Electronic Packaging and Manufacturing
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Lecture – 20
2nd Level Packaging: PCB-V

Welcome back to this course on Electronic Packaging and Manufacturing. Today what we will do is we are going to wrap up our discussion on circuit boards and circuit board manufacturing. If you recall in the last lecture we had started with the circuit board I mean in the last couple of lectures, we have been discussing circuit board manufacturing.

And in the last class what we had was we had this entire assembly having these laminates one after the other and with the wiring traces right. So, if you recall we had said that that for circuit board step 1 fabrication step 1. So, today we are going to complete that process and the final stage requires you know having these bond pads on both surfaces, and then the components being placed on that. So, once that is done then the circuit board is ready.

So, that is what we are going to discuss today, we are going to finish up the discussion on the circuit boards and then look at the final step which is assembly of components on the circuit board ok.

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So, that is the concepts that are going to be covered today, when we talk about the last stage we are going to talk about something called solder mask and screen printing and then component assembly and finally, we will summarize our discussion on circuit boards ok.

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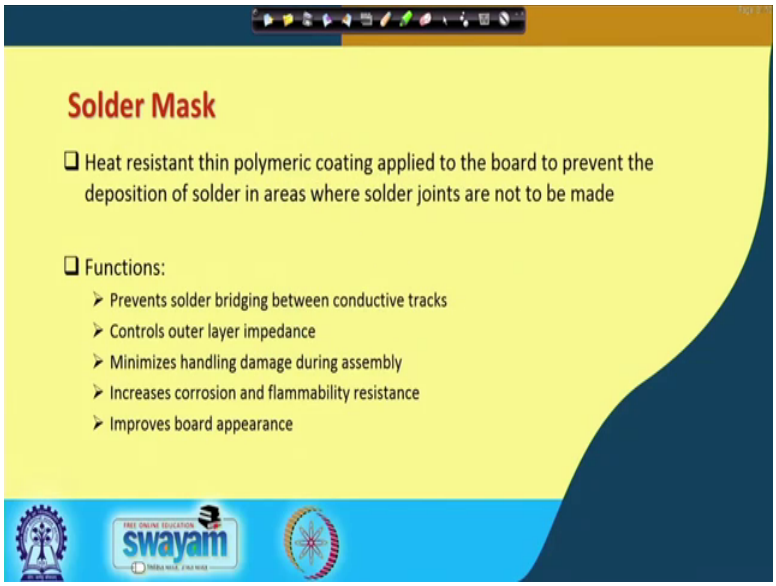

So, with that let us move on. So, first thing is what is solder mask? Let us first look at that what is solder mask and then they will see why we use that and how we use it. So, the solder mask is a heat resistant thin polymeric coating, which is applied to the board and why is it that as the name suggests solder mask. So, it is like a mask again and it covers most of the board and just exposes those portions where we need to deposit solder. Because, this is these are the locations where the solder joints will be made and the components are going to be placed ok.

So, again I repeat heat resistant thin polymeric coating applied to the board to prevent the deposition of solder in areas, where solder joints and not to be made which means in other words this solder mask also exposes those areas where solder joints are to be made. And these are the areas once again where the components are going to come and get placed. So, these are the bonding pads as we had discussed during first level packaging.

Remember we said that these leads are the solder balls that come out of the first level package the chip or the chip carrier, these are going to be attached or joined to the bonding pads on the circuit board right ok. So, what are the functions? So, functions of

the solder mask are the following. It prevents solder bridging between conductive tracks right. So, if there are two wiring traces that are going one after the other and then you put solder, maybe on some locations on that wiring trace where we are going to have this component bonded. Then how does I how do I prevent the solder from flowing and you know shorting these two traces?

So, I need to some I need some kind of a protection and the solder mask provides that. It controls outer layer impedance this is from the electrical point of view minimizes handling damage because it is also protective coating. So, during assembly when it goes through conveyor belt you have pick-and-place machine. So, you are going to see a video on that, it minimizes the damage because of handling ok. It increases corrosion and flammability resistance ok. Corrosion resistance and flammability resistance I want to this the way I have written I am now realizing, it can be you know interpreted differently it does not increase corrosion it increases corrosion resistance or resistance to corrosion ok.

So, it increases both resistance to corrosion as well as resistance to flammability ok. And finally, from the aesthetics point of view, it improves the board appearance this shiny thing that you see on the board etcetera this is the solder mask. So, it is a thin heat resistant polymeric coating.

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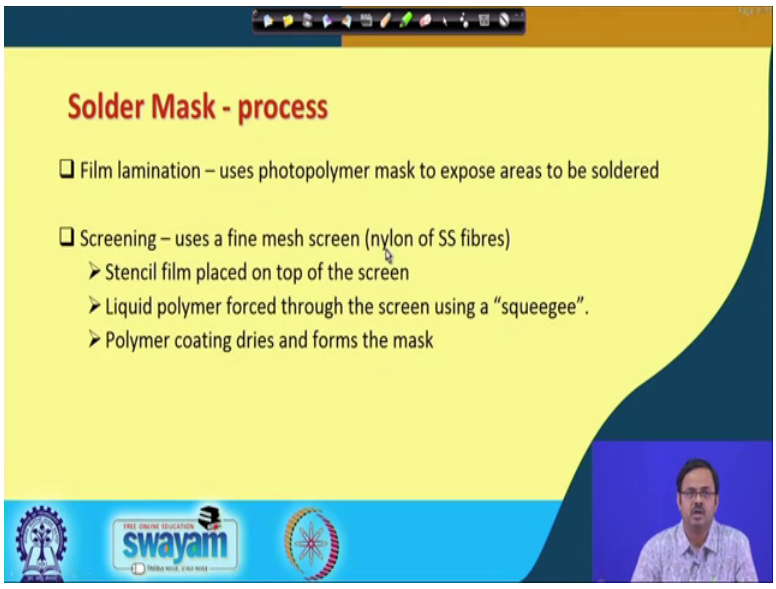

Now, what is the process, how do I put this solder mask ok? So, this is again a forty photopolymer mask to expose the areas to be soldered ok. So, the mask again is you know it is a photopolymer mask as I said before in the last slide and it is now placed on top using a film lamination process ok. So, the film lamination process is not new you know even some of our photographs, we want when we want to preserve it we film laminate that ok. So, it is a film with slight I mean you put it on the surface that you want to laminate and then you apply a little bit of pressure and temperature and you have this film lamination done ok.

Next thing is now, I have put the solder mask and then I have certain exposed areas where I need to deposit solder right are the copper traces before I need to deposit solder on those areas which are exposed. So, to do that what we do is, it is called a screen printing or stencil printing process ok. So, the screening what it does is it uses a fine mesh it can be a nylon or stainless steel fibers it is very fine and on top of that you have this solder sorry I take it back before that.

This is a screening on the stencil film that is placed on top of the screen and then you have this liquid polymer force through the screen using what is called a squeegee. And the polymeric coating dries and forms this mask ok. So, that is the film lamination and screening process after that what happens is the following.

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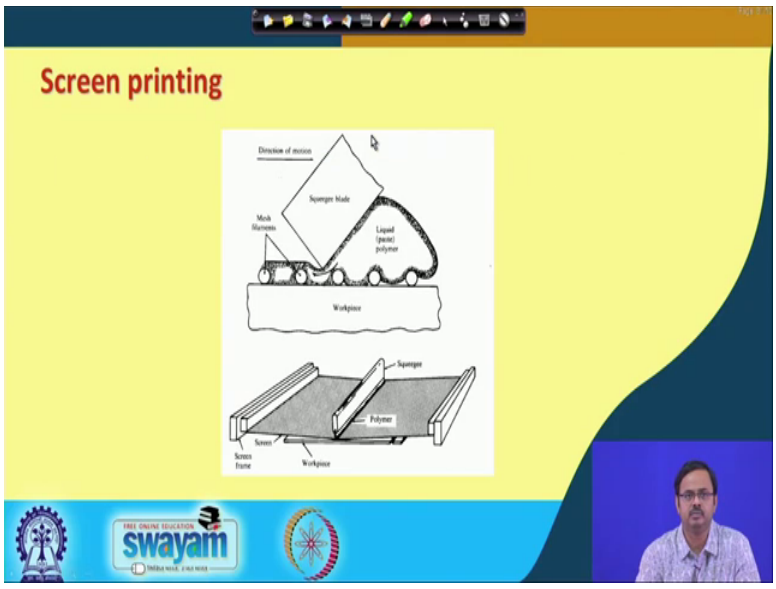

So, this is a screen printing process as you can see that this is a squeegee blade. You know if you look at a mason when he applies let us say plaster of Paris on the on the walls or even cement on the walls what you have seen is, you know the mason typically mixes a cement and sand and then he uses this thin blade, which is actually a squeegee blade. He takes a bit of this cement and then puts it in on the wall and then he kind of presses it on the wall and it forms a very thin layer both for plaster of Paris as well as for cement if you have no.

So, if you have noticed that you would have that is exactly what a screen print is not a screen printing by the way, but that is how exactly the squeegee blade works. So, except in this case, this is your workpiece as shown in this picture. And on top of that you have the screen and then you have this liquid polymer in the form of a paste actually, going through these and forming this laminate and remember there is a solder mask.

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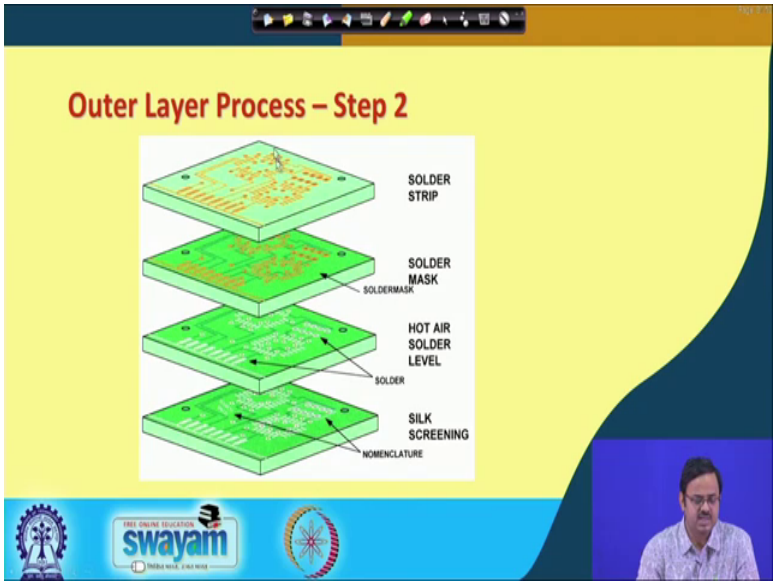

So, this is the outer process a process two; step 1 we had seen in the last lecture step 2. So, we end up with this one ok. We have ended up with a circuit board with exposed copper traces and these junction points ok. Now, what we have to do is we want to protect these wiring traces and only expose those joints or those pads where I am going to bond these components ok. So, this is outer layer of the circuit board. So, first what we will do is, we will put the solder mask and as you can see these wiring traces in the second picture this wiring traces are now covered. So, this these orange colored traces

have now become dark green because they are now covered with this solder mask the thin polymeric coating. So, after that what we will do? We are going to deposit solder ok.

So, as you can see now the exposed areas are now covered with solder the ones that we had exposed they are covered with solder. And then after that we are going to have this screening ok. We will have sometimes we also put you know some of these numbers or you know identifiers on the circuit board. So, this is how finally, this looks like. So, what do we see? We see these bonding pads on which the components are going to come and get placed.

Also look over here this is that connector piece you will recall that this connector you have seen these at least these connector pads, which typically go into a socket, the motherboards actually are placed into a kind of a holder or a socket plugged in alright.

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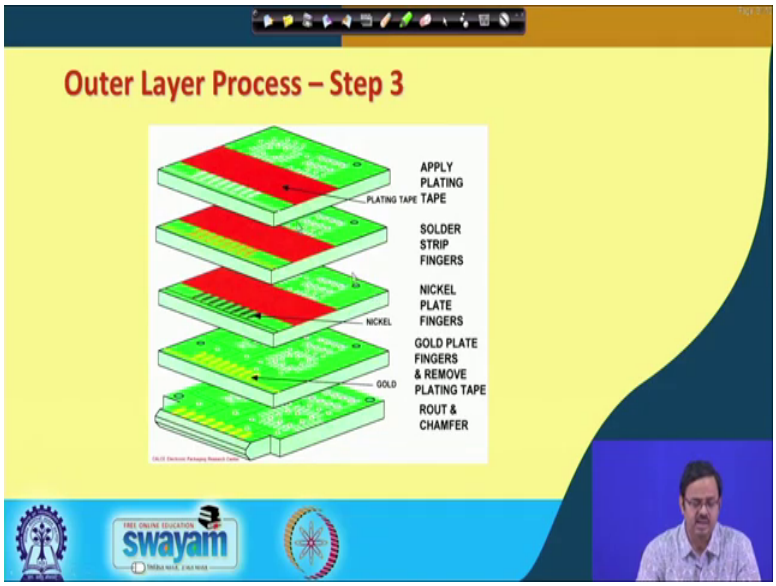

So, then let us look at step number 3. So, I have formed all the solder joints over here all the solder pads next thing what we do is, step 3 is we apply what is called a plating tape. We apply a plating tape and then on this side braking tape sometimes is put across the entire board, we are showing only part of it or in the vicinity of these connection fingers as we call it and then what we do is, we remove the solder from the strip or we strip off the solder from that position and put a nickel plating ok. On top of that we do some gold plating and that is why you see this golden connectors right it is a very thin layer of gold many a times, sometimes it can be other cheaper materials as well.

So, we would do this gold plating and then remove the plating tape gold is expensive you do not want it to go everywhere. So, at this connection you do it and then what you do is you kind of shape it off, you remove this unwanted part and you just expose this one you know this these fingers, which are going to get into your one into the circuit board socket ok. So, again I want to acknowledge here that these figures are from calce which is a Center for Advanced Lifecycle Engineering at the University of Maryland.

And these are the so, the credit for this goes to goes to that center, it is one of the leading electronic packaging centers in the world University of Maryland college park. Another similar very leading electronic packaging center is in Georgia Tech in Atlanta Georgia institute of technology in short we call it Georgia tech and the center is called PRC or Packaging Research Center ok. These have been there for many years and I think as electronic packaging engineers or people who are studying electronic packaging and manufacturing, we should know these places.

There are many others many other universities with such dedicated research centers for electronic packaging and manufacturing and I must also say that in this field of course, some universities are there, but there are also these research labs in various parts of the world which are dedicated to this industry. So, even in the in Asia, in Singapore, Taiwan these people are really good in this field ok.

So, anyway PRC and calce packaging research center Georgia Tech calce (Refer Time: 12:24) center for advanced lifecycle engineering in university of Maryland. I think these are they have been there for a long time and they have made significant contributions to this field. So, you want to acknowledge their contributions, a lot of that what I am I am teaching in this course is something I learned through the works of you know engineers scientists and professors in these centers as well as many others across the world ok.

Including where I did my PhD University of Colorado, I was part also of I was also part of a similar center which used to be quite leading at that point, but now it does not exist anymore. It was called camp mode because center for advanced manufacturing and packaging of optical and digital electronics microwave optical and digital electronics camp mode all right. So, coming back to this so, this is where your motherboard or your circuit board is now ready all right.

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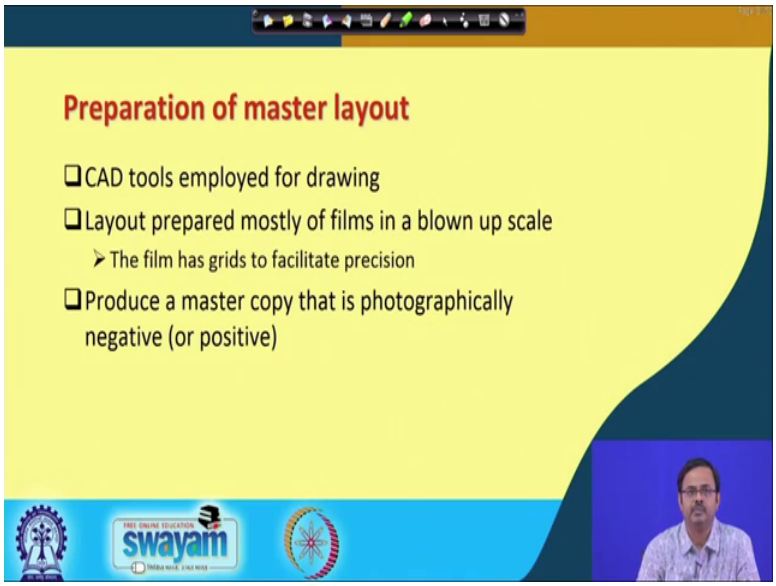

So, next what we will do is, this is the preparation of the master layout etcetera. So, layout is prepared most of your films all this ok. So, this is just for information, we are not going to spend time on this one. So, now, that I have this circuit board what do I do next? I have to place the components ok.

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So, that is the final step which is the component assembly. So, the components are placed on the board by actually robotic machines automated pick and place machines and then what happens, this components are placed and it undergoes through a soldering process it

is many a times called wave soldering. So, again it is a soldering process where it goes through kind of an oven, where similar to what we saw in the assembly of ball grid array. The solder is just melted the time temperature plot curve is maintained such that the solder just melts and forms those bonds.

And what we will also see here. So, we have a nice video from Fujitsu electronics in Japan, but they show the this last process and part of the previous ones as well as specially you will see stencil printing screen printing and so on. But, whatever what I want to mention here is the fact that, you will see in the video even though most of the components are placed by automatic pick and place there are still some components that are manually placed especially the ones that are through-hole components the larger ones are still are still manually being inserted in those. So, that the you know in those through holes. So, that the pins exactly go into the hole and then that is how the assemblies happens ok.

So, it is not many a times it is completely automated, but there are cases where it is may be some of the components are not automatically placed they are still manual. So, with that what we will do now is, we will go to this video which is quite educational I thought and I thought I will share with you.

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It is a bit long, but I think we will understand this and it also has some nice you know captions at every step. So, Fujitsu is a Japanese company, I believe most of us have heard about it and now let us go through their process.

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Now, you come to the motherboard production.

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You can see the motherboard is coming here and a bit of labeling is being done for identify as identifier. So, at this stage what we see is, the most of the motherboard is already fabricated ok

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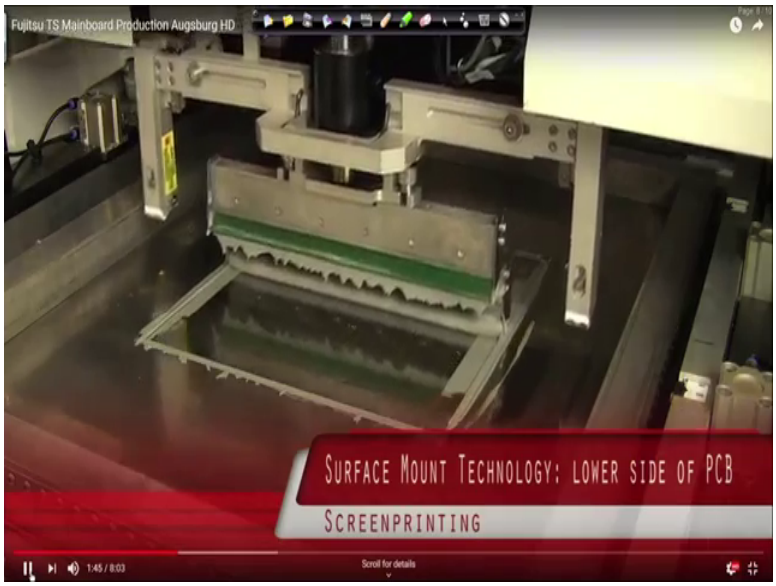

So, you can see all these pads all the wiring traces. Now, look at the screen printing this is where the solder is actually deposited through the solder mask. So, now, the board has come with the solder deposited at the locations where it is supposed to be.

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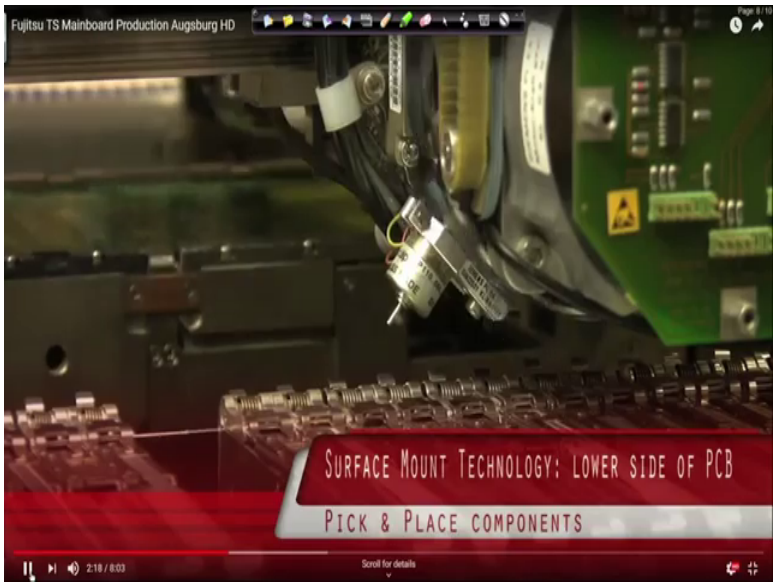

And now you see the components are being placed by the pick-and-place machines.

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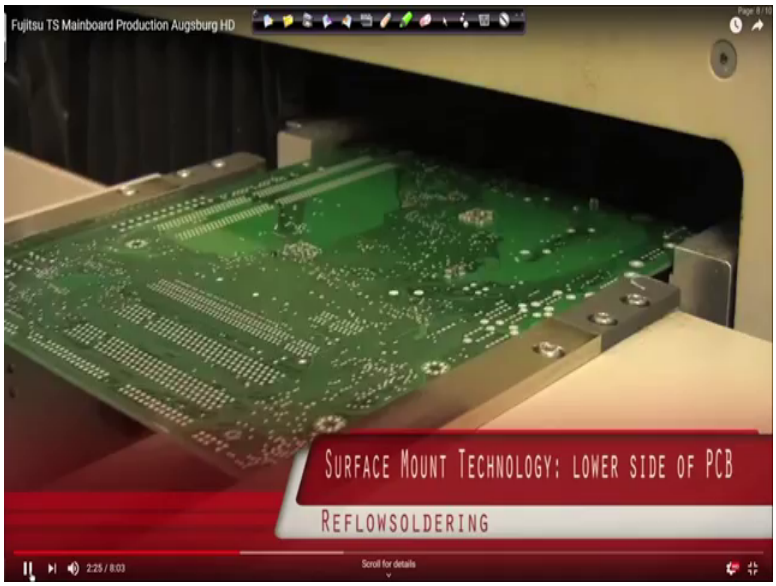

So, this is a reflow soldering sometimes also called wave soldering, where the solder will just melt the board was turned upside down there are some positioning.

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Now, the screen printing on the upper side we saw it on the one side. And now it is the other side this is where the positioning inspecting the joints.

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And now you see this component assembly. It is picking up the components from the different bins and going and placing it on the circuit board. See it is going picking up the components placing it and slowly the motherboard is or the circuit board is taking shape I can call this a motherboard though this is the large board. You will also be able to see a small BGA package on the board.

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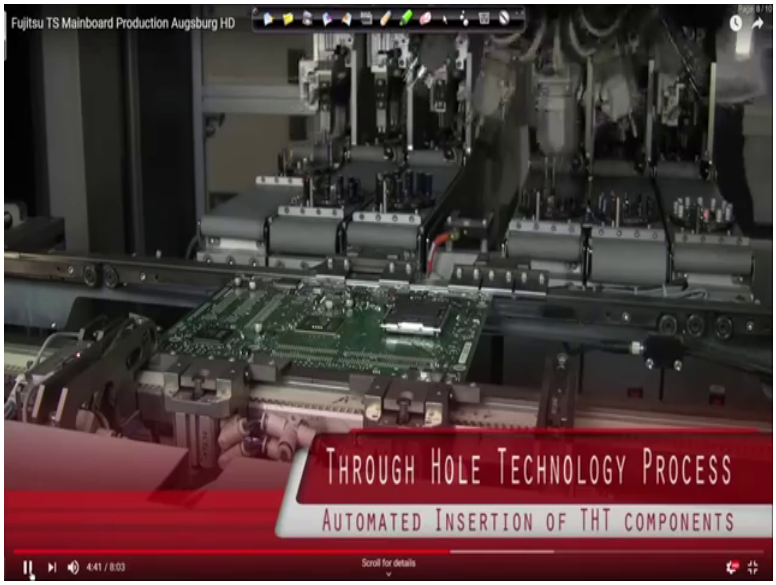

So, these are some of the through hole components, this one is automated this part the through-hole components are coming there and getting placed at the different positions.

You can see some capacitors being placed on the circuit board. Over here you see this silicon the ball grid array package.

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And now you see the manual insertion some of these components are still manually inserted especially you know these connectors like your USB your VGA and some of these as well some of the other ones as well as is as we can see the operator manually inserting them at their designated locations.

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So, this is again wave soldering. So, that the through hole components now the solder is reflowed and the connections are made. And now your motherboard has come out you can see almost all the components are there including the connectors.

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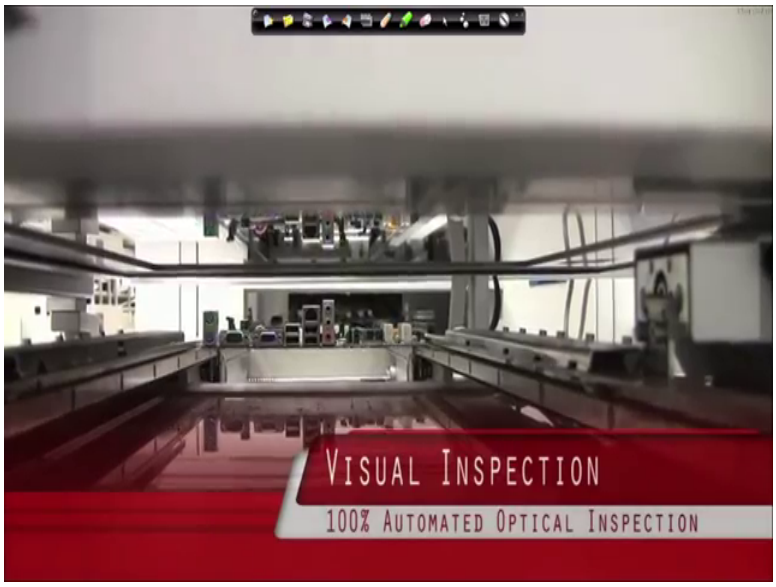

And now is a very important step which is quality ok. So, optical inspection quality inspection to see that, number one all the components are in place and they are being held properly connections are made everything is done they say it comes out ok. And the next what they do is they do some electrical testing as well ok.

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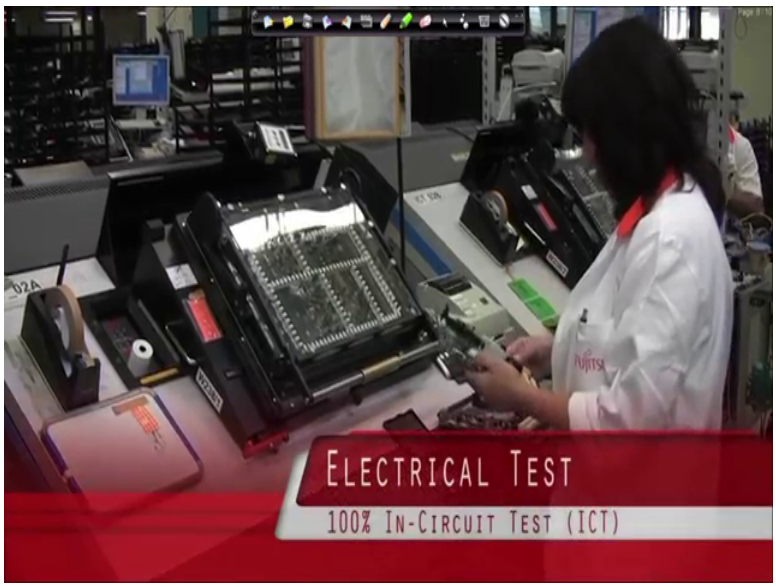

So, just to see that the circuits are completed there is no you know no unfinished or open bonds or joints. So, for that there is an electrical test as is shown here.

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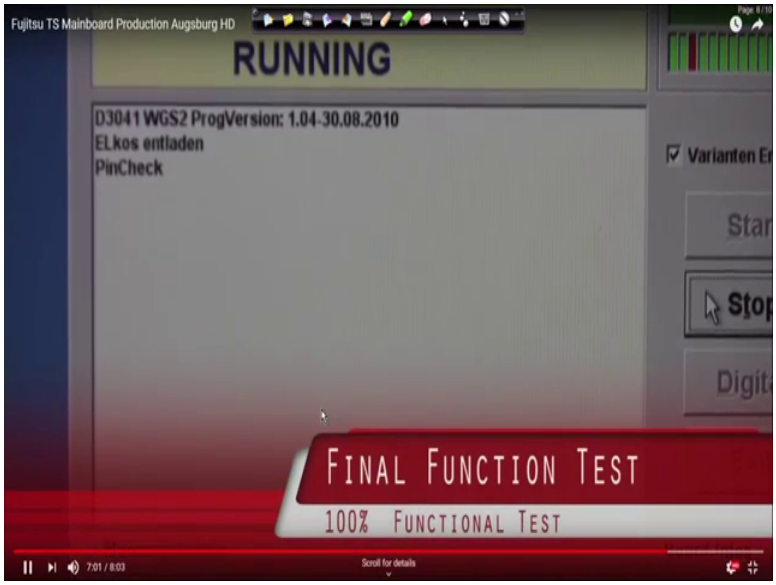

So, they run it there is a final functional test worth what they call it. So, the first one was quality was optical we you know visual inspection and now it is an actual electrical test performance test. They have the standard tests which they run and if they get desired results it means that all these connections are made they are working perfectly and the board is ready to be shipped. So, this Fujitsu plant and Fujitsu is a Japanese company, but this plant is in Germany. So, I think it was there right at there in the first screen itself when we started the video and here also you see that the most of these and what you see the language over here on the screen they are all in German ok.

So, that is it that is what I wanted to show you and I think you got a I hope you got a good feel of the process. Especially the final part where you know the motherhood is there the circuit board is there, but unless you put the component that is when the board becomes functional. So, that is what was shown over here in the video.

So, I hope you found that educational and I believe this video actually does a good job I mean I could have drawn or made slides, but that would not have given you the kind of feel that this video gives in 6 minutes ok. Finally, cleaning and coding then putting labeling etcetera and your motherboard is ready to be used or shipped and that also concludes our discussion on motherboard and second level packaging. So, we have

studied the characteristics fabrication and assembly of printed circuit boards right this is the summary slide that you see here.

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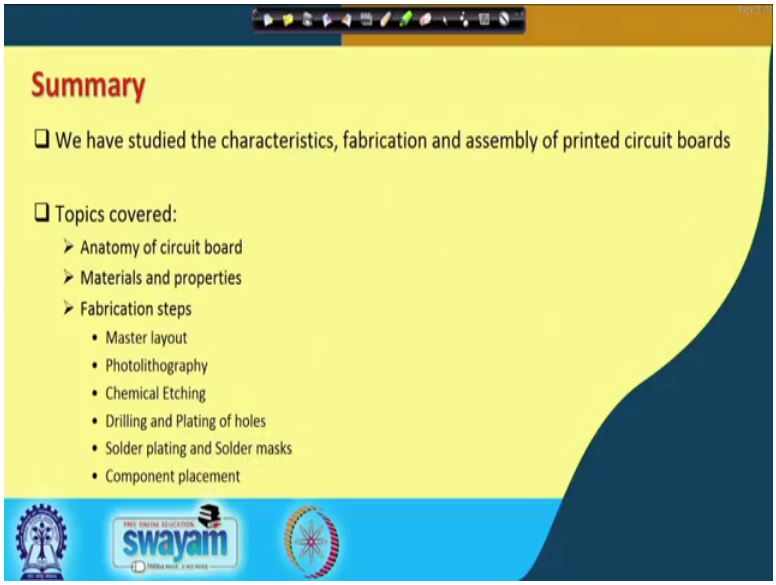

That was over the last five lectures this is what we studied. We started with anatomy of the circuit board then we looked at the materials and properties and then we went into the fabrication steps. So, we started with the master layout, the CCL Copper Clad Laminate that was a basic building block then we added layer by layer of copper using photolithography chemical etching drilling and plating of holes we talked about that.

Then finally, today we talked about solder plating solder masks and finally, component placement, which is where we took recourse of this video from Fujitsu which I believe you also found quite educational ok. So, that is about it and that kind of brings us to the end of our discussion on printed circuit boards, where we again this summary slide shows if we do a wrap up we discussed in details about how you actually fabricate a motherboard and remember the motherboard.

If I may call it it is a you can call it a cardiovascular system or you can call it the nervous system whatever it is, but motherboards because this is the medium through which the signals are passed on from the power supply to the main component and then from one component to the other and when I say components these are components on the circuit board. So, the circuit board is a very very important part.

I mean just if I just give you a processor or a memory chip or a graphics chip unless you have the circuit board you do not have a product. It is like you know giving you a brain and eyes and a heart and a stomach, but that does not make the human being unless you have the nervous system and the vascular system which helps in transmission of signals and transmission of blood providing the oxygen and all.

So, other words otherwise this it is similar here. So, just the components do not make up an electronic product. The circuit board actually is the medium that kind of adds functionality to the product makes it function and makes it usable ok. And as we see the circuit board is a green thing and we use it in some form almost every day and we have seen most of us have already seen one, but we never realize what goes inside ok. There are so, many layers of copper traces that go inside only the outer layers is where we see these components placed, but it is as I say this like a it is like an urban transport system, sometimes the two wires have to go, but unlike where roads can intersect two wires cannot intersect.

So, one has to go above the other. So, you have this different layers inside the circuit board, you are coming like this. So, you cannot meet so, move up and then go right. So, different layers and the more the number of layers of course, the more the number of places you can have or the smaller is a footprint of your motherboard because you have really gone high right. And the analogy I gave is having a number of row houses versus having a multi storied apartment complex apartment building right.

So, that is where we if you remember we started when we of talking about different layered motherboards, we saw two examples of a laptop 13 inch laptop. One was a much larger board one was a smaller board one was I think Dell the other was Apple. Because the apple motherboard is 8 layer motherboard and this one is a 6 layer motherboard. So, that is why this was much larger in surface area or in footprint as you see from the top ok.

So, motherboard I what I am trying to say is, a motherboard is a very important part and again I go back to my example and I keep on instead of circuit board I keep on using the word motherboard very often, is because at Intel I was part of a group of course, I was doing thermal design. But the partner in the sister group which was a lot much larger one was a motherboard man motherboard design group.

And it was really one of the top groups even though it was located in Intel India it was one of the top ones across the world they were real experts in motherboard design. And so, I had I interacted with them and I had a good feel first-hand feel of how difficult and how complicated those tasks can be especially the design. See one thing we did not even talk about here because this course is more about looking at the mechanical and manufacturing aspects of electronic packaging, but to design this wiring traces the wire ability that is a major part ok.

So, that we just assume that that is done and then now how do I make it is that is where we started, but in the design phase itself is extremely complicated task. I will just end with a little note of humor. So, many a times you would have this top level executives visit us and each of our groups will showcase our work and so, of course, I will show me and my teammates we will show some thermal technologies whatever we have developed, but this board group of course, first of all they had all these motherboards.

And the circuit boards and they will put that in display and so, they used to create a joke. So, you know when somebody important comes you say that will need a red carpet for them and this team used to joke and say this guy is coming so, no problem we will show we will lay the green carpet for them so green carpet the event meant is the circuit boards which a green in color organic circuit boards with organic laminates which are green in color ok.

Thank you very much. So, that kind of wraps up our discussion on circuit boards and second layer and second level packaging what we will do next is, now we will go more on the reliability side where we are going to talk about thermal, we are going to talk about structural and overall lifecycle predictions ok.

We will also talk a little bit of vibrations. So, we are I think today around half the course. So, half of the course was on manufacturing then the remaining half will be looking into these various reliability aspects ok.

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