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Theory and Practice of Non Destructive Testing

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Radiography - 3

Hi everyone so we have started this topic radiographic testing and in the previous two classes we learned about the basic principle behind this technique which was primarily based on this particular equation.

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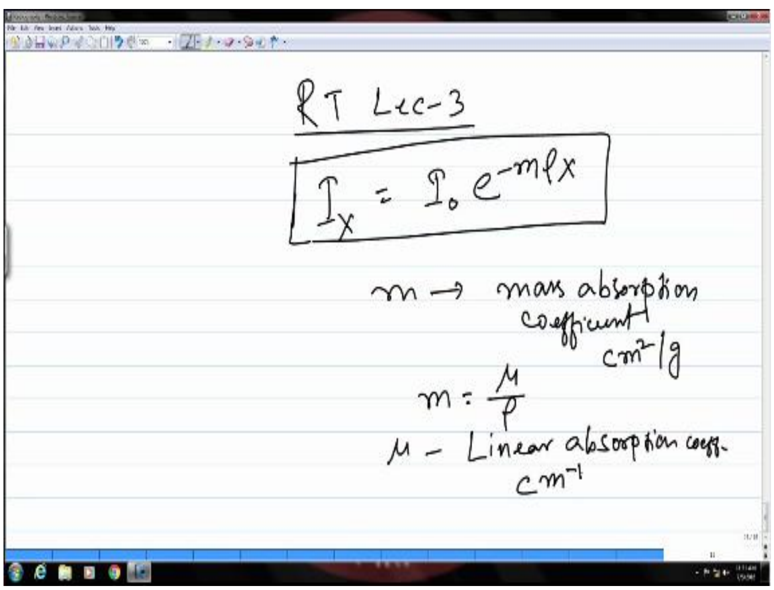

That we derived in the previous class that when next says travels through a matter there is a Tunisian or decrease in the intensity of the x-rays which is proportional to the distance through which the x rays travel and the absorption property of the material through which the x-rays are traveling so this is what we derived and this will form the basis for the radiographic testing and this is the property of the material with regard to absorption of x-rays and this is known as mass absorption coefficient and the unit for this is cm^2/g and we have also seen that m is equal to μ / ρ where in μ is the linear absorption coefficient.

And μ the unit for μ is cm^{-1} okay so this is the equation which governs radiographic testing and then we also saw that different kinds of atomic scattering events which leads to a Tunisian of the x-rays or their absorption and today we will continue on this and now we are going to see how x-rays are used to do radiographic testing and form the image.

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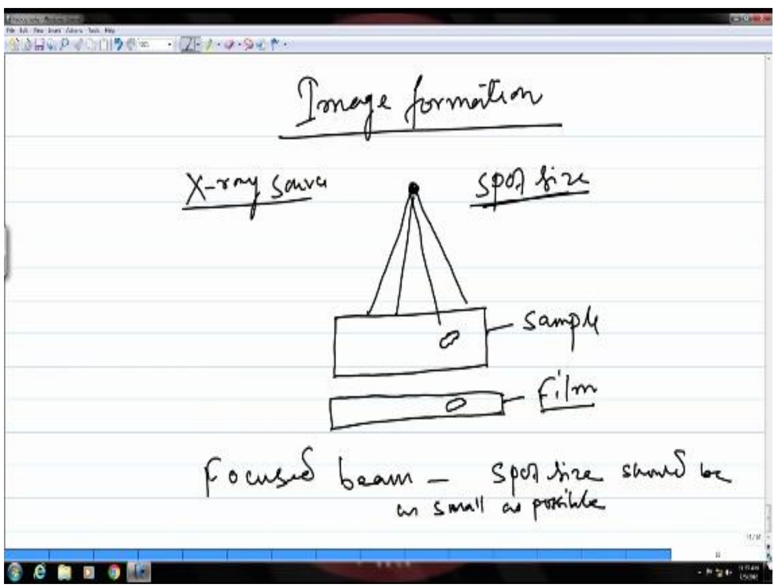

So if you talk about the image formation now the first thing that you need is an x- ray source and the source should be as small as possible in terms of the spot size if you have a point source that is best but practically using a point source there are limitations which we are going to talk about now so then you have the x- rays coming from this source I am going into the sample and now if you have any defect in the sample that will be imaged along with the sample in the radiographic film which is kept below the sample okay.

So then you will see a 2d image or the shadow of this whole sample and the defect on the image which is formed on the radiographic film okay so this is how the image is formed and as I told you need a focused beam and the focal spot size should be as small as possible because lower the spot size higher will be the image quality.

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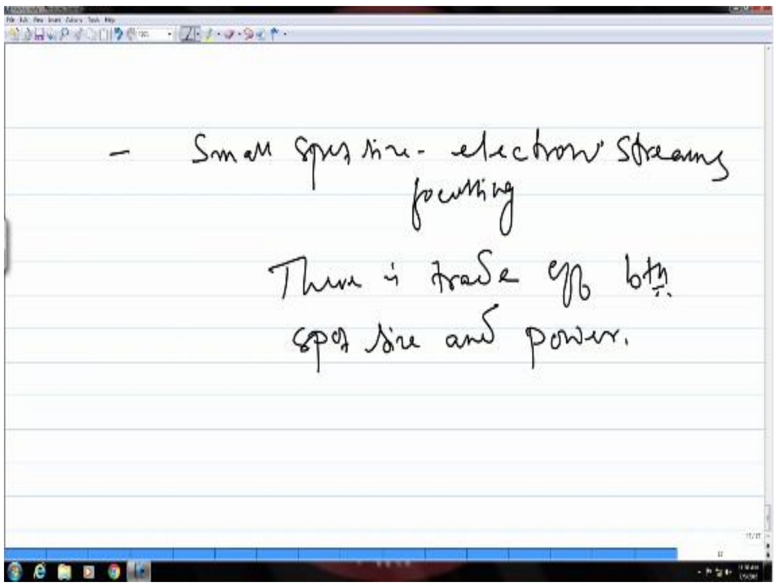

But remember one thing when you have a small spot size you have electron streams focusing on a very small area and this will lead to intensity locally around that area and as a result of that you know you have to control the power you have to reduce the power so that there is no excessive heating on the target so therefore when you try and use small spot size there is always a trade-off between the spot size and the power okay.

So there is a range of spot size which is available in the instruments which are used for a radiographic testing that we will talk about little later as to what kind of sizes are available and you know what will be their effect on the image quality so you have the primary components of this radiographic instrument is first extra source the extra tube that you have which generates the x-rays.

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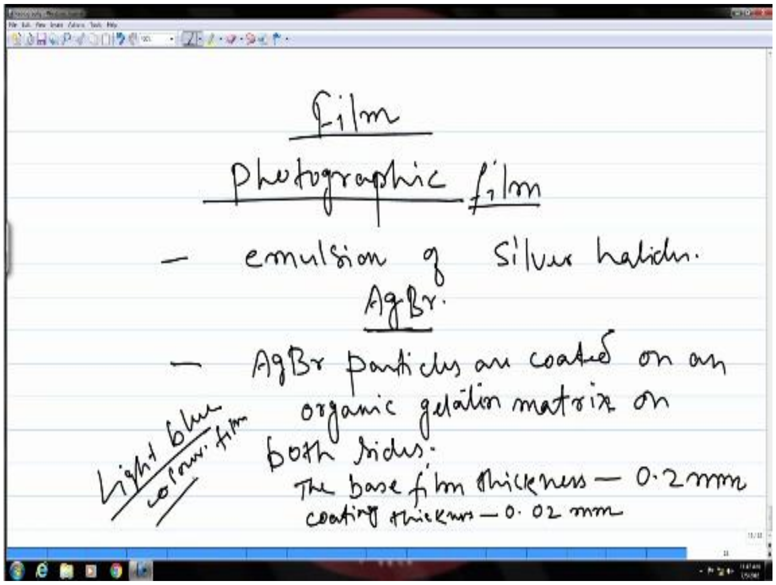

And the second one is the film on which you capture the image okay this is primarily a photographic film which interacts with electromagnetic radiation like visible light or x-ray radiation and when it interacts it darkens as I would have said you before also in the beginning when I showed you that radio graphic image of our hand so there also you saw that the whole plate is darkened and only the image of the hand you can see some white contrast for the bones okay.

So the property of this photographic film is whenever it is exposed to electromagnetic radiation it darkens and the extent of the darkening will depend on the amount of radiation which is falling on it okay if the radiation falling on the plate on the photographic film is high the darkening will be high and similarly if the radiation falling on it is low the extent of darkening will be low and that is how you see the contrast on the photographic film depending on the intensity falling on the film so this photographic film it primarily contains an emulsion of a material which can easily interact with x-rays.

So this emulsion material is silver bromide or silver lights most commonly used is silver bromide okay so this silver bromide particles that you have in this emulsion it is coated over a thin plastic sheet kind of thing because that is one that is how we have all seen this photographic film it is a thin plastic seat so this AgBr particles are coated over an organic gelatin matrix on both the sides the thickness of the base film on which this emulsion is coated is around 0. 2mm and the coating thickness is 0.02mm okay.

So this is how the film is made you have this emulsion which contains these silver bromide particles and this emulsion is quoted on a plastic material like a gelatin matrix as a thin coating and if you see this film without exposing it or before the exposure it looks like a blue color film okay so it is a light blue color film but we have most of the time seen it as a black color film because when it is exposed it becomes black okay but before exposure if you see the color is light blue.

So when this film is exposed to x-ray radiation this silver bromide particles are going to interact with the x-rays and the x-ray energy will be absorbed by these particles and it will release the silver ions and the silver ions will form that latent image which is further processed and developed and that is how the contrast is created by releasing of the silver ions when they interact with x-rays.

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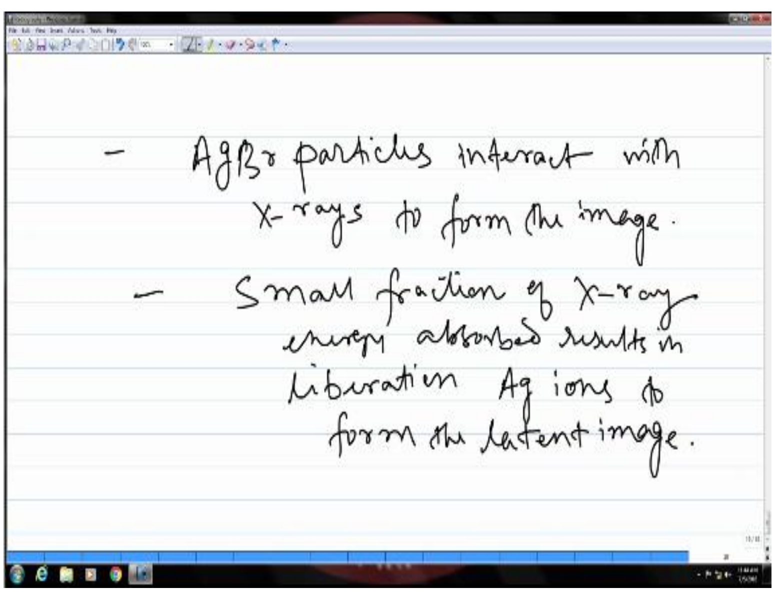

A small fraction of the x-ray energy is used in liberating the silver ions as I told which will form the latent image and when you further develop it you will get the contrast okay so this is how the image is formed by liberation of the silver ions when they interact with x-rays.

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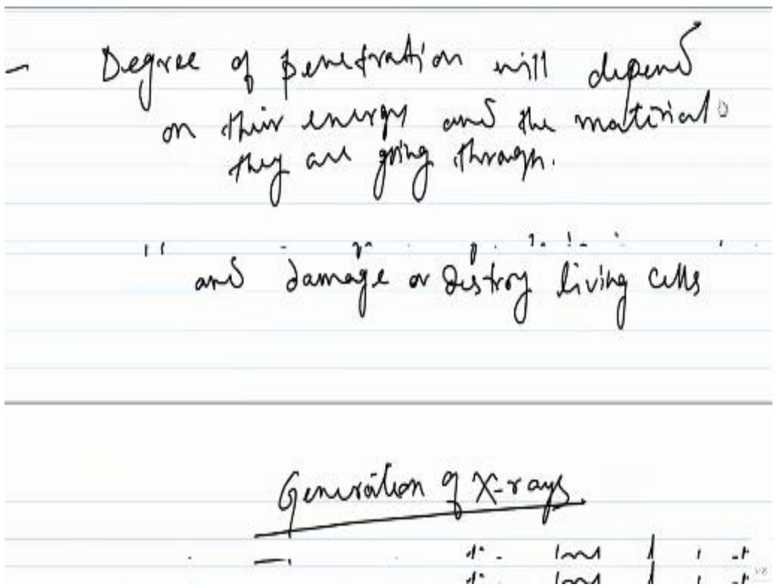

And these silver halides are most sensitive to energy in the range of around 45 kilo electron volt and the efficiency of the image formation can be improved by using what is called as intensifying screens which we are going to talk about little later okay. So now you can easily correlate if you go back to that image that I showed you in the beginning right this one.

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So now you can easily correlate why these bones are appearing quite because you have used this photographic film which gets darken when it is exposed to x-rays and as I told this darkening will depend on the amount of energy which is falling on it and since the bones will absorb the maximum amount of energy so the intensity x-ray intensity coming out from the bones will be much lower compared to the rest of the portion of the body part.

And as a result this bones will appear white because the extent of darkening from the intensity coming out from the bones will be lower okay and there are some properties that these films have so let us talk about the characteristics or properties of the extra film because these properties will finally decide the quality of the image.

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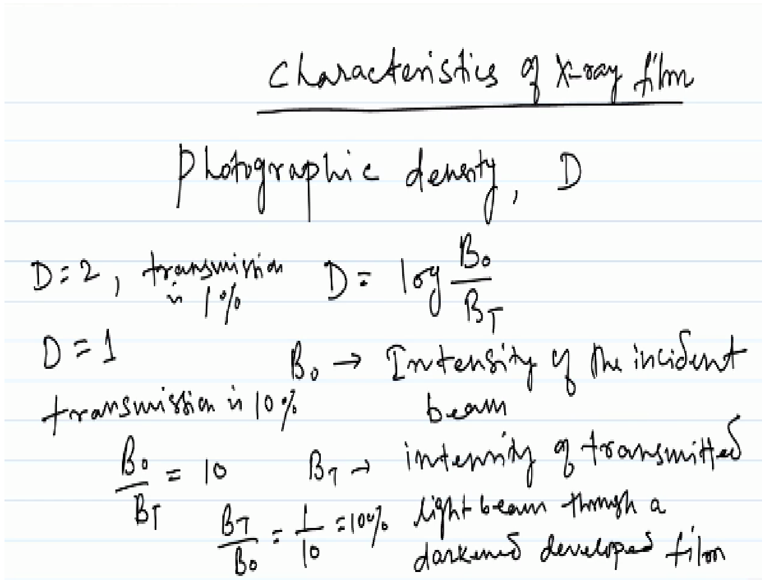

One of the most important properties of x-ray films is what is known as photographic density which is written as d and D is given by this expression log (B0/BT) wherein B0 is the intensity of the incident x-rays of the intensity of the incident beam and BT refers to the intensity of transmitted light through a completely darkened and developed film so you take the film which is already developed and darkened and then measure the intensity of light which is passing through it.

And now if you take the ratio of this incident intensity and the transmitted intensity which is B0/Bt and if you take the log of it you get the photographic density d for example if you have D equal to 1 then this means that transmission is ten percent, d1 means a B0/BT is 10 right that means BT/B0 which is the transmission is 1/10 or 10% right similarly if it is 2 then the transmission will be 1% because in that case BT/B0 will be 1/100 so it is one percent.

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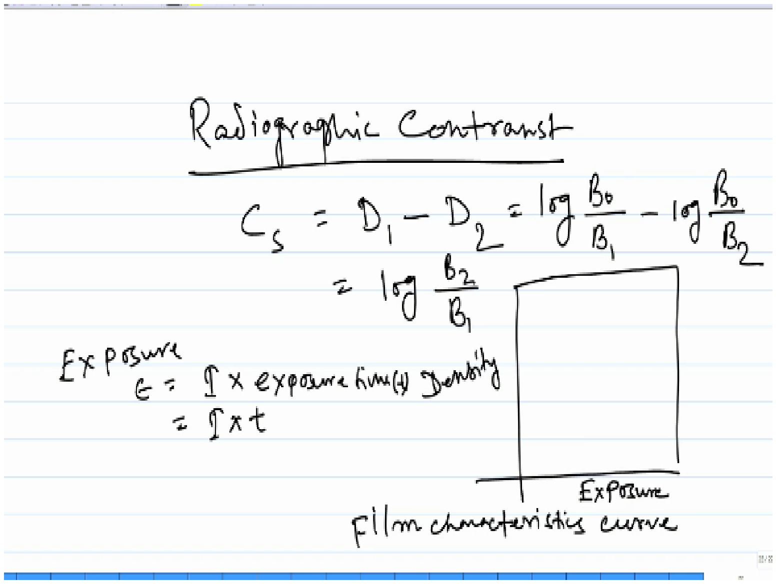

So when you see a contrast on the film it essentially means that between two regions that you see a contrast they have different density d okay, so the contrast or the radiography contrast is nothing but the difference in the densities between two regions so this is the second property of the film which is the radiographic contrast so as I said this is nothing but the difference in the densities between two regions if we call this as CS this is the density difference okay.

So this can be written in terms of that transmitted intensity B2 and B1 now the most important thing for the film is this curve which is known as a film characteristic curve, which shows you the relationship between the photographic density and the exposure, so to obtain a particular density on the image what should be the exposure that is defined by this characteristic curve and this exposure is defined as intensity I multiplied by the exposure time t. So this is I times T.

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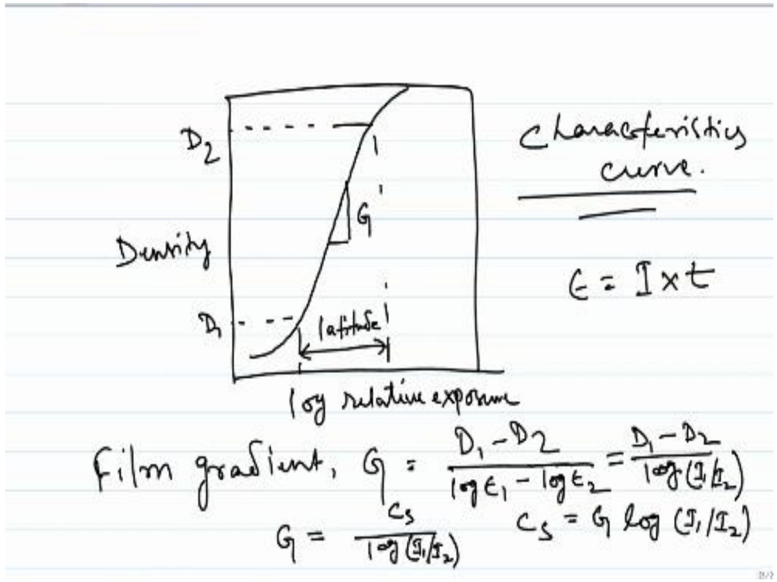

And if you now plot this identity with the exposure or log of exposure then you get a curve like this okay so this curve is known as the characteristic curve and every film is supplied with this particular curve the manufacturer has to you know do the tests and provide this curve for a particular film and from this film you can derive certain other properties for the film which are important for forming the image on a radiographic film.

So this provides you another parameter known as film gradient it is nothing but the slope of this straight line portion so if the gradient is called as G then G is the slope which is d1- d2 and log ε1 – ε2 and ε we have already defined as I times T so for the same time of exposure this will be I1/I2 and we have also seen that d1 - d2 is the contrast CS therefore C can be written in terms of the contrast CS in this fashion or CS can be written as this in terms of G okay.

So this is a very important parameter for a film for a good quality image you need a high gradient and if you consider this range of exposure between two different densities then this is known as film latitude so this is another parameter with regard to the film.

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Known as the film latitude and this is defined as the range of sample thickness that can be recorded with a single exposure okay and as you could see from this curve this gradient and latitude are inversely related to each other for high gradient the latitude will be smaller and similarly for smaller gradient the latitude will be larger okay.

So these are the different properties of the film which control the quality of the image which finally form on the film okay and with this we come to the end of today's lecture. So the rest of the things that you have for this particular topic we are going to take up in the next class, so today I am going to stop here thank you for your attention.

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