Electronic Packaging and Manufacturing
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Lecture – 07
1st Level Packaging- II

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Welcome back and to the to this course of Electronic Packaging and Manufacturing. And today, we will continue with where we left off in the last lecture. We had just introduced you to what is chip carrier and types of chip carriers. So, today what we are going to cover are ceramic chip carriers and plastic chip carriers. This will be the main focus of this lecture.

And then, we are also going to go into something called a Dual Inline Package or DIP - D I P. It is probably, the first type of package that was invented back in almost more than 50 years back. And we will end this by looking at types of leads or types of this interconnections that come out of these packages ok. So, with that let us move on and look at ceramic packages, ceramic chip carriers, so ceramic packages.

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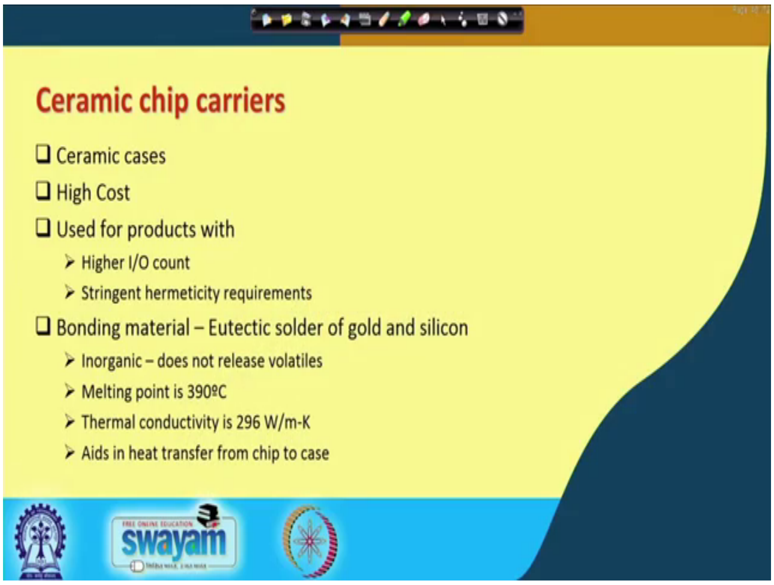

So, ceramic chip carriers as the name suggests the casing is made of ceramics ok. Now, ceramics are not inexpensive, they are they are expensive. So, the cost of ceramic chip carriers is high. So, we do not use it in you know in everyday use products like your cell phones or laptops or computers. These are used for let us say military applications avionics ok, which are the high end products ok. They are also used for products, which have very stringent ceiling or hermeticity requirements and very high and also for high IO count ok. As I said these are used in high level products, high end products.

The bonding material that is used, you know the bonding material between the chip to the chip carrier and the lead frame that bonding material here is typically eutectic solder of gold and silicon ok. A very expensive material is inorganic, so therefore does not release volatiles. The melting point is very high so, temperature wise it is stable source ceramics.

Thermal conductivity is high, because remember that was one of the primary heat conduction path from the chip into the lead frame, and then through the leads to the motherboard ok. So, high thermal conductivity is important. So, 296 watts per meter Kelvin is actually a very high thermal conductivity. To give you an idea thermal conductivity of copper, which is one of the best thermal conductors that we come across in our daily lives that is 400 watts per meter Kelvin. Next aluminium, it is pure alumina is around 238 ok. This is better than pure aluminium. The regular aluminium that we use the aluminium alloys, these are around 180, 200 kind of stuff watts per meter Kelvin that is, so this is way better than that.

So, as a result as I directly said as I already said that this high thermal conductivity helps in the transfer of heat from the chip to the casing ok. So, these are ceramic chip carriers ok. Once again, I want to mention that it is made of ceramic. Ceramic is not a cheap material. So, these are extremely expensive packages, extremely expensive first level packages and not used in you know commodities in what should I say when in high end or high use products like your cell phones, laptops, they do not have ceramic packages ok. These are used in very high end products all right.

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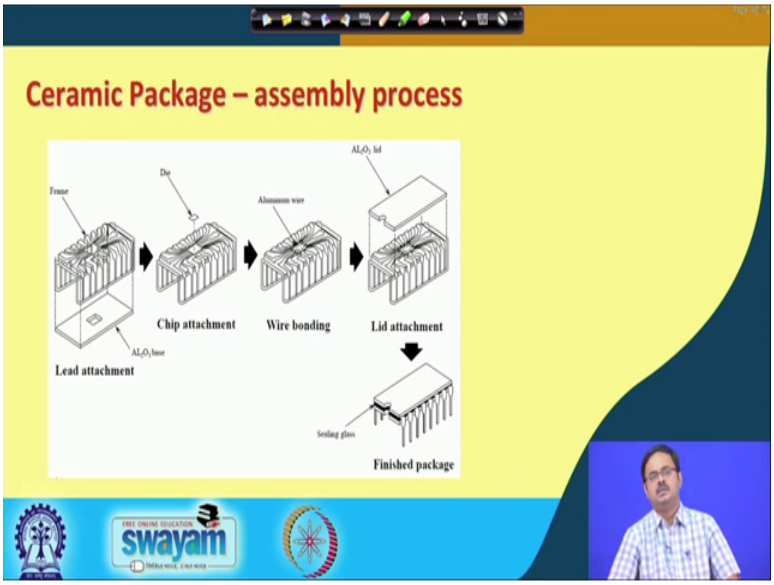

See if you look at a ceramic package, so let us spend a few minutes on this slide. This is the assembly process ok. We will see a similar one for plastic packages as well. So, if you look over here, the first thing what you see over here is a lead frame ok. So, the lead frame looks like this. So, different leads are coming out from a central you know central podium if I call it so, it is branching out ok.

And this is where the die or the piece of silicon or the chip is going to come and sit ok. Then this is going to sit on an on a base, which is aluminium AL 2 O 3 that is the ceramic all right and this is how it is? Now, that die is connected and the connection as we saw before is done by a bonding material, which is a new tactic solder of gold and silicon right with very high thermal conductivity, so that connection is met.

So, the chip attachment which is the next step is done. So, the chip is over there the leads are also there, but then I have to connect the two. And the way that is done is through this aluminium wires. So, these wire bonds that we saw in the picture remember in the 1st picture, when we saw that in the previous lecture the very basic configuration. So, these are those wire bonds probably, you can see them over here. The picture is not very clear, but you should be able to see this wire bonds, which is coming from several point different points on the chip. And to these leads that are coming out ok.

The next thing that we do is we put the lid or the cover lid lid or the cover on top. And then, we seal the sides using some glass; glass sealant ok. And this is how therefore the package finally looks like. And then, what we will do is we will trim it off, the trim of this these bottoms, so that you have these pins or leads coming out of this package. So, see what we had started with, we started with a very small piece of silicon, which you are calling the die. Again die, chip, microchip, microprocessor, IC, piece of silicon, these are all the same things. These terminologies are going to be used interchangeably throughout this course alright. So, that was my starting point this die the piece of silicon and this one is my finished product not well, I wants a finished product, this is a finished package.

To make it product this package has now has to be connected to a motherboard, motherboard to a connector; connector to a system and all that, so then finally you get this product. But, finally this is the package. So, outside what do I see? Outside I will see a rectangular box made of ceramic and with some leads coming out from both sides. But, inside if I am able to scrape off the top layer and able to see inside, this is what I am going to see, I am going to see a piece of silicon sitting inside. All these leads actually are connected to a lead frame, and then I will have this thin delicate wire typically made of gold connecting the various points on the piece of silicon to these leads ok.

So, once again let us recap what we just saw, this assembly process. We start with the lead frame and a base made of silicon made of ceramic. The piece of silicon comes, and sits on this central portion of the lead frame ok. The connections are going to be made from the top surface of the die ok. And those connections are now done through this wires.

These are typically, I mean I am showing it as aluminium wire, but these days mostly it is it is gold ok. Some of the very low end toys and all probably will have aluminium wires, but once you go, but gold is probably used more often these days ok. And then there is a ceramic lid or a cover that comes on to it the sides are sealed, the leads over here, lead leads are going to be trimmed off, so that now you have these pins that are coming out. And so these are the interconnects ok. These are the interconnects that are going to connect this piece of silicon to the wiring traces in your motherboard all right ok.

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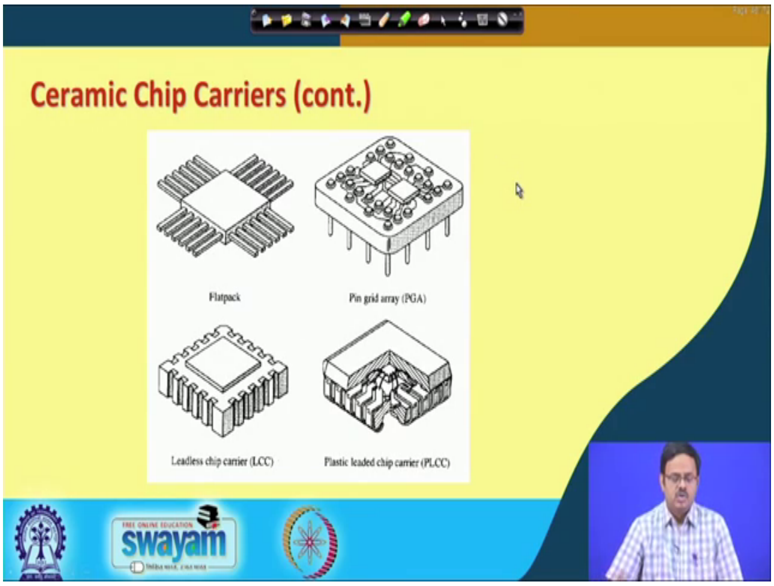

So, ceramic chip carriers if you look at it, thereof they can be of several types as is being shown here, I will I will just show these names for now, because we are going to discuss them later in more details, one is flat pack ok. Flat pack what is happening? It is flat, the leads are not taking this right angle turn as was shown in the previous slide ok, instead they just come out in the form of a plane ok. So, they fan out in a particular plane, and that is why it is called a flat pack ok. Also sometimes called quad flat pack, because the connections are coming out from all the four directions.

Then there is something called a pin grid array. So, over here you have these pins that come out ok. They can be just peripheral as is shown in this picture or there can be pins in different in several rows as is shown over here, so that is a pin grid array. So, what I will see is of course there is going to be another cover or the lid on top of the second diagram.

But, once we see that what once that lid is over there, the ceramic lid is going to be over there, what we will see is the interconnections are going to be in the form of pins that are coming out from the bottom surface ok. And it can be a pin array. It does not have to be just along the periphery. There can be another layer as is shown over here. You can see four pins on the outer layer, you can see a few more on the inner layer ok.

Then there is something called a leadless chip carrier. So, in the leadless chip carrier what happens is there is there are these cavities, which with kind of a metallized surface inside ok. So, again these are classifications under ceramic chip carrier, these are classifications based on the types of interconnections ok.

And these ones as you can see, these actually a sometimes even called the g lead carriers ok. So, the leads the interconnects actually turned I mean it is it is it kind of curves, and in the form of a g and that is why, it is called the g lead, you see this shape ok. So, these are ceramic chip carriers, I mean again some of these are in plastic as well. For example, this one PLCC is Plastic Leaded Chip Carrier, but I mean the configuration can be both for the ceramic as well as a plastic package ok.

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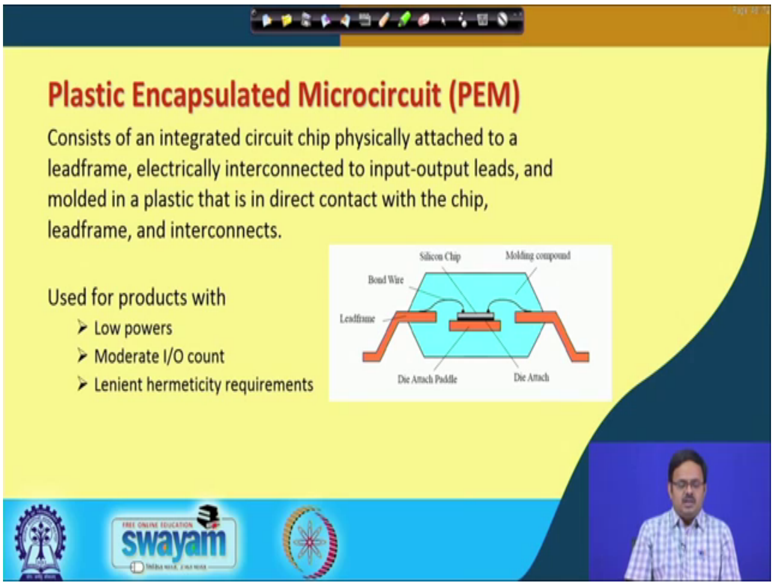

So, that brings us to the next slide, which is plastic encapsulated micro circuit or PEM ok, this is nothing but plastic chip carrier. Again I am going to show sometimes these different acronyms, because these are widely used in the electronics industry. But, what it essentially means is this configuration, which is plastic chip carrier. But, the only thing over here is the space inside is typically filled encapsulated with this material ok. And that is why, it is plastic encapsulated module or plastic encapsulated micro circuit ok.

So, what does it do, it consist of an integrated circuit physically attached to the lead frame, electrically connected to input-output leads, which is the same as what we have studied till now, and moulded in a plastic that is the important part. Moulded in the plastic that is in direct contact with the chip. Earlier there was a bottom frame a lid, but now this is all everything inside is plastic. So, it is not possible to move the lid and see these connections inside anymore ok. So, it gives us more protection definitely.

So, but this is used for products with low powers, moderate IO count, and lenient hermeticity requirements. Low powers why, because plastic is a is not a good conductor of heat alright. Next moderate I O count, because the number of interconnects that can be accommodated in a plastic chip carrier is less compared to a ceramic ok and lenient hermeticity requirements, so this is important.

Plastic as solid as they may look from outside always allows for moisture ingress ok. So, moisture ingress is inevitable in plastic. So, therefore with time there will be moisture driven degradations of these connections inside of this pins of these wires, you cannot help it, so that is why a product that is supposed to last 20 years typically will not use plastic encapsulated chips.

But, something that is supposed to last for a few years like 3 years, 5 years yes. So, if you look at your computer, the memory chips are all plastic encapsulated, many others several others. So, what I will do is in the next class, I will bring in some of these you know some devices and chips that I have in my in my office. And probably we will be able to see some of them ok.

So, if you look at this configuration in this picture, the configuration is more or less the same that parent configuration that we saw in the last class is similar. You have a silicon chip, you have a die attach what is the lead frame of the die attach paddle what is called and then it is connected by kind some kind of a bonding material.

And then you have the lead, and the lead frames and which is connected to these points on the silicon using this wire bonds. The only difference is the bonding wires ok. The only difference is you have this moulding compound, which is a plastic material that fills in this entire space inside ok, so that is the main difference with the ceramic. In terms of construction of course, in terms of materials, I O count etcetera there are lots of differences. But, in terms of just construction the main difference is the fact that this is completely encapsulated by this moulding compound plastic moulding compound all right.

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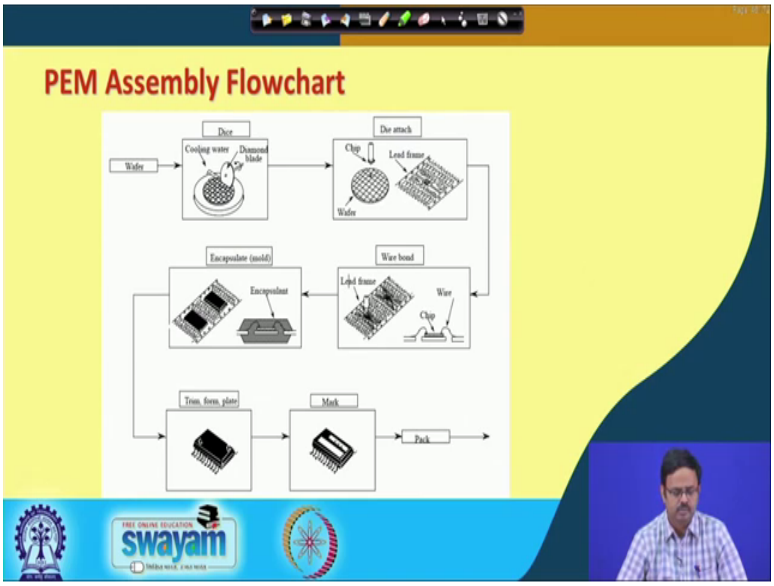

So, similarly probably a little more detailed the plastic encapsulated micro circuit assembly flowchart ok. We are starting from probably from the wafer itself. The 1st two are already done ok, the wafer and then the chip is taken out ok. The wafer is 1st taken the circuitry is you know through all these micro fabrication processes. The circuitry is there on each of these silicon pieces or the silicon dies. And then it is diced through the diamond blade to get this chips out ok. And then this is a lead frame that I have the two raw materials have the chip and the lead frame. So, the chip is attached to the lead frame.

And then, you have this wiring wire bonding that is happens over here from the points the connection points on the chip, on the top surface to these leads ok. So, all this wire bonding is done. And then this is the one, which is important, where it is the encapsulation is done. The mould it is put in the mould and this entire encapsulation is done. And so what finally comes out is typically black in colour or dark grey in colour, and that is what comes out that is your package ok.

And then, what we do is we take this v kind of shape it trim it form plating and all that stuff. And this is my depending on the type of interconnection that we will have. This is how finally my plastic encapsulated package is going to look like. From outside is very similar except the material, to a ceramic, to a ceramic package except that the material is different. But, again that is also kind of a rectangular structure with this leads coming out ok. And then and these are kind of branding and marking you will have the chip number and all that and then you send it out ok. So, this is how the package comes out finally all right.

So, again the different steps are we start with the chip, and the I am I am just skipping this first one from the wafer. We start with the chip and the lead frame ok. So, the die attach method happens to the center the die to the chip to the lead frame, then wire bonding from the chip to these leads in the lead frame ok. And then this encapsulation, which is very important, which is one of the differentiating factors from a ceramic package. And then we will we will take this lead frame, we will bend it, trim it, plate it etcetera. And then, finally my package is done. Again if you look at, if you have a memory card, you will be able to see typically depending on what type of memory you have, you will be able to see some of these, this typically plastic black coloured or dark grey coloured plastic encapsulated packages on this small memory card alright.

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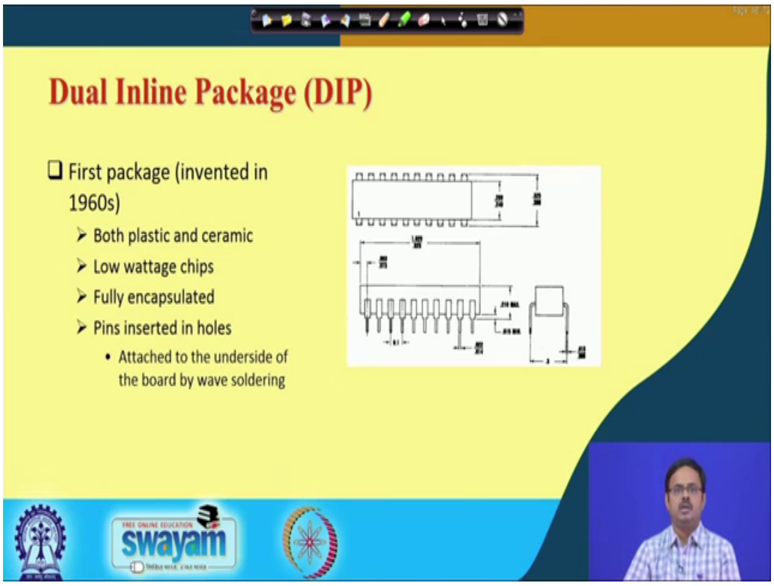

So, after plastic and ceramic packages and chip carriers. Let us move on to something called a dual inline package, which is something we saw ok, it can be plastic, it can be ceramic. But, what is important is this was the first package that was invented in the 1960s.

At that time the chips were low wattage, fully encapsulated at that time it was introduced later in the ceramic version also it is available all right. And so what comes out is it is called dual inline, because it comes the interconnections come out from both sides that is why dual. And then they are in series, so that is why, the inline part comes in all right. This picture also gives you some of these dimensions. These are all in inches by the way, and this is the structure. So, dual inline package is still a very common configuration that is used in many electronic products.

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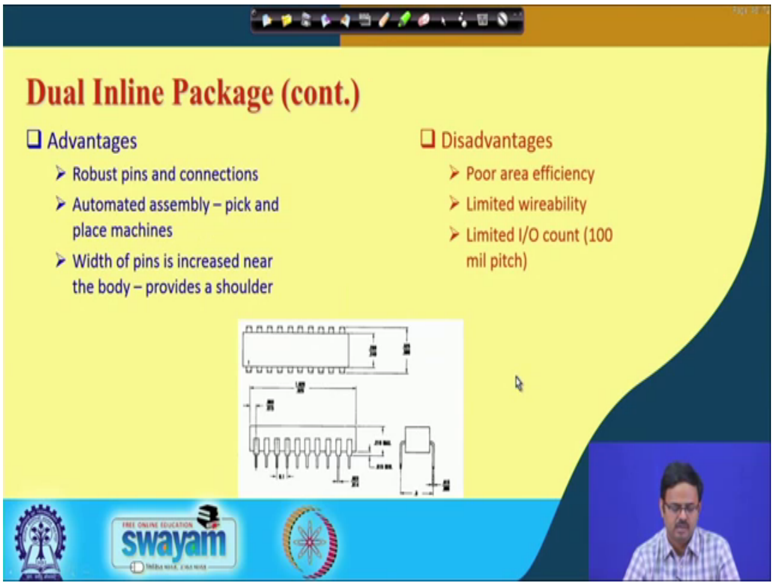

What is the advantages? The pins and connections are very robust. It is an automated assembly, we will see assembly processes later, but these are very amenable to automation in assembly line ok. The width of pins has increased their the body and as you can see here if you look at this picture, the width close to the body is wider compared to the pins that come out ok. So, this kind of provides a shoulder or strength at that location. And then these pins actually get into corresponding holes in the motherboard. So, these are some of the advantages.

What are the disadvantages? See if you look at these dimensions is a pretty large, so therefore the IO count is it is pretty low. 100 mils is; mils is mille inch 1000 of an inch. So, point one inch typically is the limit of the pitch between two successive leads ok. So, therefore it is limited variability, limited number of connections and poor area efficiency.

So, typically the amount of area the footprint that is required, which is very vey important ok. The amount of space that your device that your chip takes up in your motherboard that is very important by the way, when you when you come up with small packages and all small systems. The amount of space that you require to station a chip on the motherboard becomes very important; it is called real estate ok. Just like land price is very very costly and land so you want to have most of it in a in a limited piece of land similarly in the motherboard also. The space available is very small at the same time we want all features.

So, therefore we need packages, which can have large number of IOS over a small area ok, so that area efficiency for a dual inline package is not great, but then it is not expected also. Again remember this was the first package that was invented in the 60’s. So, at that time this is just an emerging field ok. So, after that of course there has been refinements and advancements. But, still today we have better designs of course, but the dual inline package still remains a very popular choice and for or very popular configuration ok.

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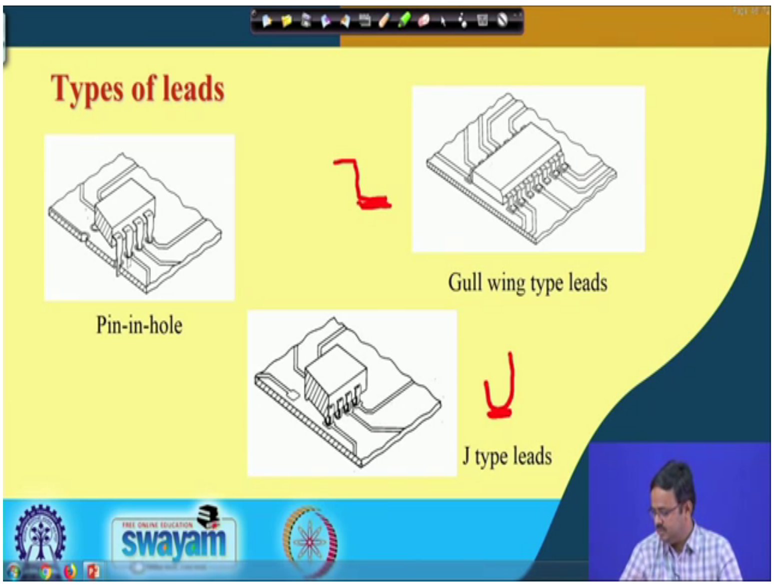

If I look at types of leads now, dual inline package. Let us take a dual inline package itself and look at the types of leads ok. The first one is as you see here, what we were seeing before? These leads come out in the form of there is a shoulder, next to the package and then that what you see is these pins go into corresponding holes in the motherboard. So, this is a pin-in-hole arrangement ok.

So, typically again I am probably jumping a little bit we will cover this more, when we go to motherboard. But, over here itself, you may appreciate that this pin has got into a corresponding hole the inside surface of which is metallized ok. And these holes in the motherboard are connected to the wiring traces ok. And this is how the connection is made ok.

So, this is how remember we started with some of these contact points on the silicon. So, from the silicon the wire bonds were used to bring the connections to these leads. And then these leads go into this corresponding pin holes or pin-in-hole or through holes, and then that is how the connection is made to the wiring traces inside the motherboard ok. So, pin-in-hole is important is common ok.

The next one is what is called a gull wing type. So, here the configuration is in this form. The gull wing, this is how it is as you can see. What is the use here, what is the difference? Differences these points that you see are no longer holes. These are not holes anymore, but these are pads. This is a wiring traces and then these are metallized pads on which this lead is going to be bonded most likely with solder ok. So, these are not holes.

The other one is J type leads ok. You will have again these pads attached at the end of this wiring trace. And the J and the lead is going to be bonded over here ok. Now, in this case the shape is in the form of a J, this was a metallized pad. So, this is how the connection is made. So, in either the gull wing type or the J type, you do not have holes in the motherboard, plated holes in the motherboard unlike the pin-in-whole arrangement.

So, is there an advantage to that you bet? Because, if you do not have holes, what happens? The reverse side of this board is also now available. And we can have probably a similar package attached on the underside of the motherboard as well ok. So, then you have a double sided board clear. If you have holes, you cannot do that alright.

So, we will end with that the overview of packages, and we will end todays lecture with that. So, what we studied as part of this to recap, we started with looking at the types of ceramic packages and plastic packages looking at their assembly processes as well ok. We saw the ceramic packages of expensive ones used in high end products. Plastic packages on the other hand are used more commonly in daily, you know consumer electronic products that we use on day-to-day basis, but of course reliability of a ceramic package is much more than plastic package, and so is the cost ok.

And after that we looked at the assembly processes. And then finally, we looked at the different kinds of leads that are used both in ceramic as well as plastic packages. There are pin-in-hole types, there are J J types, there are gull wing types and the ceramic parts, we also saw there are leadless packages and so on and so forth ok.

And somewhere in the middle, we talked a little bit about area efficiency, which becomes very important ok. Given a certain amount of area, how many interconnections can I have ok. So, this becomes very important, because space on a motherboard comes for a premium. There is a limited space and I want most maximum number of components and connections to be made ok. So, we will discuss all this, because the importance of this later as we look at different configurations ok. So, till then till the next class have a very nice day. And I hope you learn something new from these two from the last two lectures.

Thank you very much.