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Theory and Practice of Non Destructive Testing

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Radiography - 9

Hello and I will come back for last few lectures we have been discussing about this topic of radiographic technique and in previous lectures we have covered almost all the aspects related to a regular fit testing as NDT method and so far whatever we have seen it was about conventional radiography which implies radiographic films to capture the x-ray image okay and in that case there are some limitations of this technique particularly with regard to the x-ray film first of all you need this film which has to be handled carefully you can never expose it to light.

So first of all you need a sample holder which can protect it from exposure to light before you load it to the extreme machine that is one thing secondly when you expose it after the exposure you need to develop the film okay so that again involves a lot of skills and certain consumables and if you are if you're not careful enough in developing the film whatever you have done before while capturing the image can go wrong okay so that is the second limitation and the third one is about the storage of this x-ray images once you have them developed on the film okay.

Because this is based upon some silver halide emulsion as we have talked about and this kind of films you cannot store them for a long time okay so that is the problem about the storage if you want to store them for a long time there are difficulties so if you want to go back to any data and you know pull out an old image that is difficult to do in this case.

So due to this difficulty in storage you have to do the analysis and they are okay immediately after you capture the image and double of it you cannot really store it and then come back later on to do the analysis so that is the third limitation that this conventional radiography has okay so therefore in order to overcome these difficulties or the limitations associated with conventional radiography we have to think of something which can eliminate all these difficulties okay.

So that is how this digital radiography came into being which does not really need x-ray films to capture the images okay so what is done in that case in case of digital radiography is that you when you expose the sample and the x-ray intensities which are coming out from the samples are captured by a detector which can convert these x-rays into an electrical signal okay so that is what we are going to talk about today as to how digital radiography is done and what is the mechanism through which digital radiography operates and then we will see you know what kind of detector is used to perform digital radiography okay so this will be the topic for today's lecture yeah.

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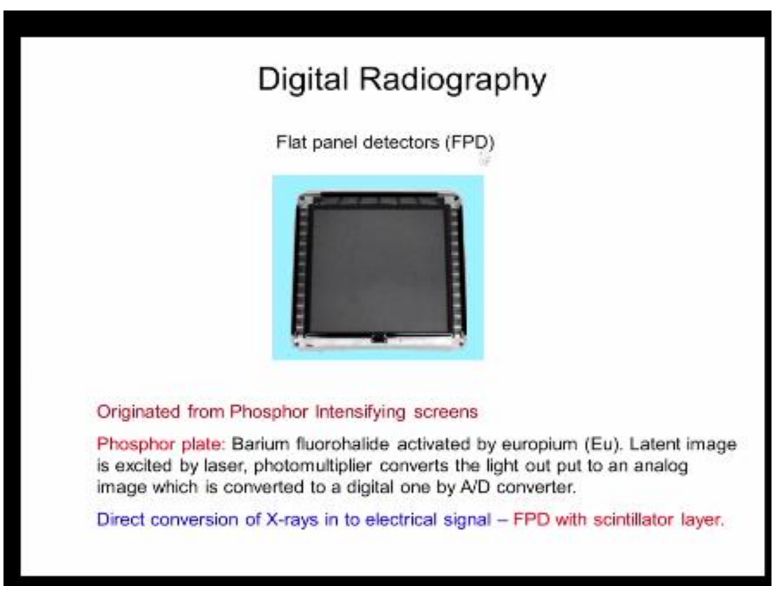

So as I said in order to do this digitally you need a detector which will capture the x-rays and convert them into an electrical signal which can finally be converted into a digital signal and then you have the digital image okay and this kind of detectors come in the shape of a flat plate or a flat panel and that is why they are known as flat panel detector as you could see over here okay so this is the diagram of a flat panel detector or FPD which is used for capturing the radiographic image okay.

So this is going to replace the film and whatever you do on the field okay so all you need in this case for exposure is this flat panel detector which will capture the image digitally and it can be then transferred to a computer and can be stored and then you can do the analysis as and when you want okay and if you remember we talked about the conversion of x-rays into light photons when we discussed about the intensifying screens okay so there we talked about an intensifying screen based upon these phosphor or these fluorescent salts which can convert x-rays falling on them into either electrons or visible light photons okay.

So the origin of digital radiography is from this kind of intensifying screens which can convert falling x-ray intensities into an electrical signal or a visible light photon okay so this FPD there are two forms it comes in two different forms one uses this kind of phosphor plates which is primarily made of a phosphor material like barium flora light which is activated by rare earth element like Europium okay.

So this europium is added into this barium chloride phosphor in order to generate the electrons when the x-ray intensity fall on this phosphor flip so the way this works is when you add this Europium what happens is this europium will be in two-plus State okay.

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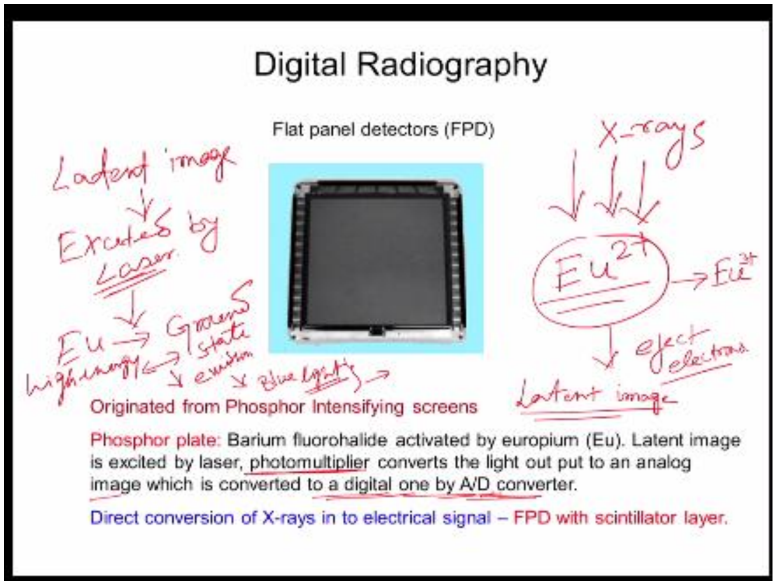

In this phosphor material now when it is exposed to incoming x-ray intensity this excess will interact with this Europium ions and they will eject electrons from this Europium and as a result of this when an electron is ejected from this Europium 2 + it will become 3 + so it will be kind of transferred into a high energy state okay from the ground state and the ejected electrons will be trapped in the band gap okay and the number of such electrons will be proportional to the x-ray intensity which is falling on the material okay.

So now that is how the latent image is formed by ejection of electrons from this Europium ions and these electrons will be trapped in the band gap okay so that is a latent image now if you want to activate this latent image and from the actual image this draft electrons have to be released further back into the Europium ions okay so that it can come back to the ground state and the energy difference between the higher energy state and the ground state that will be then released as light okay.

So in that fashion the x-ray intensities will be converted into light photons okay so that is what happens when you after the exposure when the latent image is formed this has to be excited by some low energy electromagnetic radiation like laser okay so this kind of radius and light laser they just have enough energy to you know to excite this electrons which are trapped back into the Europium okay so when you do that as I told this Europium which was in high energy state due to that ionization when it was exposed to x-rays this high energy state will come back to ground state that means Europium 3+ will again come back to European 2 +.

So this energy difference that you have when it comes back to ground state from higher energy state that will be released as light emission and in this case the light which is emitted it will be in the wavelength range which is close to blue so this will emit blue light so this kind of phosphor which is composed of barium flourohalide activated with Europium are blue emitting phosphorus okay so now you can use these light photons which are emitted by the phosphor and convert them into an electrical signal for example you can use a photomultiplier right which will convert these light photons into an analog electrical signal and that analog signal or the analog image can be further converted into a digital output using an analog to digital converter okay.

So that is how this whole thing works first you convert the x-rays into light photons with the help of these light centers provided by the Europium and then you convert these light photons into an analog signal which is further converted to a digital signal and that is how the digital image is formed okay so this is one type of FPD which is based upon a phosphor plate and which requires excitation by laser once the exposure is over okay.

So this is kind of a two-step process wherein you first take this FPD and expose the sample over it and after the exposure this has to be again exposed to laser and a unit which will first expose it to laser and then convert this blue light which is coming out into electrical signal okay so that unit will have both it has the ability to first expose this to laser and then convert the light into electrical signal and further into a digital signal okay now if you want to minimize the number of steps okay so in that case this x- rays have to be directly converted into a light photon or into an electrical signal okay.

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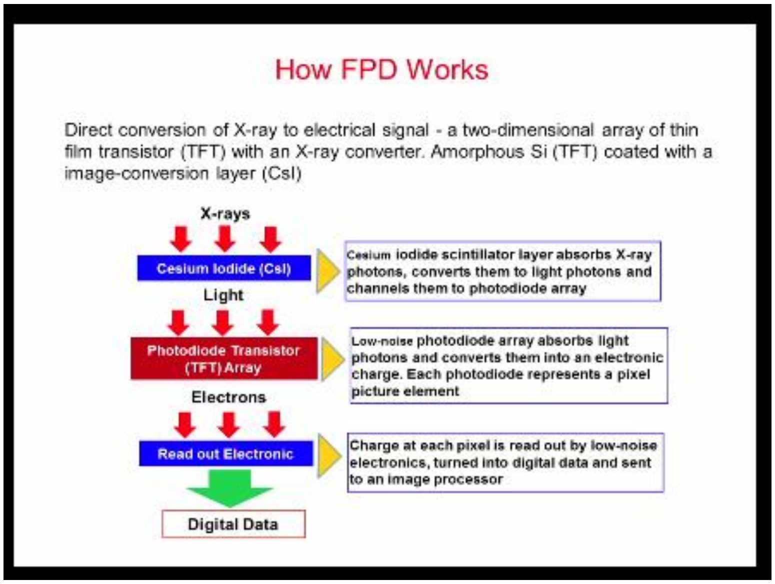

So that is another type of FPD that you have which can do that which will convert the incoming x-ray intensities directly into an electrical signal with the help of a scintillator layer which first converts these x-ray intensities into light photons and these light photons are further converted into an electrical signal with the help of a semiconductor layer just below the scintillator layer okay so this is all within the same unit ok so these x-ray intensities is converted into an electrical signal it is first converted into light photons and for that the top layer of this FPD is coated with a scintillator layer made of a material like cesium iodide okay.

So this kind of material the cesium iodide kind of materials have the ability to absorb x-ray radiation and then release light photons and once these light photons are released they will be sent to the photodiode that layer the photodiode transistor layer which is just below the scintillator layer and this photons will be now converted into electrical signal okay so this is the scheme how it works this scintillator based FPD's so the x-rays first come and fall on this cesium iodide scintillator layer which will absorb the x-ray photons and convert them to light photons okay.

And this will be channeled into the photodiode array which is just kept below the scintillator layer ok so this photo diode a transistor layer is made of low noise photo diode arrays which will absorb the light photons and convert them into an electrical charge and each of these photodiode represents a pixel so this photo diode as I am going to show you in the next slide are made in the form of a grid or form of some network ok instead of a single piece it is divided into small rectangular grid.

And each of these arrays or each of these rectangular grades will represent a pixel and the amount of light intensity falling on each of this pixel will be proportional to the x-ray intensity which is falling on that particular part okay, so once this light photons are converted into an electronic charge that will be stored through some capacitors which are built into this photo diode layer.

And finally it will be read out by the rate read out electronics which is part of this detector which will convert this analog electrical signal into a digital signal through which this digital image will be formed okay yeah so that is how the charge at each pixel is read out by low noise electronics which is part of the detector and turn into digital data which will be sent into the image processor to finally form the digital image okay. So this is how it works which is shown here schematically.

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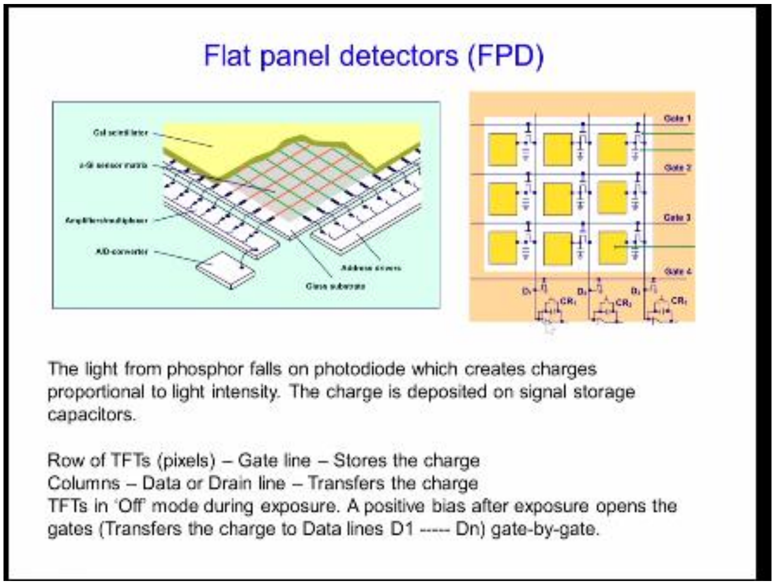

And if you now see the construction of this scintillator based large panel detectors this is how it is as I said the top layer is made of a cesium iodide scintillator layer which will convert the incoming x-ray intensity into light photons and just below this you have this amorphous silicon TFT layer the transistor layer which will capture those light photons which will absorb those light photons and convert them into electronic charge okay.

And as I said I know this is divided into this kind of network or arrays like this kind of rectangular grids so each of this array will represent a pixel in the final digital image okay and on this you have this inbuilt capacitors also which will first store the charge okay so the light from the phosphor first falls on the photo diet which creates the charges proportional to the light intensity and the charge will be now deposited on the signal storage capacitors which are connected to this TFT switch okay.

So this is how the construction of the TFT is are in terms of this small rectangular grids or arrays so you have these rows and you have this column so this row of TFT switch which represent the pixels are known as gate and these columns that you have these are known as data or data line which is also called trend line okay so what happens when you do the x-ray exposures these gates will be in off mode so that is when the charge will be stored into these capacitors and after the exposure a positive bias is provided to these gates or to this kept is to release the charge okay so first you expose and then store the charge and afterwards when you finally want to send this signal into the image processor you need to excite this at PFT's with a small positive bias which will release the charge.

And that charge will be transferred through these columns or data lines okay so this is why they are known as drain lines because they will drain out the charge which is stored okay and this transferring of the charge through the data lines happens gate by gate so first you do for gate one transfer the charge through the data line and then gate to gate three and so on okay.

So this is how finally the charge will be transferred gate by gate through these data lines or drain lines which will finally be sent to the electronics and the image processing unit which will convert this electrical analog signal into a digital signal to form the digital image okay so this is how the flat panel detectors work to capture digital images from x-ray exposures.

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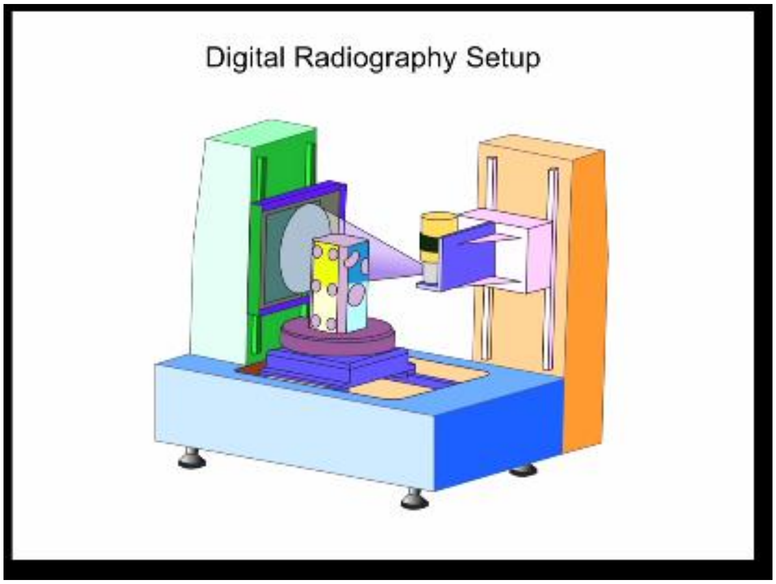

And since you have a compact detector now the whole set of also becomes quite compact compared to conventional radiography set up which will generally have a large footprint compared to this digital radiography setup okay, so these flat panel detectors they come in different sizes so depending on the size of the part or the size of the sample which is being imaged you might have seen this in nowadays it is used in medical radiography also and you might have seen this kind of detectors.

Which will be you know kept in close contact of our body and then after the exposure it is transferred to a unit which will expose this either place or it will convert that electrical signal into a digital image okay so depending on the size of the area that is to be imaged the size of this flat metal detector can be varied and they are available indifferent sizes starting from the size of a small a4 sheet from that kind of size to a bigger size depending on the area that you want to expose okay.

And this is how the whole setup is looks like which is shown here through this diagram so all you need is a small x-ray tube an x-ray source which is here okay and this is the sample which is exposed and this is the flood canal detector which is behind the sample okay the source also nowadays is quite compact these flat panel detectors as I said comes with the compact size and therefore the whole setup in terms of the footprint is quite compact and much smaller compared to conventional radiographic set up.

In fact if you could provide a exposure vault or exposure chamber which will seal the radiation this can also be taken to site and you can do radiography on-site soon-site radiography can also be done with the help of that provided you have radiation shielding when you when you are doing the exposure so this is the other advantage apart from you know eliminating all those limitations that conventional radiography has.

The other advantage that you have in this case that this is a very compact set up and it is possible to do on-site radiographic examinations with the help of this which is not possible in case of conventional radiography because that is a fixed set up which has to be kept inside a room so now that we have been talking about

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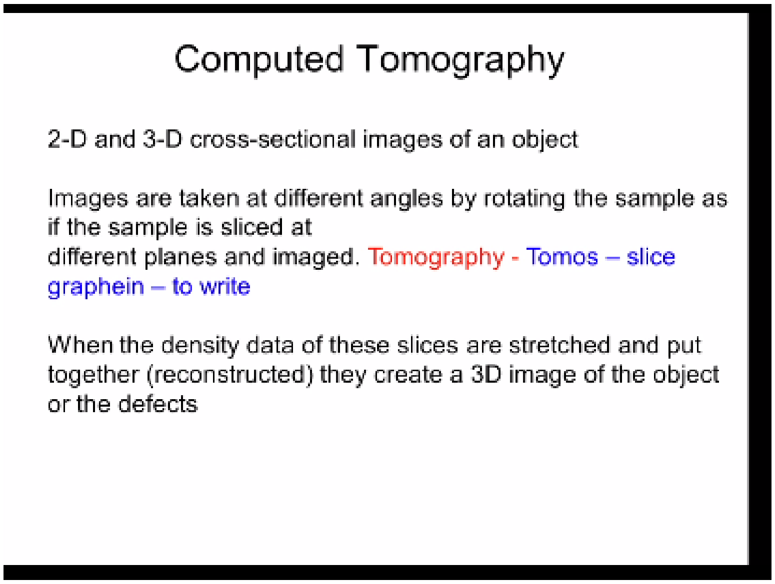

Digital radiography an offshoot of this has given rise to a very useful technique which is very useful particularly for you know medical radiography in cases where you have two pin point the damage or the defect for example if you have some damage in the brain in that case unless you pinpoint the damage it is difficult to address it medically because in a brain it's a very sensitive area you cannot play around and then try and figure out where exactly is the damage okay so in those kind of cases where you need to image it precisely to pinpoint the damage.

This technique comes very handy very useful which is known as computed tomography you all of you all might have heard about it in the short form which is known as CT scan okay so that CT stands for computed tomography and this is again a digital radiography setup but done in a different way so that you can capture the image in a manner which will finally provide you a 3d image because as I said you need to exactly pinpoint the damage and C it is two image as to how big it is and how far it has spread and all that okay.

In order to address it medically and treat it okay there could be cases in industrial or engineering components also where you need to image it in terms of a 3d image so that you can actually see what is that inside you can see the actual image of the part and if there is any features or any defect or flaws that you are looking for you can form a 3d image and see how they are actually inside the part okay so, so far whatever we have seen all are actually a 2D profile of the part infact it is a shadow of the part in which you see a 2d profile of the defects okay but in this case when you do a computed tomography the image has to be at a 3D image okay so in order to do that the image has to be captured in different planes first as if you are slicing the sample at across different planes.

And then you capture images across as many planes as possible okay so that is how this name has come because this tomography has two parts if you break it down first one is Tomos which means slice and the second one graphein or graphene is to write or to capture okay so as I said first you need to capture the image across different planes of the component as if you are slicing it okay across different planes that is how this Tomos comes into this nomenclature and then you capture it or write it so that is to grapheme.

So that is how put together it is called as tomography okay now when you finally take all these images together the images that you have captured across different slices or different planes so what you have done basically you have collected the density data the photographic density data across different planes and different layers of the sample and now finally if you can put this density data together okay and reconstruct then you can get the 3d image of the whole part so that is the whole idea behind this.

First you capture the 2d images across different slices or different plane and then this density data finally you have to reconstruct and put them together to create the 3d image.

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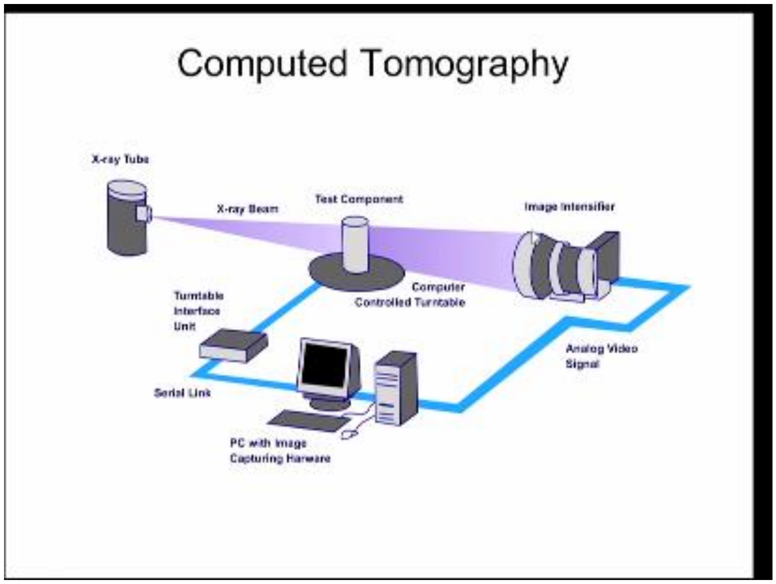

And in order to do that you need a sample holders which can manipulate the sample and can image it in across different angles and different plane planes okay so you need a five-axis manipulator as the sample holder in this case so that the samples can be moved around and rotated into different angles and you can you can capture the image across different planes throughout the sample okay so this is what you have in this case a computer-controlled turntable or the manipulator.

Which will hold the sample and then it is exposed to x-rays and then you have the detectors like those kind of flat panel detector which can convert these x-ray intensities into a digital image so first you have the analog signal through the detector which is kept behind the sample and the sample is rotated at different angles and this analog data is sent to the processing unit which will convert it into a digital data and the digital image can be stored in a computer or can be seen in the computer screen okay.

But in CT scan our sample is the human head right because most of the time CT scan is useful for brain related damage or if you want to image the brain so in that case the sample is either the human body part or the human head and in that case you cannot tear Oh Tate it you cannot rotate the sample right but you have to capture the image across different planes so that rotational motion is needed since you cannot rotate the sample in that case the source itself is rotated okay.

So that is what you might have seen that the chamber in which the image is captured it is a it has a rotatable unit so through that rotation the image of the brain or any other body part is captured across different planes and layers and finally these 2D images captured along the different planes will be put together through some kind of algorithm and the electronics.

That you have in the system and they will create the 3d image for the end user to, so this is how digital radiography and computed tomography works and with this we come to the end of this lecture also so I am going to stop here today and I will see you next time with another lecture on this particular topic thank you for your attention.

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