Electronic Packaging and Manufacturing
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Lecture – 21
System Integration

Welcome back friends. And in the last lecture, we had kind of wrapped up our discussions on second level packaging. And primarily that was to do with number 1ok, there was primarily to do with the interconnections from the package, which is a substrate to the motherboard and the connections there off right. So, as part of that we had talked about motherboard fabrication, and finally we also talked about the assembly of components on the motherboard, the different steps involved and so on.

Today, what we are going to talk about the topic of discussion today is third level packaging ok. Sometimes third and fourth levels are or you can even say third and fourth level packaging if you want to call it, because here is where you know what you call three, what you call four that gets a little hazy. So, many people say that ok, I have this motherboard and apart from the components and packages that are directly bonded on the motherboard, anything else that is connected onto the motherboard is third level packaging which is removable. And then finally, when it goes to the overall enclosure and which is finally, what is sold in the market with the protective final housing around it that is fourth level packaging ok.

And then there are some people who say now the both are not very different from each other, so anyway. So, what I am trying to say is third and fourth levels the definitions or the agreements on these become a little hazy, but nevertheless we know what steps are involved whether you call it number 3, level 3, level 4 that is not so important all right. So, today we are going to talk about both. And this is going to be one lecture. This is the concept that we will cover today is about system packaging.

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So, how do you now convert whatever we had the piece of silicon the package, and now which is connected onto the motherboard into a final system what does it entail. And as part of system packaging is where many things come into being. These are probably not very intricate from the point of electrical design or even manufacturing, but nevertheless very, very important in order to give the final user experience and of the functional device all right. So, it is start with motherboards and daughter cards then we are going to talk about connectors and finally end with enclosures all right.

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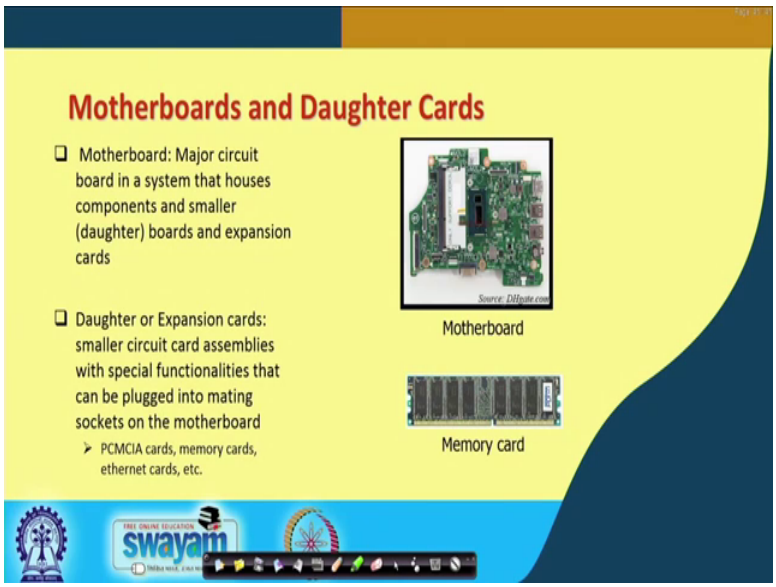

So, let us move on. The first one is motherboard and daughter cards. So, what is a motherboard and what is the daughter board or daughter card or expansion cards. So, motherboard is the largest circuit board, the major circuit board that is there in a system, which also typically is also the largest component inside any system ok. If you look at for example, a laptop computer, and most of it is a motherboard if you if you go inside, if you open the box, the bottom unit it is a motherboard which is the largest one.

Even a desktop also has a large motherboard, if it is a tower it, it is vertically aligned and so on all right so that houses the components and smaller boards and expansion cards ok. And then onto the motherboard, of course, you have components that are attached, as we saw in the last in our second level packaging. But you also have these provisions for connecting additional smaller circuit cards ok. So, those are often called the daughter boards or daughter cards, expansion cards and so on. So, these are smaller circuit card assemblies with special functionalities.

And then what happens is these are connected kind of you can even say inserted or plugged in into the motherboard through their respective connectors all right. So, typically there is a socket, and there is a connector they just go and mate and there is all the connections are made. So, one of the prime examples is memory all right. These days we also have for smaller ones we have onboard memory, but otherwise especially for desktops servers, the memory is upgradable you know we all especially in desktops, we say upgrade even for laptops. I do not know finally, how many people end up upgrading laptop memory I did it once by the way.

But even though many people do they insist on that it is just probably the sense that I am, I have that ability of the capability or the flexibility to upgrade my memory if required. Most people do not end up doing that, but it is possible. So, what you see at the bottom is the memory card, this is of us for desktop. And see many a times you see on this memory card, you have this connectors, by the way this we saw these we saw these as part of the motherboard fabrication process.

And this connector goes into a socket like this one over here. If you look at this motherboard on top, which is from a laptop, we have seen this picture before. You see this socket for a memory card, and this is where the memory card is inserted and that is how the mating will be done. So, memory cards is not the only thing, Ethernet cards

even, these days the basic this flash memory cards ok. These are all kind of small circuit boards or orbit devices inside ok. So, PCMCIA not very common these days, but that used to be common at one point of time. I have used that. It was it was pretty prevalent even 10 years back over the last few years we do not see much of those. So, these are examples of daughter cards or expansion cards.

And then so this also calls for connectors, because these are connectors you need this connector and the socket the female and male parts for this mating and what are these connectors what, what connectors are supposed to do well we know, but we will see more formally in one of the subsequent slides ok.

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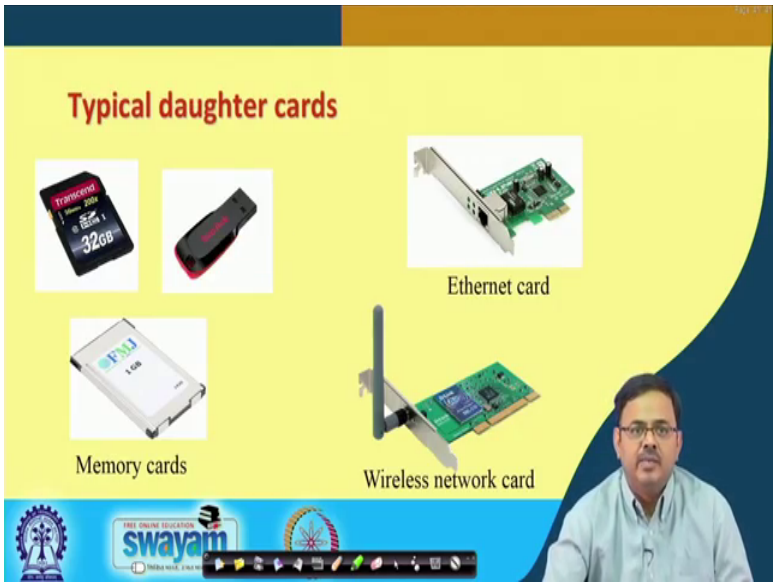

So, typical daughter cards some examples, you see memory cards on this on the on the left. I think these are all well known to you I do not need to explain right, especially, but except maybe the bottom one which is a typical PCMCIA ok. But on the right hand side you do see Ethernet card, you see wireless network card, we know these right. These are there in our lab in our desktops even laptops, laptop sometimes it is inbuilt it is not different, but in desktops we see this. There is a separate card small one ok, but what do we see here, we see this Ethernet card both this one as well as a wireless network card has a small connector which is going to plug in into a socket on the major motherboard, the main circuit board which is the motherboard ok.

So, these daughter cards as I said before they have their own functionalities Ethernet card, we know what they are supposed to do, wireless network card, we know what they are supposed to do. And you have components accomplishing, those functions with those functionalities that are bonded on these smaller circuit cards ok.

Many of them are as you can see these are peripheral packages if you can I do not know how large it is on your screens, you can see some of these can be even ball grid array packages direct bonded ok. Probably on this socket in these smaller circuit cards, it is not very common to see you know the piece of silicon on its substrate, which eventually is connected on the mother board; these are typically chip on board ok.

So, these are typical daughter cards as we see. And these as say before these daughter cards onto the motherboard that is where how I am slowly building up the system ok. Started with a piece of silicon level zero, coming out from the silicon die, silicon wafer level one put it on the chip carrier had the substrate. And finally, all these wire bonded the chip to the substrate everything done. And the substrate also has a interconnections ready to be connected to the motherboard that is where we stopped at level one, level two we went ahead and looked at motherboards ok.

Now, we are trying to see that how do I then put these sub assemblies on to the motherboard to make the form final assembly that will go, that will form the major part of the final system that we are going to sell in the market that we can buy in the market clear. Just a side note here you may also argue that in case especially for a pin grid array or a land grid array on which the CPU is resting. These are also removable this can be attached on this motherboard and removed ok, the removable part correct.

So, one can argue that well this is not is this part can I say that these packages are like daughter cards not necessary. And you can say whatever you want these are typically not we do not call them daughter cards or circuit cards these are packages specially designed to house a high performance piece of silicon or high performance chip all right.

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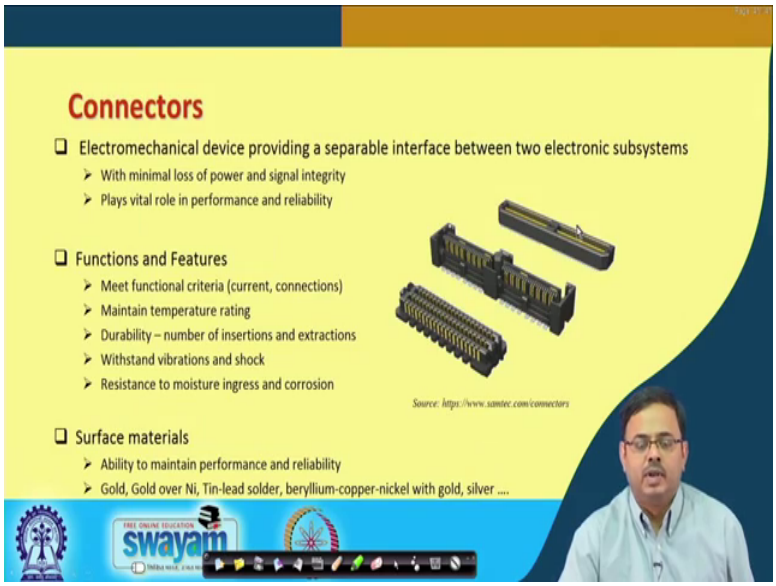

So, next thing is connectors. So, what are connectors we all know what connectors are we use it every day, but it is an electromechanical device providing a separable keep in mind, separable it cannot be a permanent attached I have connected it and that is it, no, I should be able to remove it. So, it is a separable interface between two electronic subsystems. See some, some examples of connectors ok. There are various types that are available.

So, what is it supposed to do yes it is supposed to connect to electrical systems fine well I can take two wires strip of the insulation and then connect them that is also connected a very crude one. So, how do I say what is a good connector, what is not a good connector, so with minimal loss of power and signal integrity, very, very important. The electrical connection has to be very, very good it cannot be a tarnished surface, you know there is a loss of signal and all that stuff.

Many a times we see if you do not connect our projector to the CPU tower in our desktop you will see that the, the display on this on, on the projector is very is not great and then sometimes no not tighten the connector, and then when you tighten it here suddenly now you see the better colors right. So, it does play a role, the signal integrity, the purity of the signal as well as the integrity of the signal that gets transmitted from subsystem 1 to subsystem 2 through this connector needs to be maintained very well. So, it plays a vital

role not just in performance, but also in reliability. Why it is, why it is important, because remember the, what separable, this is removable detachable.

So, I should the connector should be designed, so that it can be detached multiple times right. So, the reliable and so every time I attach and detach, I should not be losing performance right. Now, so depending on what I try to want to do or what I am trying to do these connectors can and the number of times you have to attach and detach during the life lifecycle of a product can be very variable. If I am talking about a display monitor and a desktop computer probably that is very rarely would you remove for the first time it is connected and then you work on the desktop.

On the other hand, if you are at your desk and using your laptop and you want to use the laptop as a portable device, when you go somewhere, but when you come back to your desk you want too large a screen. So, every time you have to connect this connector cable that will connect your laptop to the larger screen, so that is an example where this removability the, the number of times it is attached and detached is much higher is high correct.

Think of another connector USB connector you are plugging in your USB device and plugging it out if it is a memory stick flash memory stick, you are doing it many, many times. And you cannot say that with every time you know the, the connector performance goes down, my signal integrity goes down or the surface is getting tarnished you cannot do that ok. So, the functions and features definitely, it has to meet the functional criteria which is current the current has to flow, the connections has to in electrical connections has to remain has to be made, but there are several other functions and features as well.

It has to maintain the temperature rating ok. It cannot give rise this connection should not lead to a hot spot where the temperature is very high it cannot ok. Durability which I am just I was just talking about. The number of insertions and extra extractions number of attachments and detachments ok. It should be able to withstand vibrations and shock depending on what, what you have put in there will be some vibrations. We are going to talk about vibrations by the way when we talk about in the second half of the course when we talk about reliability.

But vibrations is important. Vibrations can happen at multiple stages for a product. For example, if you talk about military applications, space applications, automotive

electronics there is a lot of movement and vibrations all the time, but your connectors should be able to withstand, it should not you know this vibration, so this connector has become loose and then it falls off no not allowed right. During shipment it can be even if you are talking about a static product like a TV or a desktop computer or a server, during shipment it is going to be subjected to vibrations ok. So, it should be able to withstand vibrations.

Even a desktop even while it is working, you are going to have a fan inside cooling fan, the fan gives rise to some vibrations right, we try a lot to dampen it by having the right attachments and fixtures, but it is possible ok. The last thing is resistance to moisture ingress and corrosion. This is a very, very what should I say one of the major causes of failure or if not failure degradation of the performance is overtime, there is moisture ingress. The surfaces gets if there is moisture then the surface is react, there is corrosion that happens at these connector surfaces. So, all these actually degrade the performance.

So, therefore, the surface material the materials of this connector especially on the surfaces, where they meet where the connection actually happens has to be chosen very carefully so that it is able to maintain the both the performance and the reliability. It is able to maintain both performance and reliability ok. So, I have given some that I have given some materials, but this is just a small subset there are variety of materials that are available. So, these are some connectors that you see inside a system, you will see a lot of them.

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But what are some of those connectors that we see more, you know more often see. The first one is a ribbon cable. And if you open in many electrical and electronic systems a ribbon cable is quite common, you see that ok, I think all of us have seen how it looks, how the connections are all right. The round cable especially for TVs, for microphones, and even the smaller ones you know when you the older ones before USB became very popular the keyboard and the mouse those connectors used to have these rounded connectors round cable connectors ok. You also have connectors for example, stereo head the headphone jack, the mono stereo, these you will see those, these are round cable connectors.

Then some of the more common ones SCSI, SCSI we have seen this kind, kind of connectors before I they are not very common these days, but again as I said even 10, 15 years back these were very common. If you have some of the older desktops, you will see these ok. So, there will be a female part there is a male part pretty I am forgetting the number of pin counts, but they used to be large number of pin counts ok. Now what happened was that made way to not made way I would say then, but they were also parallely there was VGA connectors right. And even today a lot of the computers especially desktops and even some laptops have VGA connections ok. If you have to connect a laptop to a projector, even a few years back VGA used to be the standard.

Now, slowly that is making way for HDMI as you see over here, but even today there are many, many systems which have VGA. So, I always move around with a VGA to HDMI sorry HDMI to VGA connector or basically an adapter, because my laptop is a new one. So, it is, it is HDMI, it is slowly becoming default.

There are some laptops by the way for example, my older one which was the larger one from dell that has both, both HDMI as well as VGA. But the smaller one these days typically have HDMI only, but you know the projectors have not I mean the projectors have not been upgraded typically you do not replace a project of that often. So, therefore, many a times the projector connect the connector is still a VGA, so that is the reason I, I move around with HDMI to VGA adapter all right.

And USB and micro USB these have become so common these days USB is any of your flash drives that we use are USB drives USB 2.0. And micro USBs which is most of our cell phones today are micro USB right, it is USB 2.0 on 1 end micro USB on the other if you want to transfer files from your phone to your computer or even as a charger the charger pins are all now most of them I would say are micro USB, most of the android phones ok. Apple, Apple again uses its own connectors there is one way by the way. There is the other thing where you do not find a lot of standardization is the plug the charging plug of your laptop is very different on one hand it is a three pin plug.

But what comes out is, is not the same that is why your dell charger many people say why have I forgot my charger can I borrow yours well, but how is your pin oh no this is not going to work on mine all right. Apple again is completely as a different issue. So, the Apple charges can work across apple products many of them, but for example, an android phone charger with micro USB you cannot use that to charge your iPhone. And of course, that both all connectors are good, no, no question about that, but a lot of it is sometimes is also business driven, because companies do make some money by selling by sale of these accessories ok.

So, if an Apple owner can go and buy an android charger, then the apple charges are not going to get sold. So, there all these business angles as well same for same for the laptop charges as well. So, they would like to buy they like you to buy a charger which is specific to your laptop all right. I hope I did not offend anybody by saying these all right.

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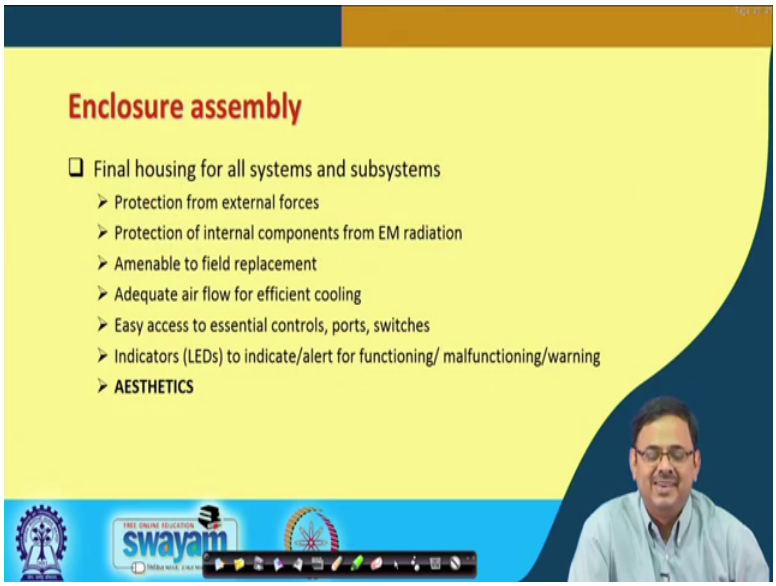

The final thing is now I have these connectors I have talked about connectors, which is a which looks a little trivial, but you know there are lots of standards especially there these are all various these need to be standardized a lot even though I talked about examples where it is not standardized even though it can be. But a lot of these SCSI, HDMI, USB these are standards right. And a lot of years of efforts have gone into coming up with these connections.

So, finally, is the enclosure assembly. So, I have now the laptop I have connectors etc, etcetera I, I have the circuit board, I have the daughter cards, I have the connectors maybe I will also have fans and all attached on the on the motherboard with a connector many a times, it is just wires or it is a ribbon cable. But finally, it goes into the assembly the chassis. So, the final enclosure is the final housing for all systems and subsystems. And what are its functions it is gives the overall protection from adverse environment ok.

Protection of internal components you have to even in internally you have to put some kind of shields etcetera for EMI radiation, electromagnetic radiation. It should be amenable to field replacement ok. So, I should be able to remove the chassis, replace any products and put it back. I should be able to especially for desktops and all I should be which is configurable, I should be able to add what I want, there are many people who actually build their desktop bottoms up it is possible to do that.

They should be adequate airflow for efficient cooling. So, chassis, chassis design actually is important especially, we are going to talk about thermal design later. And it has a great impact on the airflow inside both in terms of how much of airflow in terms of you know cubic feet per meter, per minute sorry cfm or even the flow path. If you have a fan cooling fan, you have to direct the flow towards the hot components, how do I do that. So, the chassis design is not so trivial. It is not just like an enclosure you, you take a sheet metal close it I said basically fold it fold that sheet metal to your desired shape and just put it around the system ok. So, it has more to do that.

Then easy access to essential control sports switches. So, for example, I mean if I have to plug in my USB drive, I should not have to open the chassis and put it attach it to the motherboard. The, the port, the connection port should be accessible from outside itself easily accessible all right. So, similarly for the Ethernet card right, we saw this one. So, this piece of metal that you see actually is on the backside of your desktop. And this one is visible. This port where you plug in your Ethernet cable is right there. So, you do not have to really open the chassis to access this right. So, the design of the chassis has to be like that, so that this comes right on the surface.

Say for USB ports if you have to plug in my USB port or the, or my flash USB drive or then I should be able to do this. If it is a memory card like this one yeah there also we have slots right now, correct. And earlier we used to a pcm, PCMCIA slots as well now there nowadays this is kind of becoming obsolete, we do not see that anymore, but what I am trying to say these connectors have to be easily accessible which is what I am trying to show over here easy access to essential controls which is pores connectors and then indicators to indicate or alert in terms of functioning, malfunctioning, warning.

So, for example, again go back to the previous picture over here, this Ethernet as soon as it is plugged in we know, we sometimes see a green light over here. If the connection is not very good, we see a blinking yellow light right. It gives you all this indicators. If your laptop is low on charge you have a green light if it is fully charged, but then the lights can turn into orange or yellow if it is low on charge right. So, these indicators are there. So, LEDs to indicate these and, and this is just a couple of examples I mentioned.

And finally, nothing to do with functionality, but an extremely important quality of an enclosure is aesthetics looks, because this is what you finally, see from outside. It has to

look good that increases the desirability. Why do you think people like apple laptops so much, because it looks so nice, it looks so sleek from outside right. So, that is very important.

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So, different form factors depending on this even the same product I am showing desktops for example here the same product. But if you look at the size and functionality and, and what is inside you have different form factors right. So, if you look at this towers, there are so many types. I have nowadays most computers are in this tower form factor, but I have I have used these kinds where actually this is your the base unit and the monitor actually sits on top ok.

Now, these are not very common ok. And then depending on these, these are so these are like and they were called atx jesse I believe at one point of time and these are different sizes ok. What is the material some of these are made of plastic, some of these are metal metalized some of their metals like magnesium is very, very popular and so on and so forth. And as you can see looks are important they all look very nice ok.

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And which is the last slide that I am showing here aesthetics right. I will talk about how, how looks do matter. Look at the two and you should not be comparing them, because the one on the left is a very old one we used to use that at some point of time that that used to be quite, quite the standard. This scream EBS plastic chassis, even the even the behind part which used to be metal would also be color coded. Actually at that point it looked good I, I still feel this looks pretty sober, but compare that with the designs on the right, think of this young crowd today ok, the gaming systems the gamers so if they have to choose and again by the way it also depends on the population that you are talking about.

If it is a young college going students or very young professionals, then they have, they, they prefer a certain looks and aesthetics a very cool looking, funky looking stuff that attracts them right. So, I for example, remember there was once a laptop that Sony came out Sony Vaio very nice, and they came up with came out with different color schemes purple, green I mean this you know this punk green very, very bright, light green, violet, silver, orange, several colors. And then you know what they actually put some two connectors so that you can take you can connect a strap.

And you could connect it like a bag this sling would come across your shoulder and it looked exactly from outside like a ladies handbag and apparently so we probably did

some market survey and saw that that design had some appeal for young women. They would like to carry their laptops in that manner ok. And they came up with that.

So, aesthetics do play a role there are there is a lot of market research that goes on as to how your product is going to look. And, and let us admit that today when we go to buy a tablet or a cell phone or a Smartphone looks do biases, we just do not go by the configuration inside that is important.

But I think we will all be lying if we say that we are completely, you know insensitive or we are not at all impacted by how the product looks it does matter, aesthetics do matter all right. So, that brings me to the end of this lecture again some references over here. And that kind of wraps up our discussion on the final level of packaging, which is system integration, we are calling it third level packaging, some people may call it third and fourth level packaging whatever it is.

But at the end of second level packaging, we stop with the motherboard with components and packages on top. And finally, through today's lecture we converted that subsystem if I may call it so into a full system which is housed inside a final enclosure and ready to be sold to the customer ok. And so we have therefore packaged our electronic product. Thank you very much. And from next lecture onwards, we are going to talk about the reliability aspects starting with thermal management.

Thank you very much, bye.