will also similarly take you to this microscopy and then show the actual demonstration of the different contrast which you obtain from the microscope, thank you.

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