Electronic Packaging and Manufacturing
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Lecture – 19
2nd Level Packaging: PCB – IV

Welcome back to the course of electronic on Electronic Packaging and Manufacturing. We were discussing Second level packaging and more specifically we were looking at motherboard fabrication. So, in the last lecture we looked at how the inner layers of a motherboard is made, starting with the basic elementary block of a copper clad laminate which is a laminate this organic laminate with 2 foils of copper on both sides that forms a building block. We say that this eventually becomes one of them becomes a inner layers you know in the circuit board and from that copper foil what is retained are the circuit are the features the board features like the wiring traces ok.

And the rest of the copper is removed. So, how is that done? We looked at the whole process, where we take rick or we take the help of photolithography or optical lithography process to protect the features that we want to retain and use itching to remove the remaining copper ok. So, we look at that and we looked at this processes and the important thing I want to say is or I want to again reiterate what I mentioned in the last lecture is the copper that is removed is not wasted both in terms of consult you know from economic point of view, as well as from the environment point of view the copper from the etchant is recovered and can be recycled.

And the etchant also is fed back it is a chemical. So, it is further treated and fed back to the sump, in the in the fabrication process motherboard fabric or in the circuit board fabrication process.

So, today what we will do is, so that ok, so, before therefore, the end product that we had at the end of the last lecture was a laminate layer with copper traces on both sides. That is what we have we are slowly building a circuit board, we have come to this stage where we have a you know wiring trace layers on 2 sides of a laminate ok.

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So, today the concepts covered are going to be circuit board layers, then layup and lamination and finally, through holes and plating. So, in the motherboards you also in the circuit boards we also have some through holes and a plated through holes we are going to look at that as well ok. So, this is what is going to be covered today.

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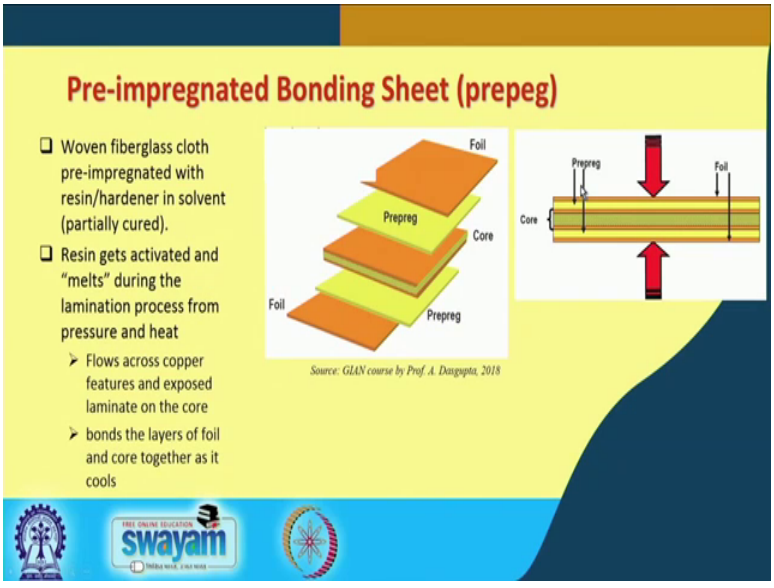

Now just like CCL or copper clad laminate that we had introduced last time, we are going to introduce another building block of a circuit board which is called pre peg standing for pre impregnated bonding shape sheet. What is that? That is a woven fiberglass cloth pre impregnated with resin or hardener in solvent, which is partially cured. Remember the laminate that we used in CCL was fully cured. So, this is partially cured why, we will see that that is what goes in the next point because the resin here gets activated and melts during the lamination process under pressure and heat ok. So, what are we talking about, let us look at this. Look at the first picture on the on the on the left.

What we have is a CCL at the center over here which is one laminate fully cured and then with copper traces on the top and bottom, copper foil at the top and bottom. Then on top of that what comes and also on the bottom of that if it is a multilayer motherboard, multilayer circuit board sorry what comes is this prepeg. Now the prepeg is also this laminate, but this is partially cured on top of that there will be another foil.

Now what happens? Why is it partially cured? Because, now what do we do with this assembly these different layers at 10 pressed together and heated ok. So, under pressure and heat what happens let us take a step back now.

This is a representative figure, but what is going to have finally, this CCL what was the end product that we had at the end of the last lecture, this entire copper sheet was not present only the wiring traces that needs to be retained were present right. So, these features are present now not the entire sheet as shown over here.

So, therefore, what happens to the other part? I had a surface, now let us say I have this wiring trace that I have left, that is left over here this is the copper trace, what about the rest. So, therefore, on top of this, when I bring that partially cured laminate and press it and apply pressure and heat both of them then the laminate because it is now soft because, because it was partially cured is going to get into the into both sides and basically you know get let us say this was a copper trace and this was another copper trace, it is going to get into it is sort of penetrate into the spacing in between all right.

And therefore, form a kind of an insulating layer between 2 adjacent traces and therefore, help in signal integrity no crosstalk and so on and so forth ok. So, the 2 wiring traces are kind of isolated from each other by this laminate layer or this laminate ok. So, going back to the slide that is what is shown here, this resin gets activated and melts during lamination and this lamination is this process you know very lamination where you hold it in layers and you press it.

And the resin therefore, flows across the copper features and exposed laminate on the core and therefore, it bonds, so the core is the middle part the CCL part and it bonds the layers of foil and together and bond it bond and core it together as it cools all right.

So, therefore, what do I have? I am having the inner layer with the circuit features and then I have the prepeg layer on both sides and then I have another copper foil on top ok. So, that is what I have over here. It is not very clear, but what happens is this central layer of this core where you see the two inner copper layers actually our circuit traces ok.

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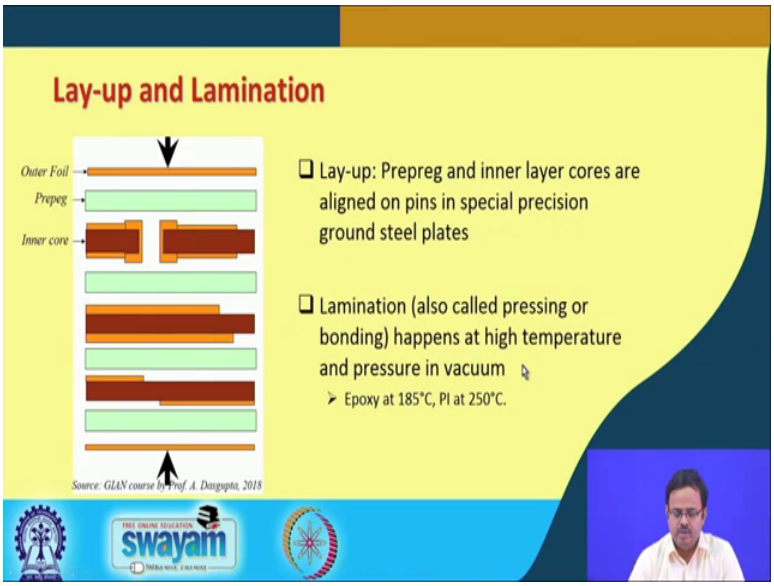

All right, so this is what is happening, probably the layup and lamination this is a little more clear. So, as you can see this is the inner core with this circuit features, maybe there is a there is a hole in between that is possible ok, then you have pre packed you have the outer foil.

You can have a pre peg and either you can have an outer foil here or you can have another inner layer another two inner layers another pre packed another two inner layers and finally, an outer layer. So, what is the number of layers in this circuit board? 1, 2, 3, 4, 5, 6, 7, 8, it is an 8 layer mother board ok. If it was a 4 layer motherboard, then what would have happened is these 2 would not have been there. It would have been this inner core pre peg outer foil on one side pre peg and then this outer foil on the other side ok. If it were to be a 6 layer motherboard then the outer layer would have come next to this pre peg right. So, the last two inner layers, so the 6th and 7th layer would not in this configuration would not have been there.

So, again let us take a step back. Each of so, what do we have we have two outer layers and then 6 inner layers. In and the 6 inner layers are in pairs of 2. Each of this pair for example, this the first 2 if I if I look at this pair, it is coming from a CCL or copper clad laminate. If you look at this next pair that is coming for another CCL, the third one again another CCL and they are separated by a pre peg layer which is that partially cured laminate.

So, then what happens is you get all these copper clad layers with the wiring traces I mean a copper clad layers that has undergone corporate laminate layers that have undergone this lithography and etching process and have these circuit traces on them, you bring them together, separate them with this free peg material and then assemble them applying heat and pressure.

And therefore, while doing that what happens is this partially cured pre peg is going to kind of quote unquote melt and flow and fill up the spaces that are of I mean that are not occupied by this copper traces and as well as form the insulating layer between the adjacent copper between the adjacent copper layers ok. This laminates this whole process is called lamination it is also called pressing called bonding, it happens at high temperature and pressure and in vacuum all right. So, this is very important this assembly is very important ok.

So, now we are slowly making this circuit board we have got everything we have got all the layers we build them in small blocks of CCL's and then they brought them together and assemble them through this lamination process and that gives you my friends your 6 layer or 8 layer circuit board.

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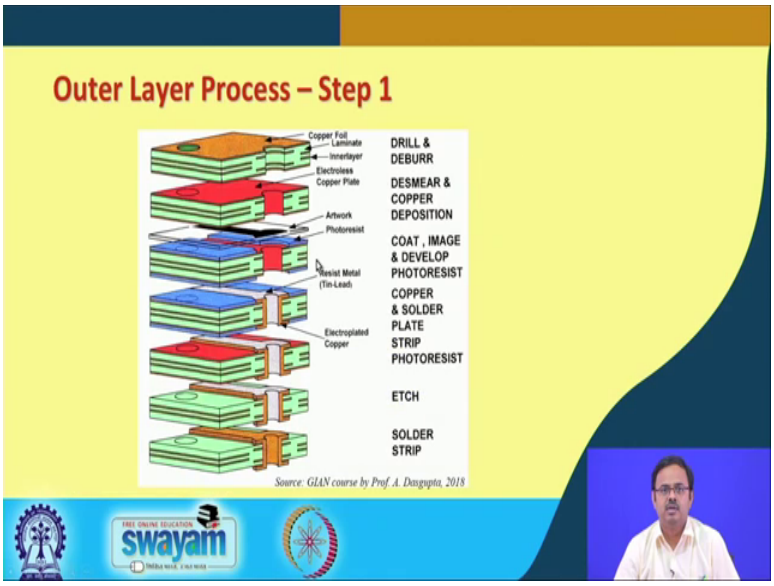

Now what happens? The outer layers, inner layers we have seen what to do with. What about the outer layers? Inner layers already the traces are there, due to up lithography and etching and then they are separated from each other by this prepeg and everything is fine as you can see the inner layers are all fine. This is a 6 layer motherboard, 1, 2, 3, 4, 5, 6; you can see 6 copper traces, but the outer layers still remain.

So, what are we going to do to the outer layer ok? One thing to be noted over here is every circuit board will have some holes ok. The holes can either be for connections between 2 layers or it can also be just mechanical holes through which you know the screws the aligning screws etcetera are going to go and hold it in place for mechanical reasons mechanical fixturing ok. The other thing I want to mention over here is as you can see sometimes 2 layers may need to talk to each other, may need to be connected. So, in those and or multiple layers may need to be connected. So, under those situations you need this plated through holes which can also be buried holes ok, in which case, like this ok.

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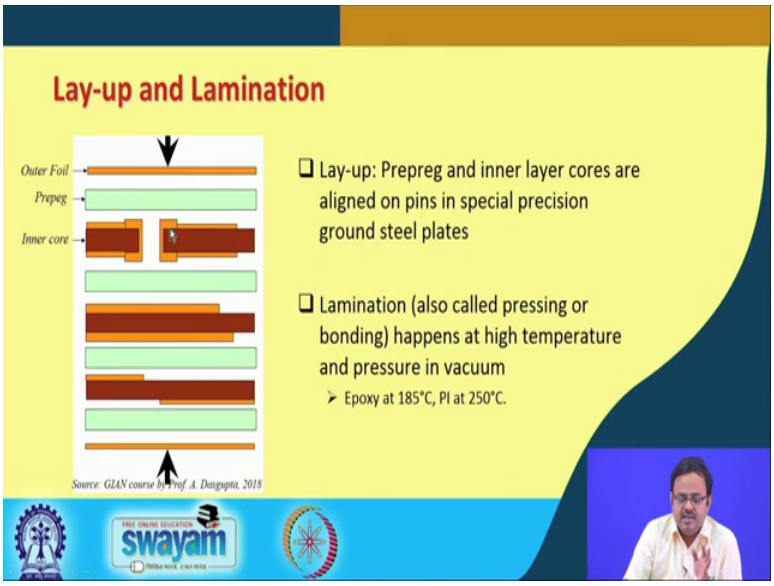

This layer had to be connected to this circuit trace and that was done by having this hole over here ok. So, you can have holes drilled or punched both in an intermediate state stage or in the final stage depending on what you need very important all right. So now let us come to the outer layer again where we started. So, this is a copper foil these are the laminates, we see we know now all this what is inside. Then this is a copper foil ok. So, on the copper foil you again put there is another electro less copper deposition ok. So, there is a copper deposition on top and what we do next is again lithography.

You have the mask, you have a photoresist coating, first you have the photoresist coating then the mask coming up and what we do is in the mask we coat image or develop the photoresist and then we put a solder plate on top. And then they remove the rest of the photoresist and once we remove the end rest of the photoresist what are we left with, we are left with this copper and coated with this lead tin solder ok. Then they will again etch away the remaining copper and on the outer layer. Therefore, you are not going to be going to have just exposed copper you are going to have exposed copper with right now this solder that is that forms a coating, why? Because otherwise I would have had to remove I mean I would have had with otherwise I needed to remove this copper away this red colored copper while retaining what I need ok.

And finally, the solder can be stripped or removed yeah clear. I repeat again, let us go through this, we started with this copper foil had another thin layer of copper on top and then went to the photoresist process by which we are going to retain only let us say this copper trace ok. So, therefore, this is the cut out in my mask it can be cut out or it can be it can be the covered portion the rest of it can be cut out depending on what is the photoresist that we are using.

We are going to remove the photoresist and retain this part, but what I am going to be left and then etch the copper away what I what I am going to left be left with finally, after etching the copper away is the copper trace, but covered with solder ok.

So, then the solder strip is going to be removed and I am left with this is my motherboard finally, you have wiring traces on the outer layers and you also have these inner layers ok.

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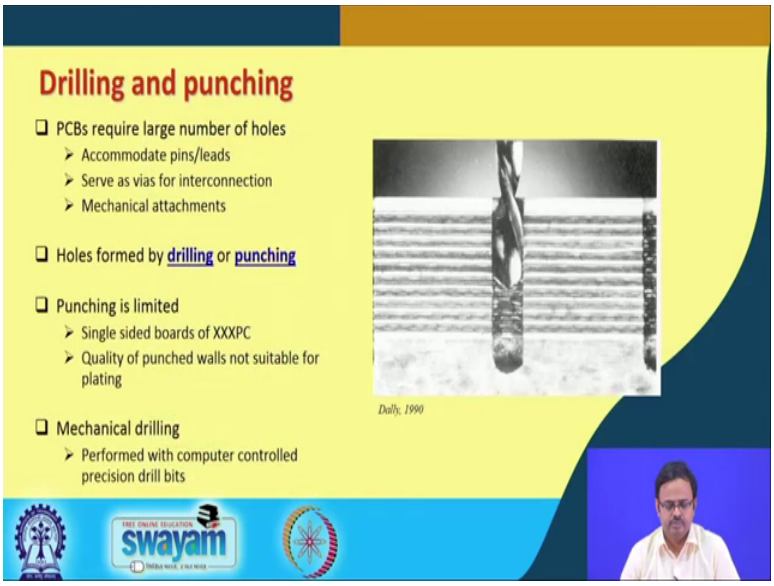

The last thing that I am going to talk about in motherboard or in circuit board is the process of drilling and punching because, PCB's as I said require a large number of holes whether it is for mechanical purpose or whether it is for interconnections or whether it is to accommodate pins. Remember the plated through hole components if it is a two layer motherboard, you can do that right; you can have just through hole going through ok.

So, the holes are formed by drilling or punching. So, the punching is limited, punching is just one process, you just you get a punch tool in and you just remove that part, but that is only possible for thin motherboards with limited number of thin circuit boards with limited number of layers ok. And the quality of punching I am depending on the punching tool, it is many a times not suited for plating or electroplating with copper or so, therefore, punching is very used in very limited cases. What is used more is mechanical drilling very thin high precision drill bits used for drilling these holes ok.

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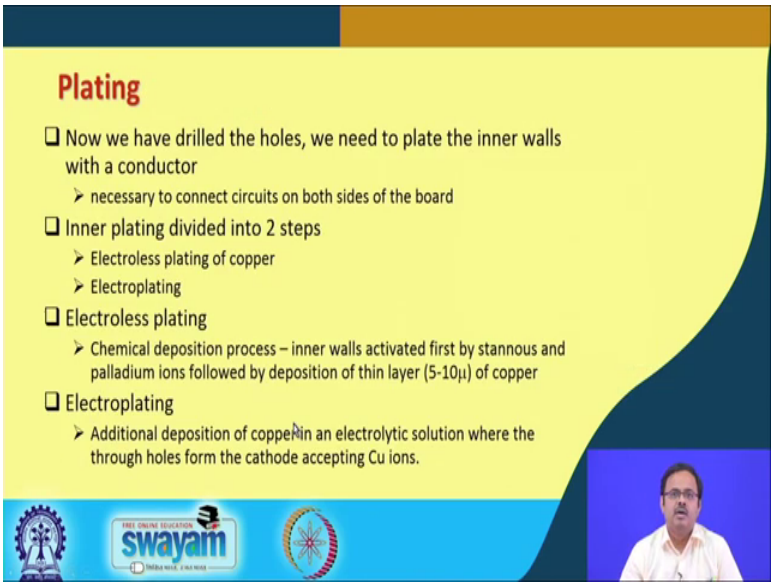

So, after this holes are punched what we do what do we have to do? We have to do the, we have to pleat the inner walls of these holes because these are supposed to if it is for electrical connections we need to do plating, otherwise how are we going to have these electrical connections. So, now, that we have drilled the holes, we need to plate the inner walls with a conductor because, that is necessary to the connect the circuits on both sides of the of the board, if it is a 2 sided board on both sides of the board or otherwise even before if it is inner layers that also we need to do that ok.

So, the inner plating is divided or can we of 2 types; one is electro less plating of copper, so what is electro less plating? It is a chemical deposition process. So, therefore, there what happens is in the electric chemical electro less plating, the inner walls are first activated by stannum stainless

or palladium ions followed by deposition of a thin layer of copper and this layer is very thin like 5 to 10 microns electroplating electroless plating, but it is a plating process chemical deposition.

And the second one is electroplating process which we know the electroplating process we know that is an additional deposition of copper in an electrolytic solution, where the through holes will form the cathode that will accept the positively charged copper ions in the electrolyte ok. So, once again let us go through the process over here, what we started by saying is this is where we had the circuit board with different layers but what we said is we will need some holes and this holes can be for different purposes, it can be to accommodate pins or leads it can be for to serve as interconnections or it can just be for mechanical attachments many circuit boards will have holes just to. So, that it can be secured in place when you put it inside the system ok.

If you think of a large motherboard for example, the one that goes into your laptop ok, if it is at least a 13 inch screen or 15 inch screen, it is a large board with a lot of components some of them quite heavy ok. So, you need to hold this motherboard in place otherwise it is going to buckle under its own load, it is going to flex which is not desirable. So, you need to give support and this support also comes for from these holes where you know you have these pins or screws going through mechanical fixtures ok. So, it is important. So, holes are just not for electrical functions, it is for mechanical functions as well.

So, these holes can be found by punching which is a punching tool just you just like we punch paper you crack and then everything go and then there is there is a hole in the board but it has 2 problems; one is it can only be applied to thin motherboards or thin circuit boards and the surface finish of the punched of the punched hole is not great because as we saw, we are going to plate this inner surface of the hole with copper or with a conducting material ok. Mechanical drilling where we used very specialized you know drill bits press high precision drill bits are more commonly used ok.

So, this picture that you see from the textbook from James Dally, so here you see that a cross section were a precision drill bit is going through different layers of a circuit board.

This is just for illustration purposes, but you can see what happens ok. And then what we said was once these holes are made, we need to do pleating of the inner layers because why because

that is necessary to have this electrical connections on both sides of the board ok. So, this plating can be done either through electro less plating which is a chemical deposition process or electroplating which is where the copper there is an electrolytic solution consisting of copper ions and these copper ions are deposited in layers on the holes which are on the holes which actually are now positive or sorry or is the cathode and therefore, accept the positively charged ions ok.

So, what we will do is therefore, today let us recap what we discussed. At the end of the last lecture we had started with we had or rather at the end of the last lecture we had a copper clad laminate with the circuit traces and that forms an inner layer. And today what we saw was those inner layers, actually form the building box blocks and you can have several of these CCL's with the wiring traces on the 2 sides which form your building block ok.

Now these copper clad laminates with the wiring traces on the two sides are separated from each other or basically are formed in the layer by layer they are stacked up and separated by this thing called prepeg which is a partially cured laminate, which under pressure and temperature becomes soft and quote unquote flows ok.

So, finally, you can have multi layer circuit board comprising of these different CCL's or copper clad laminates with the wiring traces stacked on top of each other, but finally, you will also have the 2 outer layers and the 2 outer layers again our copper starting block is copper foil and that also goes through the lithography and etching process. And finally, we get the multi layer motherboard. Once we get the multi layer motherboard, I mean I will not say once we get it I mean the, we also have this process of drilling or punching of holes.

And the holes can be required either in any of the inner layers as well or finally, through all the layers in the circuit board. So, depending on what the hole is, then we have to drill or punch these at either at one of these inner layers or finally, through and through from across the thickness of this circuit board ok. And so right now what we have at the end of everything is a multi layer circuit board with holes drilled or punch at the places where we require them all right.

So, thank you very much that is all we wanted to discuss today and when we come back in the next class, we are going to take off from here and finish the motherboard process and then

remember or sorry circuit board process and remember now it is just a circuit board with wiring traces and in the first level packaging we had all these packages with interconnects and so on. So, these 2 have to come together. So, how do we do that? So, that is that is what we are going to discuss in the next lecture ok.

And finally, our goal is to have a multi layer motherboard with components placed at appropriate locations, so that now, it can go into a system and when powered on can function as per its specifications or requirements so.

Thank you very much and see you in the next lecture.