Electronic Packaging and Manufacturing.
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Lecture – 16
2nd Level Packaging: PCB-I

Hello, good evening or maybe good morning or good afternoon depending on where you are and when you are. Welcome back to the course on Electronic Packaging and Manufacturing. So, today we start a completely new topic and that is 2nd Level Packaging. So, far we had been talking about first level packaging where the focus was more on the attachment of the chip to the chip carrier or the substrate that we talked about.

And we did talk about a little about the attachment of the package or the substrate onto the motherboard especially when we talked about pin grid array, ball grid array, land grid array and so on. Now the thing is what happens thereafter ok. Your package now goes on the motherboard and then the signals actually get transmitted or transferred through the motherboard right. So, therefore, the question now arises and which leads us to the next level of packaging is what is the anatomy of the motherboard and how do you fabricate the motherboard, what are the design parameters of the motherboard.

So, these are the things that we are going to discuss as part of second level packaging. So, today the contents that, we are going to discuss today is Printed Circuit Board or PCB.

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We will look at what is the PCB ok, what constitutes a PCB and then we are going to look at anatomy of a PCB, what does how does the PCB look like ok, what is there in the PCB and finally, we will get into the manufacturing side starting with what are the circuit board materials. So, with that introduction let us get started on the discussion about printed circuit boards.

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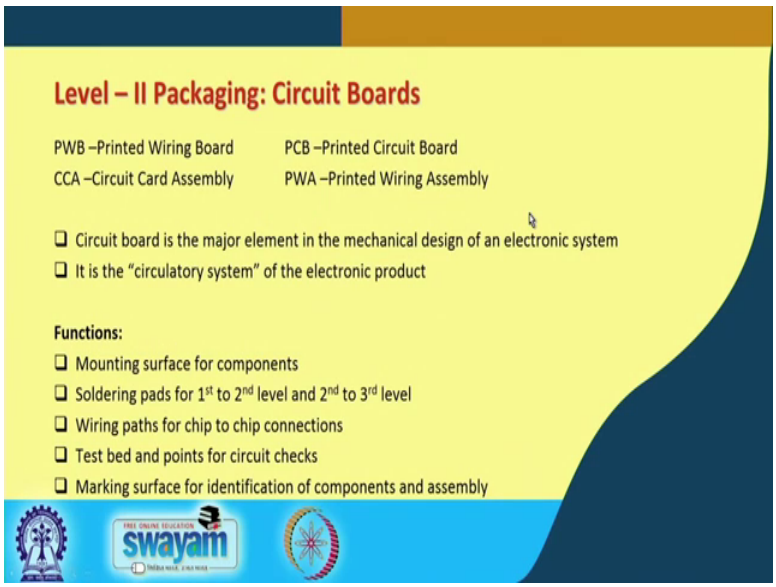

Printed Circuit Boards or PCB which is the most commonly used term; however, can also be denoted by several other synonymous technical terms Printed Wiring Board that

is also used very very commonly or PWB. CCA, Circuit Card Assembly and PWA Printed Wiring Assembly. So, these 4 terms and acronyms are used widely across this industry and most often they mean the same thing. So, circuit board if that is the most broad term, the circuit board is a major element in the mechanical design of an electronic system.

So, if you think about it Ii would say it is a circulatory system of the electronic product, if you look at you know the equivalents with the human body. You have the brain that gives us our thinking power that generates the signals and thereafter, what happens? You have these two systems the nervous system and the circulatory system. So, you can think about one for transmission of the signals, the other for submission of blood correct.

So, for circulation of blood I am sorry. So, these are both extremely important. So, you can look at the PCB as one of these systems and let us say it is a circulatory system. So, this is what is carrying the signals and carrying the information from number one from the brain which is your microprocessor to the other components in the system and also bringing in the signal and power from an external source onto the system.

So, motherboards function is of paramount importance and that is primarily the medium through which the signals get transmitted and transferred and communicated. So, if you look at these functions, what does a motherboard do? Well one of course, it is a substrate where you mount the components, whether it is your memory, whether it is your graphics, whether it is your CPU, whether it is your controller hub and various other things like a pass or the passage like capacitors, resistors, inductors, the MOSFETs.

So, all of these actually are attached to a motherboard or a circuit board or a circuit card. It also has a soldering pads for first to second level and second to third level connections. Most importantly it is the wiring paths ok; these are the wiring traces of wiring as we will see later these form the paths for chip to chip connections. If you have multiple chips on the same motherboard, how do they communicate with each other? That is through these wiring traces.

So, these are the communicating paths or communication paths between the different components that are sitting in the motherboard and which constitute the system. Circuit board is also the test bed and points for circuit checks. So, this is where you also see if once you attach all the components what is working what is not working. You looked at

you know the ball grid array, the pin grid array, land grid array; there are hundreds and thousand hundred sometimes thousand IOs right. In BJ you can have thousand; LGA we talked about the LGA is 771 which was one of the first major LGA applications in the computing industry 771 interconnections. Now which one is functioning, which one is defective if at all how will you determine that?

So, it is through that circuit bed actually gives you the, you know you the means of doing this tests and checks and finally, it is also the marking surface for identification of components as assembly. So, circuit board many a times has this letters etched or the numbers etched. So, that is a marking system that is followed and that helps you to identify which component is there or what is that design or what is the circuit board designed for which component. So, part numbers can be written or etched on the circuit board all right.

So, therefore, it is one of the major and most important components in an electronic system ok. We also talked about if you recall, we talked about chip on board. What is chip on board? These are where you do not have a first level, but you dont have a chip carrier the silicon is directly mounted on the motherboard ok. So, these are all the things the printed circuit board has I mean at that is a very very essential component of any electronic product or system. The other thing that we want to talk about is another name that is often used is the motherboard.

So, motherboard is probably many a times when he loosely used, but that is the light big board which is the main circuit board for a system and then onto the motherboard, you can have smaller boards attached which are many a times called the daughter boards or daughter cards. A very simple example is you know if you look at your desktop or laptop, you have a big motherboard with a lot of components and then sometimes you will have these you know connectors for these memory cards which has circuit cards or daughter boards which will have this that is a much smaller piece of you can still call it a printed wiring board or printed circuit board with limited number of components. So, in this case memory for example, ok. So, we see these as well.

So, motherboard that way is sometimes though many a times loosely used. It is it typically it unless otherwise stated, it is the big the primary circuit board that goes into a system all right. So, if that is the case let us move on.

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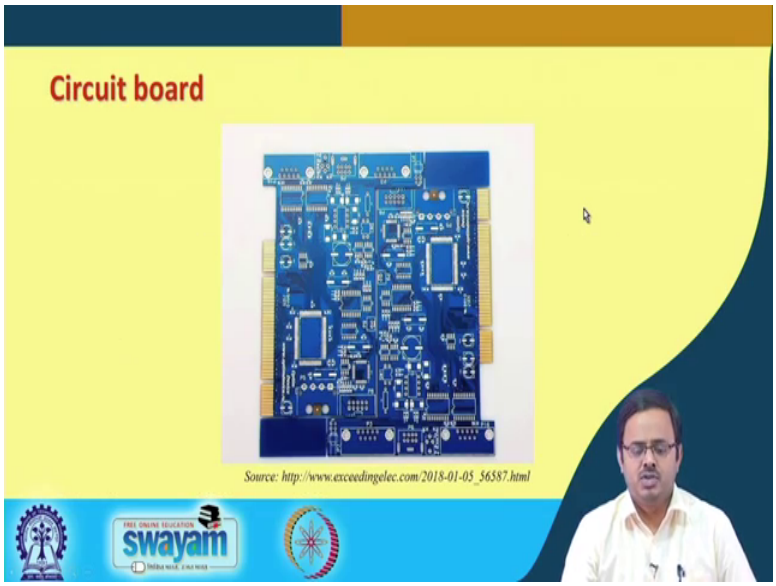

So, this is a picture of the circuit board. This is a picture of a circuit board before components have been mounted on it. So, you see you have this connect connectors at the edges right. So, these are the input output ports to the circuit board. So, one thing you can see immediately is the fact that when we talk about a chip and a chip carrier, there are probably hundreds of interconnections, but then what kinds out of the circuit board is definitely a much lesser number. There is a lot of you know interconnection between the components excreta.

But finally, what comes out or goes in into the circuit board is a far lesser number of connectors connections and that is what you see here. So, each of these probably each of these you know these markings that you see on the connector, these are one of the channels ok. So, these are these are each one interconnection. But and then if you look at finally, what happens? So, circuit board then goes into the third level packaging finally, is a system integration. And finally, what do you give to the system how many IOs come in just to because it is a plug that you plug in into your wall socket. So, that is primarily two and probably sometimes you will have the earthling as well all right.

So, if you look at this circuit board. Let us spend a little bit of time over here. This is as I said this is just the circuit board of the circuit card before the components have been mounted. So, what do we see here? We see a lot of these connection points. If you look at where my cursor is right now, what is this one? This is the place for connection of a quad

flat pack package right. You remember the quad flat pack in first level packaging where you had leads typically let us say a gullwing type lead that is coming out and that gullwing the other end of that interconnection or the lead will be connected to the circuit board as we had discussed at that time and now we see that. These are the points where those interconnects or the leads are going to be attached.

We see another one here. Here you see for example, where my cursor is many of them. These are like dual inline packages here; here these are all dual inline packages and then you also see. So, these are all surface mount technologies. So, the mounting pads of these connection points are on the surface of the motherboard, but; however, look at here where my cursor is right now or let me try to use this pen. So, this I will just go with the cursor look at here. These are through hole points over here you see these are for through hole components you can see, these holes on both sides of this component that is going to come here.

So, these are leads that are pin in hole arrangement. These are not surface mount. So, that is why you have this holes the inner surface of which is metalized so, that that connection is made electrical connection is made. You see some of those other points here as well in many places. So, this is a circuit board not a very sophisticated one or not a very dense one, but this you can see the number of components that can be mounted on a circuit board if you count 1 2 3 4 5 6 so, lots of them 7 8 9 10.

So, lots of them a circuit board has multiple components attached to it and here we see a combination of components that a surface mount and also components at a through hole. So, that is a circuit card or circuit board.

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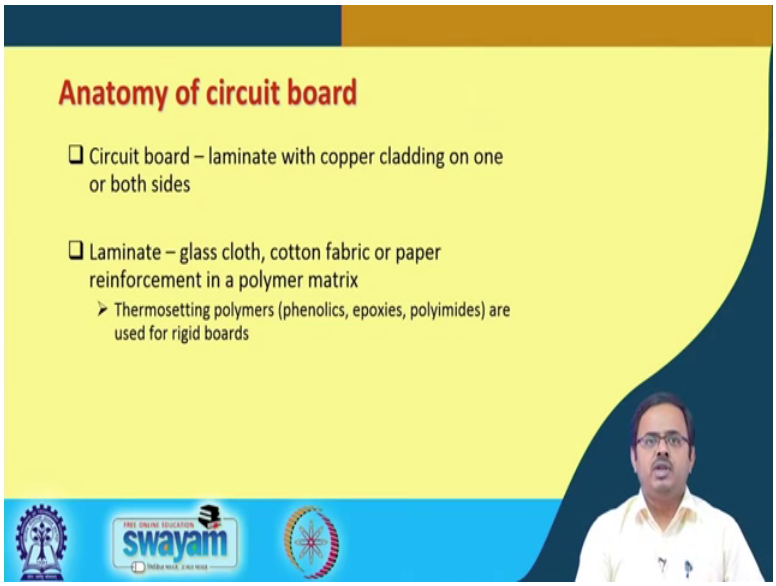

So, now let us look into the anatomy of a circuit board, what is the circuit board made of? This green thing that you see you know sometimes is green is the most common, but sometimes there are circuit boards that are red in color. If you just do a Google search you will be able to see of course, primarily you will see green, but sometimes you will see red in color, sometimes you will see yellow in color.

So, this all depend on what is the material that is used. So, therefore, that brings us to the picture what is the circuit board. And you may be wondering that if I look into this picture before ok, this connection is made over here, if I take this package ok. The leads come and make the connections or the wire would, but then what? Where are these connections going? I do not see any connection between this component and this component. So, where is this connection taking place all right? So, that brings us to the anatomy of circuit board. So, circuit board is a laminate with copper cladding on one or both sides ok.

So, once again we will look into this later, a circuit board is made of a laminate material; laminate as in different layers and it has copper cladding on both sides and sometimes the copper cladding is also removed we will see that. Now what is this laminate made off? It can be a glass cloth, it can be a cotton fabric or paper reinforcement in a polymer matrix; glass is the most common glass cloth is the most common. And sometimes if you

want very rigid and hard boards, the thermosetting polymers are used not sometimes I think it is very common these days. The thermosetting polymers are used as the binder.

So, that is what holds this glass cloth fibers as well as this copper laminates that we are going to talk about. I am sorry this copper traces or copper claddings that we are going to talk about. So, once again the laminate consists of a glass cloth most commonly a glass cloth and which is in a binding material, the binder is a polymer matrix. So, depending on this what the laminate is sometimes what is most of you will see this later, we also call it an organic laminate depending on what is used the compound used is an organic compound.

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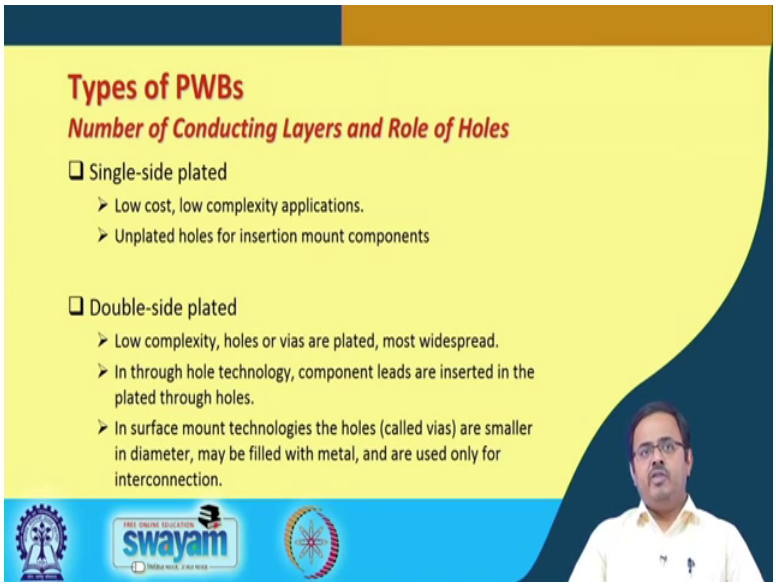

The other thing that we can we will talk about here types of PCBs.

So, what are the different types of PCBs that we know off? So, the first one is single site plated. So, components only come on one side of the motherboard or sorry one side of the circuit board. So, single side car motherboard is a common example where components are placed only on one of the sides; let us say the top side. So, for example, if you go back to this picture, the components are probably on one side we dont know what is behind, but from here it looks like the components are all on one side.

So, if components only come and get placed on top of this motherboard on this side that we see, then it is a single sided motherboard. Now of course, given that it is a single

sided motherboard and single layered also then what happens is these are low cost low complexity applications and this has insertion mount components as well. It is possible to have insertion mount comp mount components not a problem.

Next is double sided motherboard, then what happens? Then you can have components on both sides and you have wiring traces also on both sides. And how do you now connect the components on one side with the components on the other side? And that is done through what is called these wires or vias. These are holes that are filled small in diameter and these are filled with metal and these are used for in inter connections. So, you have a motherboard with components on both sides and then the components talk to each other or communicate with each other through these vias which are holes that are metalized.

So, we talked about single sided motherboard, we are talking about double sided motherboard sorry. I keep using the word motherboard that is not again a technically correct term; circuit board is the correct term or printed circuit board is the correct term ok. It is probably one bad habit I have picked up during my Intel days where I was part of a group whose core expertise of course, are part of a larger group whose main core expertise was board design.

And we would call it the motherboard design because they used to design the circuit boards for most computing products all right and so, therefore, motherboard was a term that was used so commonly in the group that I still have that bad habit of calling any circuit board as motherboard. But again technically that is not the correct term even though loosely it is used many a times circuit board, circuit card, printed circuit board, printed wiring board. These are the correct terms printed wiring assembly, circuit card assembly. These are these are the correct technology technically correct terms that should be used all right.

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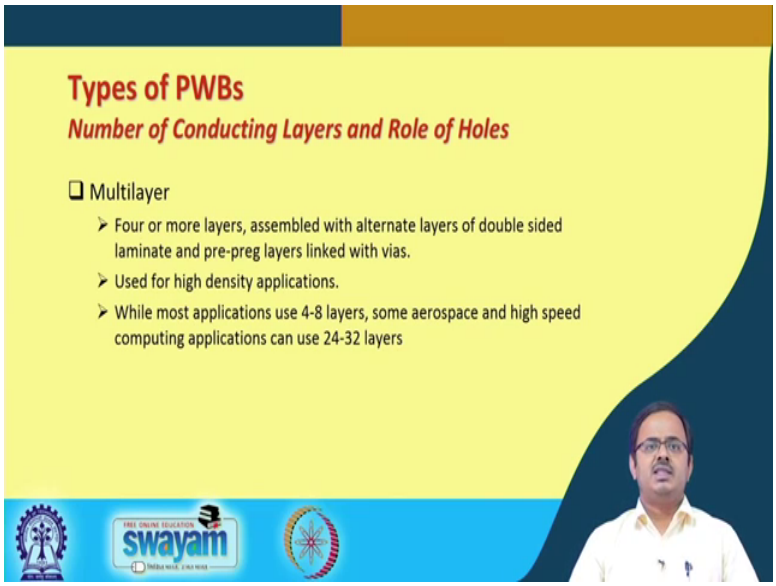

The next one is multi layer motherboards ok. So, what our multi layer motherboards? See the number of components on one side or both sides are so many and the number of interconnection points are so large that it is not possible to have these communications or these connections just on one layer or both layers. So, therefore, what happens is if for such high density applications with very large number of interconnections, what is used is motherboards with more layers and these layers are hidden. If you look at the circuit board, you will only see it is a thin card like this or the green color circuit board, but inside these there are also internal layers through which this wiring can happen ok.

. So, these are conducting layers with copper traces that form these wirings. So, while most applications use 4 to 8 layers some high speed computing applications can use or aerospace applications or defense applications, they can have really really dense circuit boards and definitely much more expensive circuit boards which can use 24 to 32 layers that is the level where we are today. Outside it looks like a, what I mean a few millimeter thicks circuit board, but inside you have so many layers of wiring traces.

So, laminate pre peg layers linked with vias whatever is written in the first bullet, I am leaving it at this point; I am not elaborating because we are going to look at each of these terms when we go to the design and fabrication and manufacturing ok. So, the analogy that I can give for a multi layer board is like if you think of your city traffic all right; you have you know you have roads on the ground, but sometimes you know there are so

many places to be connected in so many different ways and so much of so many cars and buses and trucks have to go, then that just you run out of space on the ground all right.

So, in such cases, what do we do? We go for underground subways or tunnels or flyovers sometimes different layers of flyovers, different levels of flyovers and that is what that helps us to you know have multiple connections while using the same footprint. We are going vertically; we are using the third dimension.

So, in printed wiring boards as well you know just one surface or two surface may not be enough to connect all these components and their respective interconnection points. So, therefore, that is what leads us so that is what necessitates the design of multi layered motherboards where you have different layers of these copper traces and wiring traces or wiring traces as they are called going through. So, that these all these connections can be made ok.

And again unlike you know regular road traffic where two roads can intersect, you can imagine that in a wiring board two wires cannot intersect. If you have to connect two points let us say from along x axis from right to left and along y axis from top to bottom, then how do we do? If we have wiring traces on the same plane, they are all going to intersect and there will be lot all these all the signals will be lost, there will be no connection all right. So, therefore, what do we have to do? We have to join one wire like this another wire either above or below.

So, this is what I want to talk; this is what I am trying to imply or the analogy that I am using I am trying to imply the or I am trying to underline the necessity of going for multi layer motherboards. So, that gives us the, you know the classification of printed wiring boards based on the number of conducting layers and also where the components can be placed. So, single layer, double layer, multi layer one and then we also talked about single sided wiring boards and multi sided wiring boards or double sided wiring board sorry. It cannot be multi sided because it can have only it can be on the top and the bottom.

But the internal traces are required to form all these connections all right. So, that is where we will stop today and when we come back in the next class we are going to pick up from here ok.

Thank you very much.